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Semi-Annual Report 2

RESEARCH-ENGINEERING AND SUPPORT FOR TROPICAL COMMUNICATIONS

Prepared for:

U.S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

PR&C NO. 63-ELN/R-6109
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STANFORD RESEARCH INSTITUTE

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ELECTRONICS AND RADIO SCIENCES DIVISION
PROGRAM SUPERVISOR

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PREFACE

The purpose of the project is to support the Combat and Development Test Center, a joint Thailand-United States agency, in the areas of tactical and tropical communications. The United States Army Electronics Research and Development Laboratory and Stanford Research Institute have provided an Electronics Laboratory near Bangkok, Thailand. It is staffed by both Thailand and United States personnel. A C-2 vertical incidence sounder has been supplied by the United States Radio Propagation Agency and is being used for the study of the equatorial ionosphere. Several temporary remote sites have been used for the testing of man-pack radio sets and for the study of propagation problems important to communications.

During the period covered by this report, the communications-engineering support to SRI's portion of the program was provided by the Communication Laboratory, under the supervision of W. R. Vincent; the operations analysis support was provided by the Operations Analysis Department, under the supervision of G. S. Wiley.

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I INTRODUCTION

A. HISTORICAL BACKGROUND

During World War II, United States military forces operated extensively in tropical areas, thereby gaining considerable practical experience in communication problems in tropical forest and jungle areas. The pressure of military objectives limited scientific explorations into many of the specific problems that arose, resulting in sizable gaps in our knowledge of communication in equatorial regions.

The friendly and cooperative working arrangement existing between Thailand and the United States has resulted in the joint study of tropical communication problems by staff members of the Thailand Ministry of Defense and agencies of the United States. The Combat and Development Test Center (CDTC) has been organized as a joint Thailand-United States agency to conduct operational tests of military hardware and to foster research on many subjects in a tropical environment. Communications research is a major subject of interest in the CDTC.

The United States Army Electronics Research and Development Laboratory and Stanford Research Institute have undertaken the task of establishing an Electronics Laboratory in Thailand, to facilitate a first-hand study of tropical communication problems. Staffing of the laboratory is planned as a joint United States-Thailand venture, with United States participation largely from members of the staff of Stanford Research Institute.

Over-all direction of the United States portion of the CDTC has been assigned to the Advanced Research Projects Agency (ARPA) of the Department of Defense. ARPA actively monitors and directs the work of the United States Army Electronics Research and Development Laboratory and its contractor, Stanford Research Institute.

B. OBJECTIVES

The purpose of the project under Contract DA-36-039-AMC-00040(E) is to support the CDTC-T in the areas of tactical and tropical communication. The specific objectives of this effort are to:

(1) Survey, analyze, and evaluate the capacity, reliability, and physical and tactical limitations of existing communication facilities, equipments, and techniques.

(2) Generate from the above survey, analysis, and evaluation a set of requirements for field communications based upon tactical considerations and specific equipment characteristics that will satisfy these requirements.

(3) Test off-the-shelf equipments that come as close as possible to satisfying each set of the above requirements, these tests to be first technical and then tactