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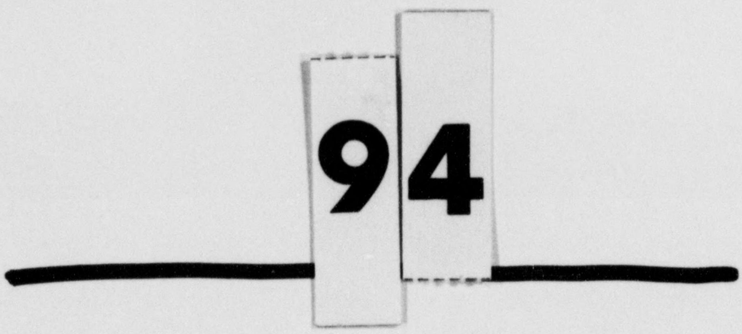

CONFIDENTIAL

684 Ranges, Guided Missiles

The Joint Research and Development Board

CONFIDENTIAL

REPORT OF THE COMMITTEE ON LONG RANGE PROVING GROUND

Prepared by

THE COMMITTEE ON

LONG RANGE PROVING GROUND

20 JUNE 1947

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REPORT SERIES NO. 1

PG 27/4

APPENDIX "B"

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REPORT SERIES No. 1
PG 27/4 20 JUNE 1947

REPORT OF THE COMMITTEE ON LONG RANGE PROVING GROUND

THE JOINT RESEARCH AND DEVELOPMENT BOARD
of the War and Navy Departments
Washington 25, D. C.

Prepared by
THE COMMITTEE ON
LONG RANGE PROVING GROUND

Approved: William L. Richardson
Brig. Gen. U.S.A.
Chairman

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COMMITTEE MEMBERS

NAME	DUTY STATION
Brigadier General W. L. Richardson, U.S.A., Chairman.	Guided Missiles and Air Defense Division, Asst. Chief of Air Staff-3, Headquarters, Army Air Forces.
Colonel H. N. Toftoy, Ord. Dept.	Ordnance Department, Washington, D. C.
Colonel John W. Davis, G.S.C.	General Staff Corps, Headquarters, Army Ground Forces.
Captain D. S. Fahrney, U.S.N.	Bureau of Aeronautics.
Captain D. A. Harris, U.S.N.	ACNO (Guided Missiles)
Commander James Scott, II, U.S.N.	Bureau of Ordnance

C O N F I D E N T I A L

S U M M A R Y

I. The Committee on Long Range Proving Ground, established by Joint Research and Development Board Directive PG 1/1, 7 October 1946, was directed to examine the entire question of a single national, long range guided missile proving ground.

II. The Committee studied the Programs of the various Services as they affected long range testing and determined that it is necessary to initiate immediate action to provide a long range proving ground for guided missiles.

III. The Committee first determined the characteristics of an ideal long range proving ground and used these characteristics as a yardstick with which to assess the value of the various possible locations and to determine the specific requirements in connection therewith. It was determined that the launching site should be located within the continental limits of the United States because of the prospective difficulty of negotiating with foreign powers for such major base areas and facilities as would be required; the difficulty, expense and time involved in transporting materials and personnel back and forth between the launching site and centers of industry and research within the United States; and the fact that sudden attack might deprive this country of its only long range proving ground at a time when its need was urgent.

The ideal proving ground should consist of:

a. A suitable launching site, supported by adequate base facilities, located within the continental limits of the United States.

b. A range, thoroughly instrumented by means of land based observation stations, at least 3,000 miles long and 300 miles wide at that distance, and with impact areas at various distances along the line of flight.

c. The climate should be such that year round operating conditions will prevail. A detailed analysis of these requirements, together with minimum acceptable standards, is contained in the main body of the report.

IV. After determining the specific requirements for; reviewing the previous studies on similar projects; conducting extensive map studies; and reconnoitering the six most promising sites; the Committee concluded that the following two ranges, in the order of preference listed below, most nearly approached the ideal range:

a. First Choice:

El Centro, California -- Gulf of California Range

This area affords the closest practicable approach to the ideal range available on the continent of North America. The launching site would be located about 20 miles west of El Centro

just north of the Mexican border. Supporting facilities at the Naval Air Station, El Centro, would be used to reduce the cost of the project. The instrumented range would extend in a southeasterly direction over the Gulf of California where land based instrumentation would be available on Mexican territory for a continuous distance of 650 miles. The range would extend on out to sea to a distance of about 4,500 miles. The total cost is estimated to be about $119,290,000.

b. Second Choice:

Banana River, Florida - Bahama Islands Range.

This range is an acceptable second choice. The launching site would be located at Cape Canaveral, Florida, with supporting facilities at the Naval Air Station, Banana River, used to reduce the cost of the project. The instrumented range would extend in a southeasterly direction for a distance of about 725 miles with land based observation stations located on the Bahama Islands (British). By moving the line of flight to the north a few degrees the range can be extended to a distance of 10,000 miles. The total cost is estimated to be about $142,055,000.

V.

It is to be noted that both choices involve the acquisition of territorial rights in foreign countries. The areas involved would be quite small. In both cases, the impact points would be at

sea with a minimum danger to life and property.

VI. Recommendations:

The Committee recommends that:

a. Immediate action be taken to provide a joint long range proving ground.

b. The joint long range proving ground be established at the El Centro-Gulf of California location (first choice) or at the Banana River-Bahama Islands location (second choice).

c. The responsibility for further planning and implementation of the joint long range proving ground be assigned to the War Department.

d. The joint long range proving ground be organized on a joint task force basis.

Details of specific recommendations are contained in Section 2.4 of this report.

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SECTION 1.0

STATEMENT OF THE PROBLEM

1.1 The Joint Research and Development Board in Directive PG 1/1, dated 7 October 1946, directed the formation of a Committee on Long Range Proving Ground. The objective, terms of reference and definition of the term "long range" are quoted below:

1.1.1 The Objective

"The objective of the Committee on Long Range Proving Ground shall be examination of the entire question of a single, national, long range, guided missile proving ground"

1.1.2 The Terms of Reference

"In pursuit of its stated objectives, the Committee on Long Range Proving Ground shall

a. Study the programs of the various Services as they affect long-range testing, and assess the overall necessity for a long range proving ground.

b. Define specific requirements for a single joint long range proving ground.

c. Conduct a study and a survey of the various possible sites.

d. Recommend a single joint long range proving ground and prescribe complete facilities required therefore."

1.1.3 Definition of "Long Range"

"The term 'long range' shall be considered to mean ranges longer than 150 miles. The proving ground should be adequate to meet estimated requirements for future testing and proving of guided missiles."

SECTION 2.0

DECISIONS WITH DISCUSSIONS

2.1 Study the programs of the various Services as they affect long range testing, and assess the overall necessity for long range proving ground.

2.1.1 A study of the programs of the various Services as they affect long range testing indicates that it is necessary to initiate immediate action to provide a long range proving ground for guided missiles. A detailed list of the programs of the various Services as they affect long range testing is contained in a supplement of higher classification.

2.2 Specific requirements of a single joint long range proving ground for guided missiles.

2.2.1 General.

A long range proving ground for guided missiles should consist of a suitable launching site, supported by an adequate base, and an instrumented range where the missile can be kept under continuous and close observation throughout its entire flight.

2.2.2. The first and most difficult requirement to fulfill is that of the instrumented range.

2.2.2.1 Means of keeping the missile under continuous and close observation throughout its entire flight should be provided. Observation of the missile during the first 500 miles of flight is a mandatory requirement. Instrumentation beyond 500 miles is highly desirable but not mandatory, except that the terminal part of the flight path of the missile should be observed.

2.2.2.2 Observations should be accomplished by means of land based observation stations located at about fifty mile intervals along the surface projection of the line of flight of the missile throughout the first 500 miles.

2.2.2.2.1 Each observation station should consist of observation points, separated by distances of about ten miles, grouped symetrically about the surface projection of the line of

flight of the missile, and not over 25 miles from such projected line of flight. Distances greater than 25 miles will reduce efficiency. Each observation point must have a line of sight to the missile, and in most cases, depending on the type of instrumentation, a line of sight to each other observation point within the station.

2.2.2.2.2 At each observation station, but not necessarily at each observation point, should be the following types of instrumentation:

(a) DOVAP (Doppler-velocity-and-position)

(b) Chain radar

(c) Search radar

(d) Optical devices consisting of high speed movie cameras and high powered photographic telescopes.

(e) Weather observation and recording devices including means of sounding the upper atmosphere.

(f) Telemetering

(g) Command and Guidance

2.2.2.2.2.1 It is considered desirable that the entire range be covered by a LORAN type of navigational system and that part of the range which is over water should be covered by a SOFAR system.

2.2.2.3 All observation stations and observation points should be connected by hard wire for communication and timing circuits. Microwave radio can be substituted provided line of sight between relay stations is available.

2.2.2.3.1 All observation stations should be equipped with emergency command fuel cut-off and destruction circuits to destroy the missile in the event of an emergency.

2.2.2.4 All observation stations should be accessible by rapid courier service in order to provide for supply, maintenance, transportation of personnel and return of necessary data to the main base.

2.2.2.5 All observation stations should possess the necessary housekeeping facilities for the maintenance of personnel during test periods and for station keepers when the range is not being used.

2.2.2.6 Observation stations and observation points should be located among themselves and with relation to the launching site to within an accuracy of ten feet and their position should not vary more than one foot without precise knowledge. The minimum requirement is for a first order survey.

2.2.2.7 Instrumentation should not be affected adversely by any natural phenomena or terrain.

2.2.2.8 The instrumented range should be at least 3,000 miles long and 300 miles wide at that distance, and proportionately narrower at shorter ranges.

2.2.2.9 Missile recovery is desirable along the range. This is not mandatory provided that means are available for ejecting selected instruments and that recovery of these can be effected.

2.2.2.10 Uninhabited impact areas should be available at various distances along the range.

2.2.2.11 Targets of various types should be available in the impact areas.

2.2.2.12 In the vicinity of the impact points continuous and close observation of the missile is necessary in the case of many types of missiles. It is highly desirable that this be land based. In lieu of anything better, ship borne instrumentation will suffice.

2.2.3 The second requirement is for a suitable launching site supported by an adequate base. Such an area should provide:

2.2.3.1 A suitable launching site located within the continental United States. The minimum requirement is within the continent of North America.

2.2.3.1.1 A safety zone of 25 miles around the launching site. The minimum acceptable requirement is that there

be no dense habitations within 10 miles:

2.2.3.1.2 A reasonably level area surrounding the launching site.

2.2.3.2 The main base should contain the following facilities:

(a) Technical

(b) Explosive storages

(c) Air terminal

(d) Housing and community services

(e) Administrative and Utilities

2.2.3.3 The terrain in the main base area should be suitable for the construction of all base facilities.

2.2.3.4 The main base should be served by adequate land and air transportation and communication facilities.

2.2.3.5 The main base area should be readily accessible to research and development centers.

2.2.4 The third requirement consists of those general factors which effect the overall selection of the area.

2.2.4.1 The climate should be such that year round operating conditions will prevail.

2.2.4.2 The visibility should be excellent at the launching site and good to excellent along the range so that

visual and photographic observations can be made.

2.2.4.3 There should be a minimum interference with commercial and private interests which might, through changes in political alignments, both foreign and domestic, jeopardize the continuation of the operation of the range.

2.2.5 Briefs of the following Panel Reports, on which those conclusions were based, are appended as:

Annex "A" Brief of Report of Panel on Test Range Procedures and Instrumentation.

Annex "B" Brief of Report of Panel on Base Facilities.

Annex "C" Brief of Report of Panel on Ship Instrumentation.

2.3 Conduct a study and survey of the various possible sites.

2.3.1 General

The Committee undertook its work with an open mind. It first reviewed all the studies of previous committees on this same subject and then proceeded to examine and critically evaluate every area in the world which had a possibility of being used as a long range proving ground. As the studies progressed, it became apparent that it was necessary to locate the launching site within the continent of North America and preferably within the continental limits of the United States. This is due to the prospective difficulty in negotiating with foreign powers for such major areas as would be required for the main base and launching site; the difficulty, expense and time involved in transporting materials and personnel back and forth between the launching site and the centers of industry and research within the United States; the fact that it would be extremely difficult to obtain the necessary civilian technical personnel to man remote facilities; and the obvious reason that sudden attack might well deprive this country of its only long range proving ground just when its need was most urgent.

2.3.2 With this as a background the Continents of Europe,

Asia, Africa, South America, and Australia as well as the Pacific Ocean Islands, were eliminated from further consideration.

An additional reason for rejecting the Continents of Europe, Asia, and Africa was the lack of security.

2.3.2.1 Australia, which has many advantages, was eliminated only after careful deliberations. The advantages and disadvantages of the Australian area are listed below:

Advantages:

a. The first 1,000 miles of the range will be over land leading to ease of ideal instrumentation; ease of missile or components recovery and ease of communication along the range.

b. There will be minimum interference with public and private interests.

c. The Australian project is already underway and by joint effort the expense of construction would be reduced.

d. The weather is favorable.

e. The range would be secure from monitoring and observation.

Disadvantages:

a. Difficulty of recruiting qualified civilian technical personnel to live in Australia.

b. Slow flow of technical information back to the United States.

c. Delays in programs and construction due to distance from the United States.

d. Security problems would be greater due to location of main base on foreign territory.

e. Difficult to defend in time of emergency.

f. Would increase the overall cost of the guided missile program due to delays occasioned by distances separating sources of test data and centers of research.

g. Communication difficulties between sources of test data and centers of research.

h. Troop training problems would be magnified.

i. During periods of national emergency there would be no test range in the United States for testing guided missiles under a stepped up schedule.

J. The Australian range could not be tied into the defense of the Continental United States.

2.3.3 Areas within the Continent of North America.

Upon further study, it was determined that land based instrumentation was mandatory for the first 500 miles. A special study disclosed the fact that ship based instrumentation would not possess sufficient accuracy and that the cost and expense of maintaining ship based instrumentation would be excessive compared with land based instrumentation. The minimum number of ships required would be fifty and if greater accuracy of instrumentation, with location of ships by doppler was necessary, some one hundred and sixty ships would be needed to maintain instrumentation over the first 500 miles.

With this as a background, it was determined that in order to obtain land based instrumentation within the continent of North America, concessions would be required from some foreign country. These concessions could be kept to a minimum by maintaining the base and launching site within the continental limits of the United States with observation stations only on foreign soil. In this connection it is pointed out that observation stations require only small plots of ground, whereas the base will require large areas.

The Alaskan and Canadian areas were rejected only after careful consideration. The principal objections being inaccessability, adverse natural phenomena, and poor operating conditions.

2.3.4 Areas within the continental limits of the United States.

The following areas were rejected, after personal reconnaissance, for reasons noted below:

a. The Key West,Florida-Bahama Banks-Range. This site was rejected because of isolation and lack of communication to base; cost of base installation; and low quality and expense of instrumentation.

b. The White Sands, New Mexico - Cape Flattery,Washington Site. This site was rejected because of the strong probability that suspensions of operations of the range would be forced by public opinion, in the form of political pressure, as soon as any of the many public or private interests involved imagined that either their person or their property was in danger; interference with innumerable commercial interests; and difficulty of obtaining impact areas.

c. The Cape Flattery, Washington Site. This site was rejected because of adverse weather conditions; interference with commercial interests; implied hazards to parallel air and shipping routes; and excessive cost of base installations.

d. The Point Arena California Site. This site was rejected because of the strong probability that suspensions of operations of the range would be forced by public opinion, in the form of political pressure, as soon as any of the public or private interests involved imagined that either their person or their property was in danger; adverse weather conditions; isolation and cost of base installations; and short distance (480 miles) of land based instrumentation with very little chance of additional land based stations down the range.

2.3.5 The Committee decided unanimously, after careful study and consideration, that the following two areas, in order of preference, came closest to meeting the specific requirements deemed necessary for a long range proving ground.

a. First Choice.

The El Centro, California - Gulf of California Range.

b. Second Choice.

The Banana River, Florida - Bahama Island Range.

Details of these sites are contained in Section 2.4, which follows.

2.4 Recommend a single, joint, long range proving ground and prescribe complete facilities required therefore.

2.4.1 The Committee unanimously recommends that immediate action be taken to provide a single, national, joint, long range proving ground for guided missiles.

2.4.2 The Committee unanimously recommends that this facility be designated as the "National Guided Missile Range".

2.4.3 The Committee unanimously recommends the selection of the range known as the El Centro-Gulf of California Range, as possessing the greatest number of mandatory and highly desirable features and as affording the closest practicable approach to the ideal range available on the North American continent. The Committee considered that it was not within its purview to evaluate the significance of international aspects, but took cognizance of the fact that concessions might be easier to obtain from one foreign country than another. Therefore, the Committee provides an alternative solution - the Banana River-Bahama Islands Range, involving concessions from the British Empire rather than from Mexico, in the belief that if the necessary concessions from Mexico could not be obtained, those from the British Empire might be.

2.4.3.1 A comparison of the specific requirements, as set forth in Section 2.2 of this report, with the conditions as they

exist in the two recommended areas, is contained in Annex "D".

2.4.4 The Committee unanimously recommends that the general facilities and services as listed in Annex "E" for the El Centro-Gulf of California Range, and in Annex "F" for the Banana River-Bahama Islands Range, be provided.

2.4.5 The Committee recommends that, upon approval by the Joint Research and Development Board, responsibility for further planning and implementation of the joint long range proving ground be assigned to the War Department.

2.4.6 The Committee recommends that, upon approval by the Joint Research and Development Board, the joint long range proving ground be organized as set forth in Annex "G".

Annex "G"	Recommended Organization of the Joint Long Range Proving Ground.
Annex "G", Appendix 1.	Recommended Organization Chart for the Joint Long Range Proving Ground Under Present Organization of the Armed Forces.
Annex "G", Appendix 2.	Recommended Organization Chart for the Joint Long Range Proving Ground Under Unification of the Armed Forces.

2.4.7 The Committee recommends that,upon approval by the Joint Research and Development Board, the War Department as a first step immediately set up the organization outlined in Annex "G",

Appendix 1 (under present organization of the Armed Forces) or
Appendix 2 (under unification of the Armed Forces) in order to
effect the above recommendations.

SECTION 3.0

STATEMENTS OF COMMITTEES HAVING JOINT OR COLLATERAL INTEREST.

3.1 The Committee on Long Range Proving Ground was directed to maintain cooperation with the Committee on Guided Missiles and the Committee on Aeronautics. This was accomplished by the free exchange of information and frequent consultations.

3.2 The statements of these two Committees are attached as the following annex: •

Statement of the Committee on Aeronautics attached as Annex "H", Appendix 1.

Statement of the Committee on Guided Missiles attached as Annex "H", Appendix 2.

SECTION 4.0

FACTS AND CONCLUSIONS ON WHICH THE DECISION WAS BASED.

4.1 Bibliography of reports, digests and opinions containing the facts and conclusions on which the foregoing report is based. Reports marked (*) are available in the files of the Secretariat.

4.1.1 General

* Test Facilities for Guided Missiles. Interim Report. JNW GMC 5/5, 20 December 1945.

* Proposed Navy Special Weapons Center. JNW GMC 5/10, 8 March 1946.

* Final Report. Board for the Investigation of Sites for a Naval Air Special Missiles Center. BuAer Navy Department, 17 March 1945.

* Studies Concerning the Selection of a Suitable Site for a Proving Ground for Long Range Guided Missiles. (Von Braun Report) Office, Chief of Ordnance, R&D Division, Fort Bliss, Texas, Report No. A--22. 30 December 1946.

Report on Certain Phases of War Research in Germany, prepared by F. Zwicky, Technical Representative, USFTAF, Director of Research of Aerojet Engineering Corporation and Professor of Aestro Physics, California Institute of Technology, 1 October 1945.

Report on Range Facilities for Ordcit Project. Corps of Engineers, 25 October 1944.

* Report on Guided Missiles Test Range, Air Materiel Command, Wright Field, Dayton, Ohio. 12 December 1946.

Preliminary Survey Report on Camp Davis,N.C. Kellex Corp. 26 April 46.

* Military Intelligence Division Report. WDGS Guided Missile and Supersonic Aircraft Testing. (Australian Long Range Proving Ground) R--156-46. 6 September 1946.

* Staff Study, Requirements for a Service Test and Practice Range for Guided Missiles. Artillery School. AGF. 29 January 1947.

* Committee on Long Range Proving Ground JRDB, PG 3/9, Annex A, PG 24/1, 14 March 1947.

* Underground Sites for Strategic Installations. Report on Existing Mines. Army and Navy Munitions Board. January 1947.

The Statesman's Year Book, 1944.

The Bahamas Handbook by Mary Moseley.

* Reports of Sub-Panels of LRPG Committee. Safety, Commercial Interests, Accessibility, Weather, Instrumentation and Base Facilities. Areas reported on: Key West, Florida, Banana River, Florida, El Centro, California, Cape Arena, California, Cape Flattery, Washington.

* Report on Minutes of Informal Meeting with Canadian Representatives dealing with proposed Canadian Proving Ground for Guided Missiles, JRDB, PG 24/1.

Report on Intermediate Test Range for Guided Missiles and Pilotless Aircraft, Bureau of Aeronautics, Navy Department, 4 February 1946.

* Climatic Factors Affecting Location of Guided Missiles Proving Grounds in the Northwest, Southwest, and Southeast United States. Headquarters, Air Weather Service, April 1947.

Flight Testing of Guided Missiles by Harold K. Cheney, Chief Flight Test Engineer. Consolidated Vultee Aircraft Corp. January 29, 1947.

* Report of Canadian Guided Missile Firing Range by Armanent Research Group, Defense Research Board of 18 April 1947.

4.1.2 Reports on Instrumentation Requirements.

* Planning Consultants, Committee on Guided Missiles, preliminary report GM 8/9 dated 9 April 1947.

* Dryden Committee Report on Accuracy Requirements of Instrumentation, JRDB, PG 3/9.

* Panel on Test Range Procedures and Instrumentation JRDB, PG 2/5 Annex D, PG 20/1 dated 17 January 1947.

* Panel Report on Ship Instrumentation JRDB, PGS 6/1.1, dated 21 February 1947.

* Basic Characteristics of Radio Aids to Navigation by Dr. J. A. Pierce, Croft Laboratory, Harvard University.

* Minutes of First Meeting of sub-panel of the Panel on Test Range Procedures and Instrumentation of the Committee on Guided Missiles, Joint Research and Development Board, dated 17 January 1947, PG 30/1.

* Loran Charts and Service Areas. Hydrographic Office, Navy Department, 1 April 1946.

* Estimates of Unit Costs of Instruments for Instrumenting the Joint Long Range Proving Ground, prepared by Colonel L. E. Simon, Ord Department, USA, Director Ballistic Research Laboratories, Aberdeen, Maryland, dated 19 May 1947.

4.1.3 Reports on Base Facilities Requirements.

* Report of Panel on Base Facilities, JRDB, PGBF 6/1 dated 31 January 1947.

A N N E X "A"

BRIEF OF THE REPORT OF THE PANEL ON TEST RANGE PROCEDURES AND INSTRUMENTATION.

I. Objective. The objective of the Panel on Test Range Procedures and Instrumentation was to determine in general terms the ideal instrumentation requirements of a long range guided missile proving ground.

The detailed report is contained in PG 30/1, 17 Jan. 47.

II. Development Test Requirements. Continuous and close observation of the missile is desirable over the entire range. It is considered to be essential over the first 500 miles of the range. In the vicinity of the impact points, close and continuous observation is necessary in many cases. For the expected trajectory of some missiles now under development, an accuracy of twenty feet or better is desirable and attainable with present types of instrumentation. In addition, an impact area should be available wherein recovery is possible.

II.1 Required Instrumentation.

II.1 A DOVAP (Doppler Velocity and Position)

II.1 A 1 The Doppler system of instrumentation seems to be the one which shows the most promise of providing the required accuracy over the whole range.

II.1 A 2. To provide continuous coverage with such a system, it will be necessary to place groups of stations at intervals of 50 miles throughout the length of the range. Each group will consist of four (4) receivers and one (1) transmitter. The four receivers must be spaced from each other at intervals depending upon the height of the missile and the required accuracy. In general, it is believed that a spacing in the order of 10 miles will suffice. All stations must have a line of sight to the missile. That is, a line of sight from the antenna (receiving or transmitting) to the missile is necessary . In addition, each of the four receivers must have a line of sight to the transmitter.

II.1 A 3. With the DOVAP instrumentation the position of the missile can be determined at a distance of 50 miles with an accuracy of 10 feet, assuming that the velocity of radio propogation has been calibrated out. At shorter distances the accuracy should be somewhat better. The accuracy of velocity determination is, of course, dependent upon the interval over which it is determined.

II.1 B RADAR

II.1 B 1. For immediate use over long ranges, providing continuous coverage, a promising line of attack is the development of "chain" radar. In this system a radar set near the launcher picks up the missile as it leaves the launcher, and tracks it to the

limit of its range. Meantime, the positional data is sent to another radar set down range, where parallax corrections are made and the data is used to position the second radar on the missile. The second radar, thus placed on target, tracks to its limit, transmitting its data on to a third set farther along. Thus the target is passed along the chain.

II.1 B 2. The microwave tracking radars in the chain should be spaced approximately 50 miles apart, assuming that radar beacons are placed in the missiles. Obviously, the radar sets must be placed with a line of sight to the missile.

II.1 B 3. It is desirable, but not necessary, that successive radar tracking stations be intervisible, as relay stations for the data transmission system will be required otherwise.

II.1 B 4. In addition, search radar sets should be provided every 100 miles, preferably at the tracking station sites and related to the tracking chain in such a manner that the search sets can be used to relocate the missile for the chain should the tracking sets lose it.

II.1 B 5. With beacon equipment installed in the missile the radar equipment will determine the position of the missile with accuracies of 50 yards in range and 1.5 mils in azimuth and elevation. These values are independent of range, out to the

range of the instrument, and are the values for single readings. The above accuracies can be expected using S band radar. If X band radar is used, the accuracies should be better.

II.1 C OPTICAL

II.1 C 1. Continuous coverage by optical means is desirable but not necessary. However, optical instrumentation should be placed and manned so as to take advantage of any fortuitous combination permitting such observations.

II.1 C 2. To this end a system of theodolities should be placed at 50 mile intervals, along reasonable base lines, perhaps at the same locations as the Doppler receivers. In addition, long focal length tracking telescopes should be provided at intervals of 50 miles, with mounts arranged for servo guiding, in order that the data from the chain radar system may be used to place the telescopes on target.

II.1 C 3. The use of optical instrumentation is considered essential at the launching area. No other method will provide the data concerning initial flight path, separation, and general functioning so rapidly.

II.1 C 4. When visibility permits the optical equipment can locate the missile with an accuracy of 0.1 mils at distances up to 50 miles.

II. 1 D TELEMETERING

II.1 D 1. It is considered that a complete system of telemetering receivers should be placed to provide continuous coverage of the range. These should be placed at 50 mile intervals, and a line of sight to the missile is necessary. Accurate positioning of the stations is not important.

II.1 E NAVIGATIONAL DEVICES

II.1 E 1. It is considered desirable that the entire range be covered by a LORAN type system. Water ranges should be covered by a SOFAR net as well.

II.1 F METROLOGICAL

II.1 F 1. Adequate facilities for metrological observations must be applied, not only at the launching area, but also along the entire range, at intervals of 50 miles.

II.2 SURVEY

II.2 A As soon as the decision is made as to the location of the range, it is necessary that a first order, or better, survey be immediately started of the range area, in order that the positions of the range observation stations can be determined with first order accuracy.

II.3 WEATHER

II.3 A The weather at a long range proving ground has a profound effect on the results obtained on range instrumentation.

Low visibility will seriously hamper the use of optical instrumentation. Good seeing conditions over a large percentage of the time are necessary in the launching area, desirable over the whole range, and highly desirable in the impact area. In addition, locations should be avoided which are known to suffer from thunderstorms or unusual electro-magnetic propogation effects. Such effects might make the use of radar and radio instrumentation impracticable as well as making the use of radio communication unsatisfactory. In general, locations should also be avoided which do not have good flying conditions a large percentage of the time.

II.4 COMMUNICATION AND TRANSPORTATION

II.4 A. Effective and adequate communication and transportation along the entire length of the range is considered to be an obsolutely necessary condition for satisfactory instrumentation.

II.5 BASE FACILITIES

II.5 A The above has considered the instrumentation requirements along the range. Additional instrumentation is needed in the launching area. Already noted are the optical facilities required. In addition, to accommodate extremely high altitude firings, in the order of hundreds of miles, it should be possible to arrange stations essentially symetrically about the firing point, at a distance of 40 miles from the launching site. The symetrical requirement is not rigid, but should be approached as closely as

possible. In addition, it is extremely desirable that the launching site be visible from the stations.

II.5 A 1. Base facilities must include adequate provision for shops, laboratories and offices for the maintenance and supervision of the instrumentation equipment, as well as facilities for the processing, reading, reduction and evaluation of data. In addition, adequate facilities for emergency modification and development, and for field testing of equipment in the development stage must be provided. The planning of transportation and communication facilities to the base must include adequate provision for instrumentation needs.

III. SERVICE TEST REQUIREMENTS

III.1 The range discussed above is considered to be for development testing. It is felt that fewer observation stations would be needed for service testing.

IV. RECOMMENDATIONS

IV. 1 Range Development

IV. 1 A The instrumentation of the range should be planned in increments of 50 miles up to at least 500 miles. It is not necessary that different types of instruments be widely separated. They can be grouped together, approximately 50 miles between groups. This will probably mean the establishment of small communities at the observation stations.

IV.1 B. The Doppler receiver and theodolite stations would be within a radius of approximately 10 miles of the center of the group. The best arrangement is to allow the center line of the trajectory to pass over the center of the groups, so that the instrumentation can be grouped symetrically about the trajectory. However, operation is possible with the groups of stations up to 25 miles to either side of the trajectory with present types of instrumentation. Other instruments than those mentioned in this paragraph can be accommodated within the limits set forth.

IV.2 INSTRUMENT DEVELOPMENT

IV.2.A. In the event that the requirement for the first 500 miles mentioned above cannot be met, an accelerated program of development of longer range instruments with the same accuracy must be instituted immediately.

IV .2 B It is considered that the above requirements for a heavily instrumented range for the first 500 miles will meet the range requirements for the next two years. It is recommended that a comprehensive program for the development of accurate instrumentation to cover areas not close to shore be undertaken immediately to provide against the event that ranges over 500 miles will involve considerable distances over water.

NOTE: The requirements for ship-based instrumentation of present types are listed:

1. The instruments must be capable of being tied to a land survey in such a manner that their positions are known to 10 feet.

2. The positions must not vary more than one foot, without precise knowledge of such variation.

3. A stabilized platform must be provided. These are not considered to be insurmountable problems, but the development necessary would require the expenditure of large amounts of money, time and highly competent scientific manpower.

A N N E X "B"

BRIEF OF THE REPORT OF THE PANEL ON BASE FACILITIES

1. Objective. The Panel on Base Facilities was directed to determine, in general terms, the base facilities initially, and ultimately, required for a long range guided missile proving ground.

Detailed report contained in PGBF 6/1 dated 31 Jan 1947.

2. Grouping of Facilities. The following grouping is used throughout the report :

a. Launching Facilities
b. Technical Facilities
c. Explosive Storage Facilities
d. Air Facilities
e. Housing and Community Facilities
f. Administrative and Utilities Facilities

3. Launching Facilities.

a. General. The launching area should contain ultimately three launching aprons, each with five launching points and a control blockhouse; a utilities distribution blockhouse and necessary communication facilities, utilities, roads and railroads. The launching aprons will be so located that their distances to any technical storage or housing facility or to the station boundary will not be less than 10 miles.

b. General Facilities. The required facilities serving the entire launching area follow:

(1) Utilities Distribution Blockhouse. This blockhouse

will be separate from the control blockhouses. It will house all utilities and control their distribution to all points in the launching area. It will include electrical, radio, telephone, telemetering instrumentation and other controls. Inside dimensions 60' x 120'.

(2) Compressed Air Blockhouse. This blockhouse to house air compressors and compressed air distribution for all requirements in the launching area. Inside dimensions 30' x 40'.

(3) Railroads. A rail spur from the main spur to the launching area with sidings to each launching site.

(4) Roads. Hard surfaced, all weather road to all launching sites capable of handling heaviest anticipated loads. Adequate vehicle parking area adjacent to launching site and the utility distribution blockhouse, roads, connecting all observation posts, tracking posts, theodolite and camera stands, and the utilities distribution blockhouse.

(5) Communications. Adequate telephone trunk lines and master switchboard, radio transmitters, and receivers, including VHF, hardwire communication facilities to all manned positions.

(6) Security. Fence in the entire launching areas with manproof type fence.

(7) Utility Landing Strip. Adjacent to launching sites

length 4,000 feet, minimum width 150 feet.

c. Facilities at Each Site. The facilities required at each launching site follow:

(1) Control Blockhouse. One Control (CIC) Blockhouse for controlling launching and for visual observations of missiles. Control of safety and fire fighting would be exercised from this blockhouse. Inside dimensions 40' x 60'.

(2) Launching Apron. Heavy concrete apron 1500' x 150'.

(3) Lighting. Flood lighting for launching site.

(4) Fire Fighting. Appropriate fire extinguishing facilities. Estimated water requirements are 200,000 gallons reserve and 6,000 gallons per minute at minimum pressure of 75 lbs. per square inch at outlets.

(5) Gantry Crane & Heavy Haulers.

1 heavy portable Gantry crane (on rails), at each site.

2 light portable (rubber tired) cranes, at each site.

4. Technical Facilities

a. Location of Area. The Technical facilities should be grouped in an area remote from the firing points.

b. General Comments on Technical Facilities. The following considerations form the basis of the subsequent estimates:

(1) The contractor who is charged with the problem of of producing a missile also provides all equipment and material

peculiar to the handling and firing of his specific missile.

(2) In regard to shop requirements, the need for very complete workshops is realized where missile components may be modified in situations which arise during firing. Reproduction of small complicated parts, which may break during firing tests, is contemplated. In this connection, there are storage requirements for large quantities of miscellaneous shapes of metals or fire-resistant plastics (bars, sheets, rods, fire-brick, etc.) for ready fabrication.

(3) In regard to the supporting industrial shops, it is contemplated that a unit assembly shop, which can accommodate one or two missile projects will have a nucleus of supporting machine, sheet-metal, electrical and piping shops, all contained in the unit shop building. This permits ready accessibility of missile assembly personnel to the machinery, which will expedite their specific work.

c. Description of Technical Facilities.

The description of the technical facilities follows:

(1) Technical Administrative Facilities:

(a) Administrative building to include the following:

Test director and staff, including aerodynamic, propulsion and electronic experts; project or proof officers; liaison (technical and public information); scientific personnel;

secretarial staff; technical library; reports and reproduction; files; large projection rooms and conference rooms; small projection rooms for proof officers - total square feet 50,000.

(b) Classrooms with training items, such as motion pictures, blackboards and demonstration equipment - total square feet 5,000.

(c) Demonstration laboratory. Assembly of study items and demonstration "breadboard" setups - total square feet 5,000.

(2) Laboratory Facilities.

(a) Air conditioned (all year constant temperature) laboratory - total square feet 32,000.

1. Electronics laboratory: Radar, radio-control; homing, guidance and computers; circuit design and analysis; circuit and functional tests, etc. - 10,000 square feet.

2. Mechanism laboratory, including vibration testing

a. Gyroscopes: Test, repair and adjustment - 8,000 square feet.

b. Mechanical Computers, including instrumentation equipment - 1,000 square feet.

c. Instrument repair, calibration and modification - 3,000 square feet.

3. Servo and Control Mechanisms (including hydraulics) - 2,000 square feet.

4. Photographic laboratory; processing; camera maintenance and repair; film and chemical storage - 8,000 sq. ft.

(b) Chemical Laboratory; Fuel analysis for qualitative check; surveillance tests - 2,000 square feet total.

(3) Supporting Facilities.

(a) Assembly Shop Building, four at 40,000 sq. feet each - 160,000 square feet total.

Each building with suitable heating, cooling and sanitary facilities for 300 persons; power at 110, 220 and 440 volts, three phase; 25 foot clearance under crane hooks (one building will require 100 foot clearance); lighting at 35 ft. candles, trackage in floor for dollies as required with supporting shops as follows:

1. Machine Shop: General purpose high accuracy machine tools - 4,000 square feet.

2. Sheet-metal shop: Airplane repair type equipment - 2,000 square feet.

3. Electrical shop: General wiring (not to include electronics, radio, radar equipment, etc.) - 1,000 square feet.

4. Pipe and tube shop: Equipment for forming, bending and welding -- 1,500 square feet.

5. Electronic operational test equipment storage -- 1,000 square feet.

6. Shop storage facilities, including tool cribs -- 5,000 sqiare feet.

7. Design and drafting rooms; offices for constractors' personnel and proof officers - 3,000 square feet.

(b) Service Shop, including foundry (non-ferrous) pattern shop, forging and heat treating shop, welding and heavy-duty machine shop - 7,500 square feet.

(c) Propulsion shop: Calibration of fuel equipment, such as pumps, flow meters, etc. (calibration of more delicate mechanisms to be carried out in mechanism laboratory) - 3,500 square feet total.

(d) Technical Facilities Maintenance Shop - 1,000 sq.ft. total.

d. Storage Facilities in Technical Area.

(1) Technical supplies: Sheet-metals, electronics, piping, tubing, bars and rods; missiles components. (General storage for technical division; to be centrally located in technical area). - 25,000 square feet.

e. Messing Facilities in Technical Area.

Small cafeteria in technical area (seating capacity 250 people) - 8,000 square feet.

f. Fire Fighting Facilities in Technical Area.

Fire fighting facilities - 2,400 square feet.

5. Explosive Storage Facilities.

a. General: It is estimated that an area of 5 square miles will be required for the construction of suitable storage facilities for explosives and propellents. To be located in accordance with safety codes.

b. Explosive Storage Facilities - Magazines will be required for storage of warheads, rockets and pyrotechnics.

c. Fuel Storage. Facilities for storing fuel and chemical components of a highly dangerous character will be required.

6. Air Facilities

a. Location - Air facilities should be located in an area remote from the launching area to avoid interference in the respective operations.

b. Runways and Taxiways. The following is the ultimate requirement for runways and taxiways:

(1) 2 runways 8,000' x 200', 140,000 lb. capacity

(2) 2 taxiways 8,500' x 75' with 140,000 lb.capacity

(3) Parking aprons, 140,000 lb. capacity, 180,000 square yards.

c. Buildings. The following buildings are required:

(1) 3 hangars 300' x 240'

(2) 3 hangar leantos 40' x 200'

(3) Operations building, including control tower, aerology room, reading room, chart room, communications, etc. - 8,000 square feet.

(4) Base engineering shop - 20,000 square feet.

(5) Paint and dope shop - 1,000 square feet

(6) Fire and crash station - 4,000 square feet

(7) Headquarters building - 4,000 square feet

(8) Aviation warehouses - 60,000 square feet

(9) Cafeteria, seating capacity 250 - 8,000 square ft.

d. Miscellaneous.

(1) Aviation gasoline storage -- 1,000,000 gallons.

(2) Radio communications, radio range, localizer,etc.

7. Housing and Community Facilities.

a. Estimates of Personnel

Prior to making any estimates of the facilities required in the Housing Area, it was necessary to make certain assumptions regarding the ultimate personnel requirements. These assumptions, which are tabulated below, represent the best estimates of members of the Panel, based on the meager information now available and are subject to change as more definite information is developed.

ASSUMPTIONS REGARDING PERSONNEL REQUIREMENTS

ITEM	OFFICERS	CIVILIANS OF OFCR STATUS	ENLISTED PERSONNEL	CIVILIANS OF ENLISTED STATUS	TOTALS
PERMANENT PERSONNEL					
Permanent personnel required *	400	500	2,400	1,000	4,300
TEMPORARY PERSONNEL					
Transients	150	150	-	-	300
Military personnel in training	100	-	1,000	-	1,100
	250	150	1,000	-	1,400
* Breakdown of permanent personnel required					
Single workers - 25%	100	125	600	250	1,075
Married workers- 75%	300	375	1,800	750	3,225
Dependents (2.8 per married worker)	840	1,050	5,040	2,100	9,030
	1,240	1,550	7,440	3,100	13,330

Total ultimate population - permanent workers, dependents, transients and trainees 14,730

It will be noted that the above figures are based on the assumption that 75% of the enlisted personnel will be married. The Panel feels that, in view of the skilled and experienced type of enlisted personnel required, this is a realistic assumption.

b. Reduction in Requirements if Outside Facilities are Available.

The following estimate of facilities required in the Housing area are made on the assumption that the final site will

not be near an existing community capable of furnishing any part of the requirements. If the site is located near such a community, it will be necessary to revise the list downward in accordance with the community's ability to provide adequate housing, recreation, schools, churches, shopping facilities and the like.

c. Housing: The following housing will be required on the basis of the assumptions regarding personnel requirements:

	UNITS
(1) Quarters for married officers and married civilians of officer status	675
(2) Quarters for married enlisted personnel and married civilians of enlisted status	2,550
(3) Quarters and messing facilities for single officers and single civilians of officer status (including 100 officers in training)	325
(4) Quarters and messing facilities for single civilians of enlisted status	250
(5) Hotel accommodations for transients	300
(6) Barracks and messing facilities for single enlisted personnel (includes 1000 in training)	1,600

d. Community Facilities. The following community facilities are required on the basis of the assumptions regarding personnel requirements.

(1) Theaters -- two with 1000 seats each

(2) Chapels -- three with 600 seats each

(3) Schools

1. Elementary schools - six for 360 pupils each

2. High School - one for 600 pupils and including a gymnasium, athletic field and auditorium.

(4) A hospital, 500 bed capacity, to serve all military and civilian personnel. Includes a dental clinic, hospital, laundry and quarters for nurses and corpsmen.

(5) A shopping center to include retail stores of all types, a bank, post office, telephone exchange, telegraph office, bus terminal, cobbler shop, barber shop, beauty parlor, restaurant, professional offices, etc. It is estimated that 160,000 square feet of floor space will be required for these activities.

(6) A garage and filling station for non-military vehicles - 15,000 square feet area.

(7) A community recreation center to include bowling alleys, dance floor, game rooms, swimming pool, snack bar, etc. - 80,000 square feet area.

(8) A community library - 3,000 square feet area.

(9) A laundry and dry cleaning plant - 60,000 sq.ft.area.

(10) A community bakery - 30,000 square feet area.

(11) A cold storage, ice making and ice cream making plant - 8,000 square feet area.

(12) Fire stations - two with three pieces of apparatus each - total 15,000 square feet area.

(13) Community administration building to include rental offices, police station, etc. - 10,000 sq. ft. area.

e. Supporting Facilities for Personnel. The following supporting facilities will be required:

(1) Club facilities for officers and civilians of officer status - 10,000 square feet area

(2) Club facilities for top grade noncommissioned officers - 3,000 square feet area.

(3) Recreation building for enlisted personnel. To be located in the barracks area and to include a gymnasium, bowling alleys, game room, library and reading room and a beer parlor - 15,000 square feet area.

(4) A post exchange to be located near the barracks area - 5,000 square feet area.

(5) A guard house, capacity 35 prisoners.

8. Administrative and Utilities Facilities.

a. Base Administrative Area Facilities. The base administrative area includes those facilities required for overall base administration and for logistic support of the specialized activities located in other areas such as Launching Area, Technical Area, Housing Area, etc.

(1) Base Administration Building to provide offices for the Commanding Officer and his staff, including supply, accounting, disbursing, security, communications, maintenance, personnel (labor relations and employment) etc. - 50,000 sq.ft.area.

(2) Operation, maintenance and repair of motor vehicles.

1. Motor pool dispatchers office - 4000 sq ft area

2. Gasoline station -- 25,000 gals. storage 1000 square feet.

3. Open paved parking area - 320,000 sq. ft. area

4. First echelon maintenance shop (for periodic inspection, minor repairs and adjustments) 5,000 square feet.

5. Second and third echelon repair shop - 10,000 square feet area.

6. Fourth and fifth echelon repair shop - 20,000 square feet area

(3) Locomotive repair shop - 4,000 square feet area.

(4) Base maintenance facilities.

1. Carpenter shop - 10,000 sq. ft. area

2. Electrical shop - 4,000 sq. ft. area

3. Plumbing and sheet metal shop - 6,000 sq ft area

4. Paint Shop - 4,000 sq ft area

5. Building material warehouse - 20,000 sq ft area

(5) General Storage Facilities.

1. General stores and supplies - 500,000 sq ft area

2. Quartermaster stores -- 50,000 sq ft area

3. Paint and oil stores - 20,000 sq ft area

(6) Fire station - 3,000 sq. ft. area

(7) Cafeteria, seating capacity 250 - 8,000 sq ft area.

b. Utilities and Services for the entire area. It is obvious to all concerned that the following list of utilities and services will be required. They are set down, however, in order that they will not be overlooked in case this report is used as a basis for making rough estimates of cost. In most cases it is not possible to make even an approximate estimate of quantities on the following facilities until some sort of general base layout is determined.

(1) Electric power required - approx. 10,000 KVA. This may be provided by a new power plant or by purchase, or by a combination of the two, depending on location.

(2) Electric distribution system as required

(3) Water treatment plant - 1,500,000 gallons per day, 3,000,000 gallon reservoir.

(4) Water distribution system

(5) Sewage disposal plant for 15,000 population ultimately.

(6) Sanitary sewer system.

(7) Storm sewer system.

(8) Telephone distribution system.

(9) Streets, walks and roads as required.

(10) Street and road lighting system as required.

(11) Railroad system and a small classification yard as required.

9. Initial Requirements and Yearly Increments.

It is the consensus of the Panel that no satisfactory estimate can be made with respect to initial requirements for facilities and yearly increments, since there is no way of telling when funds will be made available, land acquired and construction completed. It is considered that approximately 85% of technical facilities will be required initially and 50% of the housing. Some possibilities with respect to initial construction and increments are as follows:

a. Launching Facilities - Construction of the facilities for the launching area as a whole and for one launching site should be completed initially, adding the facilities at the second and third launching sites as required.

b. Technical Facilities. One assembly shop should be built initially, adding the other three as required.

c. Explosive Storage Facilities. Construct facilities as needs are indicated.

d. Air Facilities. Two runways 8,000' x 200' should be constructed initially with a 140,000 lb. base and 140,000 lb. wearing surface. Two taxiways 8,500' x 75' should be constructed initially with 140,000 lb. base and 140,000 lb. wearing surface. Expansion should be accomplished in accordance with requirements.

e. Housing and Community Facilities should be constructed as required, in proportion to development of the base.

f. Administration and Service Facilities.

Major proportion must be provided initially to meet ultimate requirements. Increments will be determined by developments.

ANNEX "C"

BRIEF OF THE REPORT OF THE PANEL ON SHIP INSTRUMENTATION

1. The Objective of the Panel on Ship Instrumentation was to determine the feasibility of ship-borne instrumentation for the observation of the flight of long range guided missiles.

The detailed report is contained in PGS 3/1 dated 19 February 1947 and PGS 6/1 dated 21 February 1947.

2. Statement of the Problem:

As defined in the objective and terms of reference of the Directive, the problem as set forth by the Committee on Long Range Proving Ground is:

a. Is it feasible to instrument a long range proving ground with ship-borne instrumentation?

b. If feasible, give magnitude of the task in terms of ships and equipment.

c. If not feasible, state why not and how close ship-borne instrumentation would meet the requirements.

3. Summary:

Guided missiles must be continuously and accurately tracked and their position in space determined to within a few feet. At

present the only known system of obtaining this information with sufficient accuracy is by the use of the DOVAP system. An error of fifteen feet in determining the location of the instrument will mean an error in locating the missile of from 225 feet to 450 feet, depending on the altitude of the missile. An error in locating the instrument of one foot will mean an error in locating the missile of from 15 to 30 feet, depending on the altitude of the missile. Ships cannot be located beyond line of sight from land much closer than 100 feet.

4. The Decision or Action:

a. It is not feasible to instrument a long range guided missile proving ground by means of ship-borne instrumentation, except under the following conditions:

(1) Ship to be tightly moored to within an accuracy of one foot and if the position changes over one foot, such change must be detected and the amount and direction of change observed and recorded; or

(2) Willing to accept the loss of accuracy of observations of position of the missile by a ratio of about ten to one or more.

(3) Willing to accept the loss, beyond the 50 mile range, of the use of the DOVAP system of instrumentation (with the inherent

accuracy).

(4) Willing to confine instrumentation to one system only, namely, "radar" with its inherent inaccuracies of about 150 feet in range and 220 feet in azimuth.

(5) Willing to accept the loss of the use of the optical systems of observation.

b. Assuming that these sacrifices must be made and the use of ship-borne instrumentation is mandatory, then the magnitude of the task is as follows:

(1) Assuming that the chain DOVAP system will be used to locate the ships from the beach in succession by each ship obtaining its position from the ones nearest to shore:
This will require a total of some 168 ships and the time required to reduce the data and determine the location of the ships at any one firing time will be stupendous. About six months to one year would be required, provided that all computing equipment available to the armed forces and all operators devote their entire time to the problem. This is patently absurd and this solution is ignored.

(2) Assuming that the location of the ships will be obtained by the most accurate radio location finding system (Shoran combined with Fire Control Radar and cycle matching Loran) and that only radar with its inherent inaccuracy will be used, then a total

of 50 LST's will be required. Each vessel will require about 50 officers and men to man and operate. It will cost about sixteen million dolllars to put these vessels into commission and maintain them at sea for the first year. This does not include the cost of installing the instruments, the cost of the equipment peculiar to this type of work, nor the pay of the technical personnel required to man the special equipment. Neither does it include the cost of tenders, repair ships, other base vessels, personnel, and equipment of the base which would be required. Such a problem is one of the first magnitude.

c. As stated in a. ship-borne instrumentation will not give the required accuracy. The Army states that the position of Hermes II, the only missile which has given a requirement as to the desired accuracy of location of the missile in space, must be known to within 20 feet. Using the only practical system of locating the position of the ships (Shoran combined with cycle matching Loran) out to 500 miles, the position of the ships might be determined to within 60 to 100 feet. This will give an error in the location of the missile of from 175 feet in range to 150 feet in azimuth, depending on the altitude of the missile, an error of at least 8 times that desired. The Hermes II is a two stage missile and if this is to be developed within a reasonable

time and at reasonable cost, then its position in space with reference to time must be known to within a few feet over a distance of 500 miles. Each early shoot will represent an investment in dollars of something like a million. In addition, it will represent an investment in man years of labor and research of such magnitude as to preclude its loss due to lack of accurate information upon which corrective action can be taken.

5. Authorities Consulted, extracts attached.

   a. Table of DOVAP errors prepared under supervision of Dr. Delsasso.

   b. Table of Radar errors prepared under supervision of Dr. Delsasso.

   c. Discussion of optical instrumentation for sea range by Dr. Reuyl.

   d. Special Problem on Position Fixing of Line of Ships out to 500 miles prepared by Bureau of Ships.

   e. Data from Lecture by Dr. J.A.Pierce on Basic Characteristics of Radio aids to Navigation.

TABLE OF DOVAP ERRORS

Rough Estimates of errors (= Standard Deviation) in 500 Mile Range Trajectory for Station Separations of 50 Miles = e. Maximum Ordinate of Missile = h.

Error in Station Locations feet.	Height of Trajectory - Miles			Cost of equip-ment.	Engineer Years to Produce
	12	100	200		
1	15	26	30	not feasible	
10	150	260	300	2,000,000	150
100	1,500	2,600	3,000	*	150
1,000	15,000	26,000	30,000	*	150
10,000	150,000	260,000	300,000	*	150

* Cost $1,000,000 plus cost of survey method used to determine position of surface stations.

Example: If the maximum ordinate of the missile is 100 miles and the station is located within plus or minus 10 feet, then the error for a 500 mile trajectory will be 260 feet.

TABLE OF RADAR ERRORS

The table gives the probable errors at the time that the missile passes at its closest approach to the radar set. The table assumes that the probable error in locating a missile with respect to the radar is 50 yards in range, and 1.5 mils in azimuth and elevation. The table gives the probable error in locating the missile with respect to a third point, as for example the launching site, with various probable errors of radar position with respect to the third point.

Case A: Missile at an altitude of 60,000 feet.

Case B: Missile at an altitude of 500,000 feet.

Case C: Missile at an altitude of 1,000,000 feet.

PROBABLE ERROR IN POSITION OF RADAR IN FT.	PROBABLE ERRORS IN MISSILE POSITION														
	CASE A					CASE B					CASE C				
	R	EL	E	Az	A	R	EL	E	Az	A	R	EL	E	Az	A
1	150	1.5	220	1.5	220	150	1.5	775	1.5	775	150	1.5	1500	1.5	1500
10	150	1.5	220	1.5	220	150	1.5	775	1.5	775	150	1.5	1500	1.5	1500
100	175	1.5	220	1.7	250	150	1.5	775	1.5	775	150	1.5	1500	1.5	1500
1000	925	3.3	480	7.2	1050	300	2.4	1250	2.5	1300	200	1.8	1800	1.8	1800
10000	9100	29.4	4280	69.9	10170	2550	19.1	9850	19.8	10240	1320	10.1	10200	10.2	10300
	Ft.	μ	Ft.	μ	Ft.	Ft.	μ	Ft.	μ	Ft.	Ft.	μ	Ft.	μ	Ft.

NOTE: E and A are the distance in feet given by the Elevation and Azimuth at the range in each case.

DISCUSSION OF OPTICAL INSTRUMENTATION FOR SEA RANGE BY DR. D. REUYL

1. Minimum instrumentation requirements for the measurement of long range missiles in flight include stations in the vicinity of the launching site and sets of stations at intervals of approximately fifty miles down range.

2. In considering requirements for a sea range it is assumed that the launcher will be land based and that a land area of radius of at least 20 miles about the launching position will be available. With this condition satisfied the instrumentation requirements for the initial portion of the trajectory may be met.

3. For the down range instrumentation, however, plans presently being formulated for land based stations must be modified in order to permit the operation of ship-based instruments. The instrumentation involved consists of the following types:

(a) Photo-theodolites for the measurement of the trajectory.

(b) Long focal length tracking telescopes for the measurement of altitude of the missile and for the recording of phenomena such as separation, ejection of apparatus, etc.

It is required that all stations be operated with a common time signal in addition to a signal system designed to give synchronous operation of all instruments belonging to a given set.

4. Present requirements of accuracy of the measured data have called for operation of photo-theodolites at their maximum degree of precision which is 0.2 mils for present instrumentation and 0.0 mil for instruments now being planned. It is therefore required that the instruments be mounted on stabilized platforms which will prevent any motion exceeding 0.1 mil about three perpendicular axes. As far as the locations of the stations are concerned it is necessary in the absence of land marks for calibration to have direct line of sight between adjoining stations and it appears that distances between adjacent stations should not exceed 15 miles.

Accordingly it is required that station positions should be known with an accuracy of three yards throughout the period of observation. When these conditions are satisfied, the requirements for accuracy of mounting and of station position for the long focal length tracking telescopes will also be met.

5. The problem of determining the station locations is one that will require a method by means of which triangulation equipment will record simultaneously with the functioning of the tracking instruments.

It is understood that further development on methods such as Loran might yield station locations with an accuracy of 100 feet. Assuming that this precision could be realized the resulting accuracy in determining the location of the missile would be reduced and given by an error of approximately 100 feet under the best possible geometrical conditions. Restrictions placed on the stability of the platform could be relaxed to a tolerance of 1 mil.

6. Considering finally the accuracy of about 1000 feet obtainable with present navigation methods it is readily seen that resulting errors in the position of the missile would be approximately 1,000 feet and that the tolerance on the stabilizing platform would be of the order of 10 mils.

Summarizing it is concluded that: (a) In order to obtain measurements with an accuracy of 10 feet by making full use of the quality of the optical instruments an intricate Radio Doppler triangulation net would have to be set up to determine station positions during the period of operation with an accuracy of 8 feet. Moreover stabilizing platforms would be required with a tolerance of 0.1 mil, or auxiliary instrumentation to record the motion of the platform with this degree of accuracy during the period of operation; (b) In order to obtain a positional accuracy of 100 ft. for the missile the instrumentation would be operated at 10% of its maximum performance, tolerances on the stablizing platform would be 1 mil and further developments to increase the accuracy of navigation methods would be required in order to give station position with an accuracy of 100 feet; (c) That in order to obtain measurements of the missile with an accuracy of 1000 feet, the Loran system of navigation could be used and tolerances of 10 mil for the stabilizing platform would suffice. It is noted that in this case any measurements other than rough circle reading would be illusory.

SPECIAL PROBLEM ON POSITION FIXING OF LINE OF SHIPS OUT TO 500 MILES, PREPARED BY THE BUREAU OF SHIPS

SYSTEM	ACCURACY (plus or minus)
Shoran used with Fire Control Radar and Cycle Matching Loran (Standard)	24 feet
Shoran pair alone. (Can be used with Fire Control Radar)	Only good to 200 miles but will give 40 feet
Shoran pair used with other Shoran pairs	100 feet
Low Frequency Loran with Cycle Matching	90 feet
High Frequency Loran	1,000 feet
Standard Loran Cycle Matching (3 Stations)	60 feet
Standard Loran Envelope Matching (3 Stations)	1,500 feet
SOFAR - average conditions	500 feet

Beam antennas assumed in Standard Loran Systems.

All systems adjusted for the special circumstances of this problem and worst shore-line conditions assumed. A concave shore-line would perhaps give more accuracy.

DATA FROM LECTURE BY DR. J. A. PIERCE ON BASIC CHARACTERISTICS OF RADIO AIDS TO NAVIGATION

SYSTEM	RANGE	ACCURACY
Mark III Oboe Micro H (3000 M.C.)	Optical "	Few tens of yards. Less accurate than Oboe
Shoran (30 M.C.)	Optical	60 feet at 250 miles
Omnidirectional	Optical	Azimuth error 3 degrees at 50 miles.
Gee (25-80 M.C.)	Optical	200 yards near transmitter to 5 miles at maximum range of 350 to 400 miles
H.F.D.F.(10 M.C.)	Sky waves up to thousands of miles	At 1000 miles little more accurate than D.R.
LORAN (2 M.C.)	Sky waves up to 1600 miles at night Ground waves 800 miles over sea during day and 600 at night.	1000 feet at short range to 1-1/2 miles at 800;night sky-waves 1-1/2 miles at 300 to 8 miles at 1400.
Sonne	Optical	1 degree at 800 miles but occasional large errors.
L.F. Loran (180 MC)	Up to 1500	5 to 20 miles at 1000 over land and 1500 over sea.
L.F.Loran (cycle matching)	750	160 feet at 750 miles 3 times out of 4.
Decca (100 KC)	Limited to 150 to 200 miles.	A few yards.

ANNEX D

(FIGURE NUMBER 1)

COMPARISON OF SPECIFIC REQUIREMENTS WITH CONDITIONS AS THEY EXIST IN

SPECIFIC REQUIREMENTS	CONDITIONS PREVAILING ALONG EL CENTRO, CALIFORNIA GULF OF CALIFORNIA RANGE
Range should provide facilities for keeping the missile under continuous and close observation. The first 500 miles is a mandatory requirement and must be thoroughly instrumented by means of land based observation stations. Any additional distances will increase effectiveness.	The first 700 miles of the range can be thoroughly and continuously of land based instrumentation stations on Mexican territory along th the Gulf of California.
Observation stations should be located at about 50 mile intervals along the surface projection of the line of flight of the missile.	Observation stations can be located at precisely 50 mile intervals; such that any other interval can be used which might prove to be mor
Each observation station should consist of observation points separated by distances of about ten miles;	Terrain is such that intervals of ten miles between observation point or any other intervals which might prove desirable.
grouped symetrically about the surface projection of the line of flight of the missile, and	Observation points will not be grouped symetrically about the horiso of the line of flight of the missile but to the west of it. This is view of the great flexibility as to location of stations.
should not be over 25 miles from such line of flight of the missile (greater distances mean reduced efficiency;)	Surface projection of the predicted line of flight of the missile wi 25 miles of observation points.
observation points should have a line of sight to the missile;	All observation points will have a line of sight to the missile.
and in most cases, depending on the type of instrumentation, a line of sight with each other observation point in that group.	The terrain is such that observation points will have a line of sigh
Each observation station should be capable of being equipped with various types of observation instruments.	Each observation station can be equipped with any type of observatio necessary.
Entire range should be covered with a LORAN type of network.	None of the range is covered by LORAN ground waves. Reliable covera by LORAN sky waves from three stations for the first 300 miles; by t for the first 500 miles; and by one station for the first 1000 miles.
Entire over water range should be covered with SOFAR type of network.	None of the range is covered by SOFAR but such an installation is fe vided the personnel and funds are made available.
Observation stations and observation points should be connected by hard wire or micro-wave radio for timing and communication circuits.	The first six hundred and fifty miles of observation stations can be with hard wire communication lines.
All observation stations should be equipped with emergency command circuits for destroying the missile in event of emergency	All observation stations can be equipped with emergency command circu destroying the missile in event of emergency.
Observation stations should be accessible by rapid courier service.	Observation stations can be made accessible for rapid courier servic combination of landing strips, the use of seaplanes, small craft, and trails.
Observation stations should possess the necessary housekeeping facilities.	The necessary housekeeping facilities can be installed at each obser
Observation stations should be surveyed in with the equivalent accuracy of a first order survey.	The first 650 miles of land based observation stations can be tied in launching site with a first order survey within a period of 6 months two survey teams of about 30 men each. Additional time will be required to reduce the data.
Instrumentation should not be adversely effected by natural phenomena or terrain.	There are no known natural phenomena which would effect adversely any instrumentation, except occasional thunderstorms during July and Augu down the range.
Range should be 3000 miles long and 300 miles wide at that distance and proportionately narrower at shorter distances.	A range of 4500 miles is feasible from this site. The first 700 mile thoroughly instrumented by means of land based observation stations. ranges or observation of impact areas, land based stations on the mai Mexico (1000 miles range,) the Galapogas Islands (2200-2300 miles ran Mid-Pacific Islands (beyond 2400 miles range) are feasible.

Fig. # 1, Pg. # 1

ANNEX D

(FIGURE NUMBER 1)

ANNEX D

(Figure # 1)

REMENTS WITH CONDITIONS AS THEY EXIST IN THE TWO RECOMMENDED AREAS

CONDITIONS PREVAILING ALONG EL CENTRO, CALIFORNIA GULF OF CALIFORNIA RANGE	CONDITIONS PREVAILING ALONG BANANA RIVER, FLORIDA BAHAMA ISLANDS RANGE
ange can be thoroughly and continuously instrumented by means n stations on Mexican territory along the western shore of	The first 800 miles will have fair to good land based instrumentation but such instrumentation will not be continuous. The most serious defect will be the gap between 25 and 150 miles; another gap will exist between 485 and 525 miles. The instrumentation stations will be on British Territory in the Bahama Islands.
located at precisely 50 mile intervals; the terrain is can be used which might prove to be more effective.	Observation stations will not be located at precisely 50 mile intervals due to the fact that the islands are irregularly spaced. Stations will be located at approximately the following intervals; 25-50 (but off to one side;) 175; 225; 250; 300; 350; 400; 425; 460; 550 (but well off to one side;) 600; 660; 700 and 725 miles.
ls of ten miles between observation points is available might prove desirable.	The observation points will not be located at 10 mile intervals due to the location and size of the islands, but the distances are satisfactory.
be grouped symetrically about the horizontal projection missile but to the west of it. This is acceptable in as to location of stations.	The observation points will not be grouped symetrically about the horizontal projection of the predicted line of flight of the missile. However, they will be spaced in approximately equal proportions on either side of the predicted line of flight and will be satisfactory.
dicted line of flight of the missile will pass within ts.	Observation points, with but two exceptions, will be within 25 miles of the predicted horizontal projection of the predicted line of flight of the missile and will be satisfactory.
have a line of sight to the missile.	All observation points will have a line of sight to the missile.
rvation points will have a line of sight to each other.	The terrain is such that observation points will have a line of sight to each other.
be equipped with any type of observation instruments	Each observation station can be equipped with any type of observation instrument necessary.
by LORAN ground waves. Reliable coverage is given stations for the first 300 miles; by two stations by one station for the first 1000 miles.	The range is covered by reliable LORAN ground waves from two stations up to a distance of 200 miles. Such coverage is increased to 400 miles for one station. The range is covered by reliable LORAN sky waves from two stations up to a distance of 800 miles. About 700 miles of the range is covered by 3 stations for reliable sky waves.
by SOFAR but such an installation is feasible, pro- are made available.	None of the range is covered by SOFAR at present. Such an installation is possible over the reaches of the Atlantic Ocean. SOFAR would be of little use and difficult to install in the islands themselves where reflections, refractions, and shallow water would tend to destroy its effectiveness.
fty miles of observation stations can be equipped lines.	Observation stations cannot be connected by hard wire except by means of underwater sea cable which is both difficult and expensive to install. Micro-wave radio can be installed and will serve as an acceptable substitute.
be equipped with emergency command circuits for nt of emergency.	All observation stations can be equipped with emergency command circuits for destroying the missile in event of an emergency.
made accessible for rapid courier service by a s, the use of seaplanes, small craft, and short jeep	Observation stations can be made accessible for rapid courier service by means of seaplanes for long jumps; small craft for interstation service; and also jeeps on some of the larger islands.
facilities can be installed at each observation station.	Each station is capable of having the necessary housekeeping facilities constructed. In this area the cost will be greater due to the fact that the observation points will often times be located on different islands and each island may require its own housekeeping facilities.
based observation stations can be tied in with the order survey within a period of 6 months by using men each. ired to reduce the data.	A first order survey, by land means, will not be possible on this group of islands but recent work completed in this area by the use of planes and SHORAN measurements has indicated that the equivalent of a 1st order survey is possible by this system and such will suffice.
henomena which would effect adversely any of the sional thunderstorms during July and August, well	Instrumentation is subject to the following adverse natural phenomena; rain squalls which might blank out radar screens; a tropical front which might interrupt operations occasionally; and hurricanes which will undoubtedly cause occasional interruptions.
sible from this site. The first 700 miles can be eans of land based observation stations. For longer act areas, land based stations on the mainland of he Galapogas Islands (2200-2300 miles range) and the 2400 miles range) are feasible.	A range of 10,000 miles is feasible from this site. The first 775 miles can be instrumented by means of land based observation stations. By shifting the line of flight a few degress to the north, additional islands become available; Puerto Rico (1000-1150 miles range;) Barbuda (1300 miles range;) St. Lucia (1500 miles range;) Barbados (1600 miles range;) and occasional islands in the Central Atlantic.

Fig. # 1, Pg. # 1

ANNEX D

(FIGURE NUMBER 1)

EL CENTRO, CALIFORNIA
GULF OF CALIFORNIA RANGE

SPECIFIC REQUIREMENTS	
Missile recovery is desirable at various distances along the range or recovery of ejected parts to be effected.	The chance of missile recovery along the range is remote. The terrain on th peninsula of California is rugged and recovery of heavy objects would be dif The missiles would have to be dumped in the ocean. Recovery of ejected inst is possible either over water or over land, by means of helicopter teams.
Uninhabited impact areas should be available at various distances along the range.	The entire range beyond 100 miles is overwater and uninhabited impact areas available at most any distance desired. Some fishing in parts of the Gulf o California and some intercoastal shipping can be expected, but impact areas readily available.
Targets of various types should be available in the impact areas.	Targets of various types can be mounted on barges and made available in the areas. The water is too deep to anchor and the fact that these barges will is a disadvantage but not impossible of solution. Barges may be kept on sta by radio controls operated from planes.
The range should afford close observation of the missile in the vicinity of the impact areas by means of land based observation stations; but ship based stations will suffice if land based stations are not available.	The first 700 miles and from 800 to 1100 miles will afford land based observa stations for the impact areas. Cliperton Island is located at about 1300 mil from the launching site. The Galapagos Islands are located at a distance of 2300 miles and afford an area of about 200 by 80 miles which can be thoroughl instrumented. The Mid-Pacific Islands, starting with the Hawaiian Islands lo at about 2400 miles distance, afford impact areas up to 4500 miles where inst can be land based.
Suitable launching site should be located within continental limits of the U. S.	The launching site is suitable and located within the continental limits of t
Safety zone of 25 miles should surround the launching site or; minimum requirement of no dense habitations within ten miles.	The ten mile safety zone includes the following: a. Two villages: Coyote Wells, population, 15; and Plaster City, population Both villages are located to the rear of the line of flight. b. U. S. Highway No. 80; The Southern Pacific Railroad; Power lines: and tel lines, all pass about 8 miles north, to the rear of the line of flight, o launching site. These utilities and transportation systems in general co El Centro with San Diego, passing thru both Plaster City and Coyote Wells. The 25 mile safety zone includes, in addition to the above, a total of 16 vil population unknown, and 3 towns of a total population of 32,500.
Area surrounding the launching site should be reasonably level.	The area surrounding the launching site is reasonably level.
Main base should contain the following facilities in addition to the launching site: Technical Explosive storage Air Housing and community services Administrative and Service	The main base area can be constructed to contain any and all facilities neces The Naval Air Station at El Centro, which is at present in a reduced maintena status, contains various facilities which can be used in connection with init installations and the air facilities necessary for the main base.
Terrain of main base should be suitable for construction of main base facilities.	The terrain is suitable for main base construction.
The main base should be served by adequate land, air and communication facilities.	The main base area is served by two railroads, two highways, has a landing fie capable of taking B-29's and the Naval Air Station at El Centro has the usual teletype and other communication facilities already installed.
Main base area should be readily accessible.	The main base is readily accessible to the centers of industry and research wi in the United States.
Climate should be suitable for year round operations of the range.	The climate is considered to be the most suitable for year round operations of site within the continental limits of the United States.
Visibility should be excellent at launching site.	The visibility is excellent at the launching site.
Visibility should be good to excellent along the range.	Visibility is good to excellent along the first 700 miles of the range.
There should be a minimum interference with commercial and private interests, which might through changes in political alignments, force the suspension of operations at the range.	There are 7 settlements located within 50 miles of the predicted line of flight of the missile; total population, 15,300. The delta of the Colorado River is irrigated and reported to contain some 40,000 inhabitants engaged in various farming activities. But the line of flight of the missile passes about 15 mile to the west of the western limit of this area. There are several fishing craft engaged in commercial fishing out of San Felipe, population about 500. There is a ferry service connecting Guaymas and Santa Rosalia. These are small craft. There are no commercial waterborn traffic lanes in the Gulf. Some sport fishing is conducted out of San Felipe.

ANNEX D

(FIGURE NUMBER 1)

EL CENTRO, CALIFORNIA
GULF OF CALIFORNIA RANGE

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to be dumped in the ocean. Recovery of ejected instruments
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elipe.

BANANA RIVER, FLORIDA
BAHAMA ISLANDS RANGE

Missile recovery is possible in shallow water at the following distances along the range: 120 to 250 miles. Other than this area, recovery will have to be of ejected instruments landed in the water.

All impact areas on this range will be in the ocean and uninhabited except for the coastal shipping route up the coast of Florida; the Crooked Island Passage shipping route and to a lesser degree, other passages; and local fishing craft.

Targets will have to be located on barges at sea. From 120 to 250 miles these barges at sea. From 120 to 250 miles these barges may be anchored but other than that they will have to be left adrift or controlled by remote control from land or from airplanes. This will be satisfactory.

The first 775 miles of impact points can be observed from land based stations. Other impacts, up to 1600 miles, can be observed from land based observation stations by slightly changing the direction of the line of flight. Most distances beyond 1600 miles will have to be observed from ship based observation stations.

The launching site is suitable and located within the continental limits of the U. S.

The ten mile safety zone includes the following:

The village of Cocoa Beach, population 250.

The 25 mile safety zone includes 14,000 inhabitants in 5 towns.

The area surrounding the launching site is perfectly flat.

The main base area can be constructed to contain any of the desired facilities. The Naval Air Station at Banana River, which is to be declared surplus, contains various facilities which can be used in connection with initial installations and the air facilities necessary for the main base.

The terrain is suitable for main base construction.

The main base area is served by a branch highway from U. S. No. 1 via bridges over the Indian River. It is about 14 miles from the nearest railhead. A railroad spur could be run by building a bridge over the Indian River. The Naval Air Station at Banana River has adequate air and communication facilities.

The main base is readily accessible to the centers of industry and research within the United States.

The climate is suitable for year round operations but hurricanes during August, September and October, and thunderstorms make this area less desirable than the El Centro range.

Visibility is good at the launching site but thunderstorms and rain squalls during the summer will interfer with visual observation.

Visibility is good along the range but clouds will reduce effectiveness of visual observation.

There will be a moderate amount of interference with both commercial and private interests. This area supports a shrimp industry valued at $1,000,000. per season at present prices; the Indian River is noted for its citrus fruits and it is estimated that the minimum ten mile safety zone will include some three to five million dollars worth of citrus groves; the entire sand spit is the center of a growing winter tourist trade; the main shipping lanes pass within a few miles of the launching site; U. S. Highway No. 1 passes within 13 miles of launching site; the Florida East Coast Railroad passes within 13 miles of the launching site; the intercoastal waterway passes within 12 miles of the launching site; and in addition, the predicted line of flight crosses the Crooked Island Passage shipping route. With the exception of the ocean shipping routes, which pass to the east and the airlines which pass directly overhead, all these activities are located to the rear of the launching site. Nassau, the capitol of the Bahama Islands, and a growing center for the tourist trade, is located 40 miles to the southwest of the line of flight, 300 miles down range.

ANNEX D

(FIGURE NUMBER 1)

EL CENTRO, CALIFORNIA
GULF OF CALIFORNIA RANGE

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All impact areas on this range will be in the ocean and uninhabited except for the coastal shipping route up the coast of Florida; the Crooked Island Passage shipping route and to a lesser degree, other passages; and local fishing craft.

Targets will have to be located on barges at sea. From 120 to 250 miles these barges at sea. From 120 to 250 miles these barges may be anchored but other than that they will have to be left adrift or controlled by remote control from land or from airplanes. This will be satisfactory.

The first 775 miles of impact points can be observed from land based stations. Other impacts, up to 1600 miles, can be observed from land based observation stations by slightly changing the direction of the line of flight. Most distances beyond 1600 miles will have to be observed from ship based observation stations.

The launching site is suitable and located within the continental limits of the U. S.

The ten mile safety zone includes the following:

The village of Cocoa Beach, population 250.

The 25 mile safety zone includes 14,000 inhabitants in 5 towns.

The area surrounding the launching site is perfectly flat.

The main base area can be constructed to contain any of the desired facilities. The Naval Air Station at Banana River, which is to be declared surplus, contains various facilities which can be used in connection with initial installations and the air facilities necessary for the main base.

The terrain is suitable for main base construction.

The main base area is served by a branch highway from U. S. No. 1 via bridges over the Indian River. It is about 14 miles from the nearest railhead. A railroad spur could be run by building a bridge over the Indian River. The Naval Air Station at Banana River has adequate air and communication facilities.

The main base is readily accessible to the centers of industry and research within the United States.

The climate is suitable for year round operations but hurricanes during August, September and October, and thunderstorms make this area less desirable than the El Centro range.

Visibility is good at the launching site but thunderstorms and rain squalls during the summer will interfer with visual observation.

Visibility is good along the range but clouds will reduce effectiveness of visual observation.

There will be a moderate amount of interference with both commercial and private interests. This area supports a shrimp industry valued at $1,000,000. per season at present prices; the Indian River is noted for its citrus fruits and it is estimated that the minimum ten mile safety zone will include some three to five million dollars worth of citrus groves; the entire sand spit is the center of a growing winter tourist trade; the main shipping lanes pass within a few miles of the launching site; U. S. Highway No. 1 passes within 13 miles of launching site; the Florida East Coast Railroad passes within 13 miles of the launching site; the intercoastal waterway passes within 12 miles of the launching site; and in addition, the predicted line of flight crosses the Crooked Island Passage shipping route. With the exception of the ocean shipping routes, which pass to the east and the airlines which pass directly overhead, all these activities are located to the rear of the launching site. Nassau, the capitol of the Bahama Islands, and a growing center for the tourist trade, is located 40 miles to the southwest of the line of flight, 300 miles down range.

C O N F I D E N T I A L

A N N E X "E"

GENERAL FACILITIES AND SERVICES RECOMMENDED FOR THE EL CENTRO-GULF OF CALIFORNIA RANGE

Appendix 1. Discussion of basis of estimates for required base and range facilities for the El Centro Gulf of California Range.

Appendix 2. Estimates of required base facilities with cost estimates.

Appendix 3. Estimates of required range facilities with cost estimates.

Appendix 4. Details of Facilities required for a typical down-range instrumentation station.

Appendix 5. Instrumentation equipment required for the El Centro-Gulf of California Range with cost estimates.

Appendix 6. Layout of the proposed El Centro base area.

Appendix 7. Area Chart showing general layout of proposed El Centro-Gulf of California Range.

Appendix 8. Photographs of base area and range terrain of the proposed El Centro-Gulf of California range.

ANNEX "E"

APPENDIX 1

DISCUSSION OF BASIS OF ESTIMATES FOR REQUIRED BASE AND RANGE FACILITIES FOR THE EL CENTRO-GULF OF CALIFORNIA RANGE

1. Estimates of cost, based upon preliminary surveys, are not sufficiently accurate for budgetary purposes. However, an initial appropriation of funds, in amount of $25,000,000 would permit preparation of detailed plans for the first phase construction and the accomplishment of more urgently needed construction. Should it be possible to allocate funds for surveys of the selected site, in advance of appropriations for construction, the work would be speeded up.

2. A discussion of the information presented in tabular form follows:

a. Requirements, Base Facilities. The Panel on Base Facilities submitted a report on 31 January 1947 describing the base facilities required for ultimate use of a long range proving ground and indicated the increments of construction. The estimate of facilities was predicated on guided missile development schedules and experience at White Sands Proving Ground to date, but is obviously little better than a guess in view of the indeterminate

status of development of guided missiles. It is considered reasonable and forms the basis for determination of construction requirements as listed in Annex E, Appendices 2 and 3.

Actual construction will necessarily proceed in accordance with development of missiles, but provision should be made for ultimate needs in planning and construction of utilities.

b. Feasibility and Cost of Construction of Base Facilities. The El Centro site offers the most favorable situation both with respect to availability of existing facilities, acquisition of additional land and construction of new facilities. The time available for the survey was extremely limited. Cost data was obtained locally and more complete estimates have been prepared subsequently. Such estimates are satisfactory for general study purposes only. Detailed surveys and preparation of plans for the selected site are essential for budgetary purposes.

c. Geodetic Control. First order geodetic control (error of one part in 25,000 or better) has been established in the United States and a limited portion of Mexico. Survey of lower California with first order control by usual geodetic methods and Shoran is feasible. No known method of geodetic surveying is

sufficiently accurate to meet completely the requirements for location of observing stations down-range. Developments are in progress which should increase materially the accuracy of geodetic surveys and Shoran is susceptible to great improvement. It is therefore reasonable to expect that if development of more accurate equipment and methods is pursued that a satisfactory degree of accuracy may be attained.

d. Facilities for Observation Stations. Temporary occupancy only is contemplated with caretakers to maintain and guard equipment and facilities between launchings. A minimum of permanent construction is contemplated. Housing and other structures will be prefabricated for ready erection. Access by seaplane, amphibian aircraft or boat is most feasible and facilities are planned on that basis. Construction, also, can probably be accomplished best by working from an LST or other floating base which will provide quarters and messing facilities.

e. Increments of Construction. The increments of construction are governed largely by the program for the launching facilities. The first phase provides for one launching apron with five firing points and all the facilities necessary for operation, including supporting facilities and housing. The time required for the first phase construction is estimated at two years. Allocation

of funds for advance planning, when the site is selected and construction authorized would accelerate construction. Also in case of need, operations might be initiated without waiting for completion of all facilities. In this case some interference between operations and construction activities will result. The second and third phase are based on adding launching apron and facilities in proportion in each case. When the time comes for such increases the requirements should be more definitely indicated.

ANNEX E

APPENDIX 2

(FIGURE NUMBER 2)

ESTIMATES OF REQUIRED BASE FACILITIES WITH COST ESTIMATES FOR THE EL CENTRO-GULF OF CALIFORNIA RANGE

ULTIMATE REQUIREMENTS	AVAILABLE	FIRST PHASE CONSTRUCTION Approximately two years.
1. LAND Acquire land for expansion of housing, community and administrative facilities, fuel and explosive storage and launching facilities, providing a 10 mile safety radius from launching sites. ESTIMATED COST LAND $375,000	785 acres owned by Navy at Naval Air Station, El Centro, California	Acquire approximately 1100 acres now under lease for temporary use and 1000 acres to the north of NAS El Centro to provide for expansion of housing construction. Acquire 100,000 acres for safety zone around launching site. All but 5000 acres in Public Domain. Land to north of railroad and highway within 10 miles radius not to be acquired. $375,000
2. LAUNCHING FACILITIES		
a. Utilities Distribution Blockhouse. This blockhouse will be separate from the control blockhouses. It will house all utilities and control their distribution to all points in the launching area. It will include electrical, radio, telephone, telemetering instrumentation and other controls. Inside dimensions 60' x 120'.		Construct Blockhouse to meet ultimate requirements and provide utilities, communications and controls necessary for one launching apron.
b. Compressed Air Blockhouse. This blockhouse to house air compressors and compressed air distribution for all requirements in the launching area. Inside dimensions 30' x 40'.		Construct Blockhouse to meet ultimate requirements and provide equipment for one launching site.
c. Railroads. A rail spur from the main line to the launching area with sidings to each launching site.	Mainline of San Diego and Arizona Eastern RR passes abt.8 miles north of launching area.	
d. Roads. Hard surfaced, all weather road to all launching sites capable of handling heaviest anticipated loads. Adequate vehicle parking area adjacent to launching site and the utility distribution blockhouse, roads, connecting all observation posts, tracking posts, theodolite and camera stands, and the utilities distribution blockhouse.		Rebuild and widen to 30 ft. approximately 24 miles of road including the reconstruction of bridge over New River. Improve 10 miles of road and construct 5 miles of road for access to launching site and fuel and explosive storage. Construct access roads to observation stations.
e. Communications. Adequate telephone trunk lines and master switchboard, radio transmitters, and receivers, including VHF, hardwire communication facilities to all manned positions in launching area.		Construct as required for one launching site with trunk line from Base Area.
f. Security. Fence in the entire launching areas with man proof type fence.		Construct to enclose ultimate launching area.
g. Utility Landing Strip. Adjacent to launching sites length 4,000 feet, minimum width 150 feet.	Emergency field at Coyote Wells suitable after minor improvements.	Improve grading and surface.
h. Control Blockhouse. Three Control (CIC) Blockhouses for controlling launchings and for visual observations of missiles. Control of safety and fire fighting would be exercised from this blockhouse. Inside dimensions 40'x60'.		Construct for first site.
i. Launching Aprons. Three heavy concrete aprons 1500' x 150'.		Construct for first site.
j. Lighting. Flood lighting for launching site.		" " " "
k. Fire Fighting. Appropriate fire extinguishing facilities. Estimated water requirements are 200,000 gallons reserve and 6,000 gallons per minute at minimum pressure of 75 lbs. per square inch at outlets.		Drill wells, construct water supply reservoir and mains to meet ultimate requirements and provide facilities for one site.
l. Gantry Crane and Heavy Haulers. 1 heavy portable Gantry crane (on rails) at each site. 2 light portable (rubber tired) cranes, at each site.		Provide equipment for first site.
ESTIMATED COST LAUNCHING FACILITIES - $5,320,000.		$3,090,000

ANNEX E

APPENDIX 2

(Fig. # 2; Pg. 1)

CONFIDENTIAL

ANNEX E

APPENDIX 2

(FIGURE NUMBER 2)

ESTIMATES OF REQUIRED BASE FACILITIES

WITH COST ESTIMATES FOR THE EL CENTRO-

GULF OF CALIFORNIA RANGE

AVAILABLE	FIRST PHASE CONSTRUCTION Approximately two years.	SECOND PHASE CONSTRUCTION As required.	THIRD PHASE CONSTRUCTION As required.
785 acres owned by Navy at Naval Air Station, El Centro, California	Acquire approximately 1100 acres now under lease for temporary use and 1000 acres to the north of NAS El Centro to provide for expansion of housing construction. Acquire 100,000 acres for safety zone around launching site. All but 5000 acres in Public Domain. Land to north of railroad and highway within 10 miles radius not to be acquired. $375,000	None	None
	Construct Blockhouse to meet ultimate requirements and provide utilities, communications and controls necessary for one launching apron.	Add utilities, communications and controls for one additional launching site.	Complete utilities, communications and controls for three launching sites.
	Construct Blockhouse to meet ultimate requirements and provide equipment for one launching site.	Add equipment for one additional launching site.	Add equipment for one additional launching site.
Mainline of San Diego and Arizona Eastern RR passes abt. 8 miles north of launching area.	Rebuild and widen to 30 ft. approximately 24 miles of road including the reconstruction of bridge over New River. Improve 10 miles of road and construct 5 miles of road for access to launching site and fuel and explosive storage. Construct access roads to observation stations.	Initiate construction of approximately 14 miles of RR. Build access roads to observing stations as necessary.	Complete construction of railroad. Build access roads to observing stations as necessary.
	Construct as required for one launching site with trunk line from Base Area.	None contemplated	None contemplated
	Construct to enclose ultimate launching area.	None	None
Emergency field at Coyote Wells suitable after minor improvements.	Improve grading and surface.	None	None
	Construct for first site.	Construct for second site.	Construct for third site.
	Construct for first site. " " " "	Construct for second site. " " " "	Construct for third site. " " " "
	Drill wells, construct water supply reservoir and mains to meet ultimate requirements and provide facilities for one site.	Provide facilities at second site.	Provide facilities at third site.
	Provide equipment for first site.	Provide equipment for 2nd site.	Provide equipment for third site.
	$3,090,000	$1,090,000	$1,140,000

ANNEX E

APPENDIX 2

(FIGURE NUMBER 2)

ULTIMATE REQUIREMENTS	AVAILABLE	FIRST PHASE CONSTRUCTION
3. TECHNICAL FACILITIES		
a. Administrative building to include the following: Test director and staff, including aerodynamic, propulsion and electronic experts; project or proof officers; liaison (technical and public information); scientific personnel; secretarial staff; technical library; reports and reproduction; files; large projection rooms and conference rooms; small projection rooms for proof officers - total square feet 50,000.	While no single building of floor space adequate for total administration of the station exists, there are groupings of smaller buildings which can be modified and which will be entirely adequate for such offices.	Modify existing buildings to meet new requirements.
b. Classrooms with training items, such as motion pictures, blackboards and demonstration equipment - total square feet 5,000.		
c. Demonstration laboratory. Assembly of study items and demonstration "breadboard" set-ups - total square feet 5,000.		
d. Air Conditioned (all year constant temperature) laboratory — total square feet 32,000.	No single building or group of buildings available to meet these requirements without extensive alterations, and due to importance of this work, it is considered desirable to construct a complete new structure housing the electronics, mechanism, servo and control mechanism and photographic laboratories.	Construct laboratory facilities for ultimate requirements.
(1) Electronics laboratory: Radar, radio-control; homing, guidance and computers; circuit design and analysis; circuit and functional tests, etc. — 10,000 sq. feet.		
(2) Mechanism laboratory, including vibration testing.		
a. Gyroscopes: Test, repair and adjustment — 8,000 square feet.		
b. Mechanical Computers, including instrumentation equipment — 1,000 square feet.		
c. Instrument repair, calibration and modification — 3,000 square feet.		
(3) Servo and Control Mechanisms (including hydraulics) — 2,000 square feet.		
(4) Photographic laboratory; processing; camera maintenance and repair; film and chemical storage — 8,000 sq. feet.		
e. Chemical Laboratory: Fuel analysis for qualitative check; surveillance tests — 2,000 square feet total.	Existing structure available.	Modify existing structure as necessary to meet requirements.
f. Static Test Stand: Facilities for static testing of rocket motors, comprising:	The characteristics of this installation make it particularly well adapted to construction on the face of a cliff or steep hill having sufficient height to provide for necessary free path for the flame and the protection for observation positions. Suitable sites are available in the vicinity.	Not required during this phase of construction.
(1) Motor mounting capable of withstanding an instantaneous thrust of up to 600,000 pounds with axis of motor inclined not more than 45 degrees from vertical and providing a free path for the flame for at least 100 feet.		
(2) Protected fuel tanks, pumps, piping and control system to meet requirements of motor being tested.		
(3) Protected observation and instrumentation positions not in line with blast from motor and adequately ventilated.		
(4) Fire fighting and deluge water system to meet safety requirements.		
g. Assembly Shop Buildings: Four at 40,000 sq. feet each — 160,000 sq. feet total.	Ten (10) hangars, totalling about 70,000 square feet of floor space, and having 25 feet of clearance under the trusses may be readily provided with gantry cranes with about 20 feet of clearance to the crane hook, and extended where more than 90 foot lengths are required. A lean-to on either side of each hangar may be converted into shop space and office space to meet most of the requirements of supporting facilities except the service shop and propulsion shop.	Modify approximately half of existing hangars and lean-to to meet requirements of the technical area during first phase.
Each building with suitable heating, cooling and sanitary facilities for 300 persons; power at 110, 220, and 440 volts, three phase; 25 foot clearance under crane hooks; lighting at 35 ft. candles, trackage in floor for dollies as required with supporting shops as follows:		
(1) Machine Shop: General purpose high accuracy machine tools - 4,000 square feet.		
(2) Sheet-metal shop: Airplane repair type equipment — 2,000 square feet.		
(3) Electrical Shop: General wiring (not to include electronics, radio, radar equipment, etc.) — 1,000 square feet.		
(4) Pipe and tube shop: Equipment for forming, bending, and welding — 1,500 square feet.		
(5) Electronic operational test equipment storage - 1,000 square feet.		
(6) Shop storage facilities, including tool cribs — 5,000 square feet.		
(7) Design and drafting rooms; offices for contractors' personnel and proof officers — 3,000 square feet.		

ANNEX E ; APPENDIX 2; (FIGURE NUMBER 2)

AVAILABLE	FIRST PHASE CONSTRUCTION	SECOND PHASE CONSTRUCTION	THIRD PHASE CONSTRUCTION
While no single building of floor space adequate for total administration of the station exists, there are groupings of smaller buildings which can be modified and which will be entirely adequate for such offices.	Modify existing buildings to meet new requirements.	None	None
No single building or group of buildings available to meet these requirements without extensive alterations, and due to importance of this work, it is considered desirable to construct a complete new structure housing the electronics, mechanism, servo and control mechanism and photographic laboratories.	Construct laboratory facilities for ultimate requirements.	None	None
Existing structure available.	Modify existing structure as necessary to meet requirements.	None	None
The characteristics of this installation make it particularly well adapted to construction on the face of a cliff or steep hill having sufficient height to provide for necessary free path for the flame and the protection for observation positions. Suitable sites are available in the vicinity.	Not required during this phase of construction.	Initiate construction	Complete construction
Ten (10) hangars, totalling about 70,000 square feet of floor space, and having 25 feet of clearance under the trusses may be readily provided with gantry cranes with about 20 feet of clearance to the crane hook, and extended where more than 90 foot lengths are required. A lean-to on either side of each hangar may be converted into shop space and office space to meet most of the requirements of supporting facilities except the service shop and propulsion shop.	Modify approximately half of existing hangars and lean-to to meet requirements of the technical area during first phase.	Complete modification of existing hangars and leantoes to provide additional space as required.	Construct one assembly shop building to meet known and anticipated requirements not available through alteration of existing structures.

ANNEX E

APPENDIX 2

(Fig. # 2; Pg 2)

FIRST PHASE CONSTRUCTION

	ULTIMATE REQUIREMENTS	AVAILABLE	
3. Con't.			
	h. Service Shop, including foundry (non-ferrous) pattern shop, forging and heat treating shop, welding and heavy-duty machine shop, 7,500 square feet.	None	Construct service shop meeting ultimate requirements.
	i. Propulsion shop: Calibration of fuel equipment, such as pumps, flow meters, etc. (calibration of more delicate mechanisms to be carried out in mechanisms laboratory) -- 3,500 square feet total.	None	Construct propulsion Shop meeting ultimate requirements.
	j. Technical Facilities Maintenance Shop -- 1,000 sq. ft. total.	Included with assembly shops, above.	None
	k. Storage Facilities in Technical Area.		
	(1) Technical supplies: sheet-metals, electronics, piping, tubing, bars and rods; missiles components. (General storage for technical division; to be Centrally located in technical area). 25,000 square feet.	Ample storage facilities available.	None
	l. Messing Facilities in Technical Area.		
	Small cafeteria in technical area (seating capacity 250 people) 8,000 square feet.	Cafeteria seating 254 available.	Alterations or modifications of existing structure as required.
	m. Fire Fighting Facilities in Technical Area.		
	Fire fighting facilities - 2,400 square feet.	Fire fighting facilities adequate with minor modifications.	Alterations or modifications of existing structure as required.
	Estimated Cost Technical Facilities $4,420,000		$2,000,000
4.	Explosive Storage Facilities: Total Area 5 Square Miles.		
	a. Explosive Storage Facilities - Magazines will be required for storage of war heads, rockets and pyrotechnics.	Existing magazine area required for expansion of base	Prepare entire area for ultimate requirements, including security and fire fighting facilities. Construct storage facilities to meet expected requirements for operations during first and second phases.
	b. Fuel Storage. Facilities for storing fuel and chemical components of a highly dangerous character will be required.	None	" " " " " " "
	Estimated Cost Explosive Storage Facilities $000,000		$600,000
5.	Air Facilities.		
	a. Location - Air facilities should be located in an area remote from the launching area to avoid interference in the respective operations.		
	b. Runways and Taxiways. The following is the ultimate requirement for runways and taxiways:	Available facilities at the NAS, El Centro, consist of two parallel runways, NE-SW 6800 ft.long and 250 ft.wide, one concrete and one asphalt, with an asphalt runway at right angles 6000 ft.long and 250 ft. wide and two N-S runways,one concrete and one asphalt, ea. 5000 ft.long and 250 ft. wide. By extending the longer concrete runway to 8000 ft.,extending the parallel asphalt runway for use as a taxiway,extending the 6000 ft. runway to 8000 ft.with taxiway, constructing additional parking areas, the available facilities may be readily adapted to meet anticipated requirements.	Construct runways and taxiway extensions and portion of additional parking area required.
	(1) Two runways 8000' by 200', 140,000 lb. capacity.		
	(2) Two taxiways 8500' by 75', 140,000 lb. capacity.		
	(3) Parking aprons, 140,000 lb. capacity 180,000 sq. yards.		
	c. Buildings. The following buildings are required:	Available structures may be readily modified to meet requirements for all air facilities buildings except hangars. Existing hangars are not large enough and will be utilized as assembly shops in connection with the technical area.	Modify existing structures as necessary to meet ultimate requirements. Construct one hangar and leanto.
	(1) 3 hangars 300' x 240'		
	(2) 3 hangar leantos 40' x 200'		
	(3) Operations building, including control tower, aerology room, reading room, chart room, communications, etc. 8,000 square feet.		
	(4) Base engineering shop - 20,000 square feet		
	(5) Paint and dope shop - 1,000 square feet		
	(6) Fire and crash station - 4,000 square feet		
	(7) Headquarters building - 4,000 square feet		
	(8) Aviation warehouses - 60,000 square feet		
	(9) Cafeteria, seating capacity 250 - 8,000 square feet		
	d. Miscellaneous.	Storage for 700,000 gallons of aviation gasoline available. Available structures may be modified to meet radio and communication requirements.	None Modify existing facilities
	(1) Aviation gasoline storage - 1,000,000 gallons.		
	(2) Radio communications, radio range, localizer, etc.		
	Estimated Cost Air Facilities $4,655,000		$2,285,000

	FIRST PHASE CONSTRUCTION	SECOND PHASE CONSTRUCTION	THIRD PHASE CONSTRUCTION
	Construct service shop meeting ultimate requirements.	None	None
	Construct propulsion Shop meeting ultimate requirements.	None	None
y shops, above.	None	None	None
ies available.	None	None	None
available.	Alterations or modifications of existing structure as required.	None	None
ies adequate one.	Alterations or modifications of existing structure as required.	None	None
	$2,000,000	$1,600,000	$820,000
e required	Prepare entire area for ultimate requirements, including security and fire fighting facilities. Construct storage facilities to meet expected requirements for operations during first and second phases.	Construct additional storage facilities as required.	Construct additional storage facilities as required.
	" " " " " " "	" " " " " " " "	
	$600,000	$200,000	$100,000
t the NAS, El Centro, l runways, NE-SW t.wide, one concrete an asphalt runway t.long and 250 ft. ys,one concrete and ft.long and 250 ft. longer concrete run- ing the parallel asphalt xiway,extending the 6000 with taxiway, construct- areas, the available ly adapted to meet te.	Construct runways and taxiway extensions and portion of additional parking area required.	Complete parking apron.	None
y be readily irements for all e except hangars. t large enough assembly shops technical area.	Modify existing structures as necessary to meet ultimate requirements. Construct one hangar and leanto.	Construct second hangar and leanto.	Construct third hangar and leanto.
lone of aviation ailable structures radio and com- .	None Modify existing facilities	None None	Construct storage facilities to meet ultimate requirements. None
	$2,285,000	$1,235,000	$1,135,000

	ULTIMATE REQUIREMENTS	AVAILABLE	FIRST PHASE CONSTRUCTION
6.	**HOUSING AND COMMUNITY FACILITIES**		
a.	**Estimates of Personnel**		

ITEM	OFFICERS	Civilians of Officer Status	Enlisted Personnel	Civilians of Enlisted Status	TOTALS
		PERMANENT PERSONNEL			
Permanent personnel required *	400	500	2,400	1,000	4,300
		TEMPORARY PERSONNEL			
Transients	150	150	-	-	300
Military personnel in training	100	-	1,000	-	1,100
	250	150	1,000	-	1,400
		* Breakdown of permanent personnel required			
Single workers - 25%	100	125	600	250	1,075
Married workers- 75%	300	375	1,800	750	3,225
Dependents (2.8 per married worker)	840	1,050	5,040	2,100	9,030
	1,240	1,550	7,440	3,100	13,330
Total ultimate population - permanent workers, dependents, transients and trainees					14,730

It will be noted that the above figures are based on the assumption that 75% of the enlisted personnel will be married. It is believed that, in view of the skilled and experienced type of enlisted personnel required, this is a realistic assumption.

Bachelor housing available at the NAS, El Centro for approximately 5500 people. An FPHA project adjacent to the station will accommodate 212 families. Only two sets of family quarters are available on the station, although some 20% of the bachelor housing might be readily converted into dependent housing as a temporary measure. It will be necessary to acquire additional land to the north of the station to provide for the ultimate housing requirements.

It is possible that many of the community facilities will ultimately be provided in El Centro, and other nearby towns. Therefore this estimate of requirements represents the maximum. It will undoubtedly be possible to scale down the requirements as the area is developed and as outside communities begin to absorb the population. At present no housing is available and community facilities are inadequate.

			300 (plus construction force)
			25
			0
			25
			75
			225
			630
			930
			955

b. **Housing:** The following housing will be required on the basis of the assumptions regarding personnel requirements:

	UNITS		
(1) Quarters for married officers and married civilians of officer status	675	50 units (FPHA development)	220 units
(2) Quarters for married enlisted personnel and married civilians of enlisted status	2,550	162 units (FPHA development)	843 units
(3) Quarters and messing facilities for single officers and single civilians of officer status (includes 100 officers in training)	325	Existing facilities adequate with some alterations	Modify sufficient existing structures to provide approximately 130 units
(4) Quarters and messing facilities for single civilians of enlisted status	250	ditto	Provide for 100 units
(5) Hotel accommodations for transients	300	"	Provide for 120 units
(6) Barracks and messing facilities for single enlisted personnel (includes 1000 in training)	1,600	"	Provide for 600 units
ESTIMATED COST HOUSING FACILITIES	$32,750,000		$11,580,000

c. **Community Facilities.** The following community facilities are required on the basis of the assumptions regarding personnel requirements:

(1)	Theaters - two with 1,000 seats each	One theatre, 1050 seats	None
(2)	Chapels - three with 600 seats each	One chapel available, 400 seats	Construct additional chapel
(3)	Schools		
	1 Elementary schools - 6 for 360 pupils each	None at NAS and school facilities at El Centro are critical	Construct two elementary schools
	2 High school - one for 600 pupils and including a gymnasium, athletic field and auditorium.		None
(4)	A hospital, 500 bed capacity, to serve all military and civilian personnel. Includes a dental clinic, hospital laundry and quarters for nurses and corpsmen.	100 bed hospital available at NAS	Construct facilities for an additional 100 beds.

AVAILABLE	FIRST PHASE CONSTRUCTION	SECOND PHASE CONSTRUCTION	THIRD PHASE CONSTRUCTION
lor housing available at the NAS, ntro for approximately 5500 people. HA project adjacent to the station accommodate 212 families. Only two of family quarters are available on tation, although some 20% of the lor housing might be readily con- into dependent housing as a temporary e. It will be necessary to acquire ional land to the north of the on to provide for the ultimate ing requirements. possible that many of the nity facilities will ultimately be ded in El Centro, and other nearby . Therefore this estimate of ements represents the maximum. ll undoubtedly be possible to scale the requirements as the area is oped and as outside communities to absorb the population. At t no housing is available and nity facilities are inadequate.	300 (plus construction force) 25 0 25 75 225 630 930 955	1,700 120 400 520 425 1,275 3,570 5,270 5,790	3,000 210 750 960 750 2,250 6,300 9,300 10,260	4,300 300 1,100 1,400 1,075 3,225 9,030 13,330 14,730
	Construct housing adequate to care for estimated population during second phase (see tabulation above)	Construct housing adequate to care for estimated population at beginning of 3rd phase (see tabulation above)	Construct housing to meet ultimate requirements.
ts (FPHA development)	220 units	Provide an additional 195 units	Provide an additional 210 units
its (FPHA development)	843 units	Provide an additional 780 units	" " " 765 "
ng facilities adequate some alterations	Modify sufficient existing structures to provide approximately 130 units	Provide an additional 100 units	" " " 95 "
ditto	Provide for 100 units	" " " 75 "	" " " 75 "
"	Provide for 120 units	" " " 90 "	" " " 90 "
"	Provide for 600 units	" " " 500 "	" " " 500 "
	$11,580,000	$10,565,000	$10,605,000
atre, 1050 seats	None	None	Construct additional theatre, if conditions at that time indicate requirement
pel available, 400 seats	Construct additional chapel	None	Construct additional chapel.
NAS and school facilities at re are critical	Construct two elementary schools None	Construct 2 elementary schools Initiate construction of high school facilities, if required	Construct two elementary schools, if required Complete construction of high school facilities
hospital available at NAS	Construct facilities for an additional 100 beds.	Construct facilities for an additional 200 beds.	Complete to meet ultimate requirements.

ULTIMATE REQUIREMENTS	AVAILABLE	FIRST PHASE CONSTRUCTION	SE
6. c. Community Facilities. (Continued)			
(5) A shopping center to include retail stores of all types, a bank, post office, telephone exchange, telegraph office, bus terminal, cobbler shop, barber shop, beauty parlor, restaurant, professional offices, etc. It is estimated that 160,000 sq. ft. of floor space will be required for these activities.	Many of these facilities will undoubtedly become available in nearby communities, as expansion increases.	Construct minimum facilities to serve anticipated requirements during 1st and 2nd phases.	Exp nee
(6) A garage and filling station for non-military vehicles - 15,000 square feet area.	Not available	Construct to meet ultimate requirements	
(7) A community recreation center to include bowling alleys, dance floor, game rooms, swimming pool, snack bar, etc. - 80,000 sq. ft. area.	Existing facilities include an indoor swimming pool, tennis courts and bowling alleys. Will require expansion during second and third phases.	None	Con req bas
(8) A community library - 3000 square feet area	Library available	None	Mod as req
(9) A laundry and dry cleaning plant - 60,000 sq.ft.area.	Present facilities at NAS about 25% adequate.	None	Exp
(10) A community bakery - 30,000 sq. ft. area	Present facilities abt.50% adequate	None	
(11) A cold storage, ice making and ice cream making plant - 8,000 sq. ft. area.	Present facilities about 75% adequate	None	
(12) Fire stations - two with three pieces of apparatus each- total 15,000 sq. ft. area	Present facilities inadequate	Construct one fire station	Con
(13) Community administration building to include rental offices, police station, etc. - 10,000 sq. ft.	Suitable structure available	Modify existing structure	
d. Supporting Facilities for Personnel. The following supporting facilities will be required:			
(1) Club facilities for officers and civilians of officer status - 10,000 sq. ft. area	Suitable club building available	None	
(2) Club facilities for top grade non-commissioned officers - 3,000 sq. ft. area	Not available	Construct NCO Club	
(3) Recreation building for enlisted personnel. To be located in the barracks area and to include a gymnasium, bowling alleys, game room, library and reading room and a refreshment bar - 15,000 sq.ft.area	Existing structure about 50% adequate.	None	Co ul
(4) A post exchange to be located near the barracks area - 5,000 sq. ft. area.	Suitable PX available.	None	
(5) A guard house, capacity 35 prisoners.	Suitable Guard House available	None	
ESTIMATED COST COMMUNITY AND SUPPORTING FACILITIES - $15,620,000.		$4,850,000	
7. ADMINISTRATIVE AND UTILITIES FACILITIES			
a. Base Administration Building to provide offices for the Commanding Officer and his staff, including supply, accounting, disbursing, security, communications, maintenance, personnel (labor relations and employment), etc. - 50,000 sq. ft. area.	Many of the existing smaller structures at NAS may be used to house administrative offices (see "Technical Facilities"). There is an insufficient number of these structures to meet the combined requirement of 100,000 sq.ft. for both technical and base administration facilities. Therefore one new structure housing these administrative functions which cannot be taken care of in existing buildings will eventually be required.	Modify available structures to meet first phase requirements.	Con ulti
b. Operation, maintenance and repair of motor vehicles.			
(1) Motor pool dispatchers office - 4000 sq.ft.area (2) Gasoline station - 25,000 gals. storage 1000 sq. ft. (3) Open paved parking area - 320,000 sq. ft. area (4) First echelon maintenance shop (for periodic inspection, minor repairs and adjustments) 5,000 sq. ft. area.	Existing facilities abt. 50% adequate	None	Exp
(5) Second and third echelon repair shop - 10,000 sq. ft.			
(6) Fourth and fifth echelon repair shop - 20,000 sq. ft.area	Not available	None	Con
c. Locomotive repair shop - 4,000 sq. ft. area.	Not available	None	Con

(FIGURE NUMBER 2)

AVAILABLE	FIRST PHASE CONSTRUCTION	SECOND PHASE CONSTRUCTION	THIRD PHASE CONSTRUCTION
of these facilities will undoubt- become available in nearby nities, as expansion increases.	Construct minimum facilities to serve anticipated requirements during 1st and 2nd phases.	Expand facilities as may be necessary.	Expand facilities as may be necessary.
available	Construct to meet ultimate requirements	None	None
ting facilities include an indoor ing pool, tennis courts and bowling s. Will require expansion during d and third phases.	None	Construct additional facilities as required due to development at base.	Complete facilities for ultimate requirement.
ry available	None	Modify or alter existing structure as may be necessary to meet ultimate requirements	None
nt facilities at NAS about 25% ate.	None	Expand as required	Complete to meet ultimate requirements
nt facilities abt.50% adequate	None	None	Complete to meet ultimate requirements
nt facilities about 75% adequate	None	None	Complete to meet ultimate requirements
nt facilities inadequate	Construct one fire station	Construct second fire station.	None
ble structure available	Modify existing structure	None	None
ble club building available	None	None	None
available	Construct NCO Club	None	None
ing structure about 50% adequate.	None	Construct service club to meet ultimate requirements.	None
ble PX available.	None	None	None
ble Guard House available	None	None	None
	$4,850,000	$6,230,000	$4,540,000
of the existing smaller structures may be used to house administrative s (see "Technical Facilities"). is an insufficient number of these tures to meet the combined require- of 100,000 sq.ft. for both technical se administration facilities. fore one new structure housing these istrative functions which cannot be care of in existing buildings will ally be required.	Modify available structures to meet first phase requirements.	Construct administration building to meet ultimate requirements.	None
isting facilities abt. 50% adequate	None	Expand motor pool facilities as required	Complete motor pool facilities to meet ultimate requirements.
available	None	Construct 4th & 5th echelon repair shop	None
available	None	Construct locomotive repair shop	None

ULTIMATE REQUIREMENTS	AVAILABLE	FIRST PHASE CONSTRUCTION
7. ADMINISTRATIVE AND UTILITIES FACILITIES (CON'T)		
d. Base maintenance facilities.		
(1) Carpenter shop - 10,000 sq. ft. area (2) Electrical shop 4,000 sq. ft. " (3) Plumbing and sheet metal shop - 6,000 sq. ft. area (4) Paint Shop - 4,000 sq. ft. area (5) Building material warehouse - 20,000 sq. ft. area	Existing facilities about 30% adequate	Construct minimum facilities to meet second phase requirements.
e. General Storage Facilities.		
(1) General stores and supplies - 500,000 sq. ft. area (2) Quartermaster stores - 50,000 sq. ft. area (3) Paint and oil stores - 20,000 sq. ft. area	Existing structures about 20% adequate	ditto
f. Fire station - 3,000 sq. ft. area	Existing structure inadequate	Construct fire station
g. Cafeteria, seating capacity 250 - 8,000 sq. ft. area	Existing cafeteria inadequate	Construct cafeteria
(a thru g) ESTIMATED COST BASE ADMINISTRATIVE AREA FACILITIES $3,760,000		**$1,130,000**
h. Utilities and Services for the entire area.		
(1) Electric power required - approx. 10,000 KVA This may be provided by a new power plant or by purchase, or by a combination of the two, depending on location.	Approx. 1000 KW available at NAS. A proposed steam plant at El Centro now under contract, will have sufficient capacity to cover the demands.	Provide portable generators, as required for construction and limited operations outside base area pending completion of power transmission lines and permanent power facilities.
(2) Electric distribution system as required.	Existing distribution system at NAS abt 75% adequate. No power available at launching site, magazine area or static test area.	Extend distribution system as required and construct transmission line to launching site and magazine area.
(3) Water treatment plant - 1,500,000 gallons per day, 3,000,000 gallon reservoir.	Existing treatment plant at NAS, with capacity of 1,500,000 gals. per day is adequate for domestic use at base, technical and housing areas. No water supply exists at launching, magazine or static test areas. Experience indicates a requirement of 200 gals. per man per day, including water for evaporation coolers.	Develop water supply at launching, magazine and static test area. Local information indicates that wells may be practicable but as an alternative a ten mile pipe line might be constructed from the West Side Main Canal.
(4) Water distribution system.	Water distribution system at NAS about 75% adequate. Resevoir capacity of 2,500,000 gallons adequate for base and technical areas.	Construct distribution system, storage and treatment facilities at launching magazine and static test areas.
(5) Sewage disposal plant for 15,000 population ultimately.	No treatment plant used. Sewage discharged directly into New River.	Construct sewage treatment plant at base and technical area and septic tanks outside of base area.
(6) Sanitary sewer system.	Present sewer system at NAS about 75% adequate.	Construct additions to sewage system to meet first phase requirements.
(7) Storm sewer system.	Present storm sewer system at NAS about 75% adequate.	Construct addition to storm sewer system to meet first phase requirements.
(8) Telephone distribution system.	Present telephone system about 50% adequate.	Construct additions to telephone system to meet first phase requirements.
(9) Streets, walks and roads as required.	Present streets, walks and roads about 75% adequate.	Construct streets, roads and walks to meet first phase requirements.
(10) Street and road lighting system as required.	Present system about 75% adequate.	Construct street and road lighting to meet first phase requirements.
(11) Railroad system and a small classification yard as required.	Rail facilities available at El Centro	None
ESTIMATED COST UTILITIES & SERVICES - $2,950,000		$1,600,000
8. INSTRUMENTATION FACILITIES MAIN BASE AREA.	None	Provide sufficient for one launching site.
These facilities will consist of 6 towers 150 feet high; concrete slabs with tie downs, and pole masts for antenas.		
ESTIMATED COST FOR INSTRUMENTATION FACILITIES FOR MAIN BASE $500,000		$300,000
TOTAL ESTIMATED COST OF BASE FACILITIES $71,250,000		$27,810,000

	FIRST PHASE CONSTRUCTION	SECOND PHASE CONSTRUCTION	THIRD PHASE CONSTRUCTION
...LE			
...ities about 30% adequate	Construct minimum facilities to meet second phase requirements.	Expand shop facilities as required	Complete shop facilities to meet ultimate requirements.
...tures about 20% adequate	ditto	Expand storage facilities as required	Complete storage facilities to meet ultimate requirements
...ture inadequate	Construct fire station	None	None
...teria inadequate	Construct cafeteria	None	None
	$1,130,000	$1,590,000	$1,040,000
...W available at NAS. A ... plant at El Centro now ...t, will have sufficient ...ver the demands.	Provide portable generators, as required for construction and limited operations outside base area pending completion of power transmission lines and permanent power facilities.	Arrange for increase in capacity of incoming transmission line to meet ultimate requirements and transformers for indicated load for second phase.	Add transformers to meet ultimate needs.
...ribution system at NAS abt ... No power available at ...e, magazine area or static	Extend distribution system as required and construct transmission line to launching site and magazine area.	Extend distribution system as required and construct transmission line to static test area.	Complete distribution system to meet ultimate requirements.
...tment plant at NAS, with ...,500,000 gals. per day is ...domestic use at base, ... housing areas. No water ... at launching, magazine or ...reas. Experience indicates ... of 200 gals. per man per ...g water for evaporation	Develop water supply at launching, magazine and static test area. Local information indicates that wells may be practicable but as an alternative a ten mile pipe line might be constructed from the West Side Main Canal.	Increase capacity of present treatment plant to 3,000,000 gals per day to meet ultimate requirements. A possible saving would be to use chlorinated water for cooling if indicated by engineering analysis.	None
...bution system at NAS about ... Resevoir capacity of ...llons adequate for base ... areas.	Construct distribution system, storage and treatment facilities at launching magazine and static test areas.	Extend distribution system at base area as required.	Complete distribution system to meet ultimate requirements.
... plant used. Sewage ...irectly into New River.	Construct sewage treatment plant at base and technical area and septic tanks outside of base area.	None	Complete facilities as required to meet ultimate requirements.
... system at NAS about 75%	Construct additions to sewage system to meet first phase requirements.	Extend system as required	Complete system to meet ultimate requirements.
... sewer system at NAS about	Construct addition to storm sewer system to meet first phase requirements.	Extend system as required	Complete system to meet ultimate requirements.
...hone system about 50% ade-	Construct additions to telephone system to meet first phase requirements.	Extend system as required	Complete system to meet ultimate requirements.
...te, walks and roads about	Construct streets, roads and walks to meet first phase requirements.	Extend system as required.	Complete system to meet ultimate req'ts.
... about 75% adequate.	Construct street and road lighting to meet first phase requirements.	Extend system as required.	Complete system to meet ultimate requirements.
...ies available at El Centro	None	See Launching Area for spur line	
	$1,600,000	$850,000	$500,000
	Provide sufficient for one launching site.	Provide for second launching site.	Provide for third launching site.
$300,000		$100,000	$100,000
$27,810,000		$23,460,000	$19,980,000

ESTIMATES OF REQUIRED RANGE FACILITIES WITH COST ESTIMATES FOR THE EL CENTRO-GULF OF CALIFORNIA RANGE

ULTIMATE REQUIREMENTS	AVAILABLE	FIRST PHASE CONSTRUCTION
1. Land. There will be a total of 13 observation stations, each consisting of a headquarters area of about five acres, three outlying observation points of a total of about five acres. Total for 13 stations will be 130 acres of Mexican territory. No attempt is made to estimate the total ultimate cost but the value of most of the land is negligible.	None	Obtain clearance and title to all ne
2. Geodetic Surveys.	First order geodetic control has been established in the base area. None available in Mexico.	Extend control along range to southe of Lower California and locate stati maximum possible accuracy.
ESTIMATED COST SURVEYS $600,000		$500,000
3. Facilities for Range Instrumentation. (See Appendix I for detailed list.)	A map study indicates that suitable sites exist along the eastern coast of Lower California. Access by amphibian aircraft or by boat is indicated.	Construct stations and facilities to Lower California.
ESTIMATED COST OF FACILITIES FOR RANGE INSTRUMENTATION $8,550,000		$5,850,000
4. Hard Wire Communications from Launching Site to Range Instrumentation Groups.	None available.	Construct hard wire communications fr site to all groups of stations to ti California. (Note: Estimate based u Cable on account of vulnerability of pilfering and damage and higher maint pole line.)
ESTIMATED COST HARD WIRE COMMUNICATIONS $1,000,000		$1,000,000
TOTAL ESTIMATED COST RANGE FACILITIES $10,150,000		$7,350,000

RECAPITULATION OF COSTS

ESTIMATED TOTAL COST FOR BASE FACILITIES	$ 71,250,000
ESTIMATED TOTAL COST FOR RANGE FACILITIES	$ 10,150,000
ESTIMATED TOTAL COST FOR INSTRUMENTATION EQUIPMENT	$ 37,890,000
ESTIMATED TOTAL OVERALL COST FOR ENTIRE RANGE	$119,290,000

ANNEX E

APPENDIX 3

(FIGURE NUMBER 3)

ESTIMATES OF REQUIRED RANGE FACILITIES WITH COST ESTIMATES FOR THE EL CENTRO-GULF OF CALIFORNIA RANGE

	FIRST PHASE CONSTRUCTION	SECOND PHASE CONSTRUCTION	THIRD PHASE CONSTRUCTION
	Obtain clearance and title to all necessary land.	Improve liveability as necessary.	
e control has the base area. xico.	Extend control along range to southern tip of Lower California and locate stations with maximum possible accuracy.	Determine location of observing stations further out along range, as may be required, employing Shoran or other suitable methods.	Determine location of stations to provide required instrumentation for ultimate range requirements.
	$500,000	$50,000	$50,000
s that suitable e eastern coast . Access by or by boat is	Construct stations and facilities to tip of Lower California.	Extend stations and facilities as required.	Complete stations and facilities to meet ultimate range requirements.
	$5,850,000	$1,350,000	$1,350,000
	Construct hard wire communications from launching site to all groups of stations to tip of Lower California. (Note: Estimate based upon subterranean Cable on account of vulnerability of pole line to pilfering and damage and higher maintenance cost of pole line.)	None	None
	$1,000,000	-----	-----
	$7,350,000	$1,400,000	$1,400,000

ANNEX E

APPENDIX 3

(FIGURE NUMBER 3)

A N N E X "E"

A P P E N D I X 4.

DETAILS OF FACILITIES REQUIRED FOR A TYPICAL DOWN-RANGE INSTRUMENTATION STATION.

1. An instrumentation group, as referred to herein, consists of a main station plus three outlying stations located at distances of ten to thirty-five miles from the main station. Thirteen groups of this type will be required along the first 650 miles of the range at intervals of about fifty miles.

2. MAIN STATION. The following facilities will be required at the main stations of each group:

a. A 150' tower with an 8' x 8' open platform at the top. Instrument load at the top of the tower will not exceed one ton. There is no objection to guy wires, if desired.

b. A weatherproof room in the tower base (200 sq. ft.)

c. An electronics hut, 800 sq. ft. air conditioned.

d. Three concrete slabs 20' x 20' with tie down lugs for anchoring radar vans.

e. Powerhouse, 400 sq. feet.

f. A small boat pier capable of handling one LST alongside and including a twenty ton crane. (The crane will be

c. Small generator building, 100 sq. ft.

d. A small boat pier and five ton crane (where required).

e. A seaplane anchor float (where required).

f. Housekeeping facilities for ten people on a temporary occupancy basis plus a permanent guard.

(1) Evaporator building, 200 sq. ft. (may possibly be combined with generator house).

(2) Water storage tank, 2,000 gallons.

(3) Quarters for ten people.

(4) Messing facilities.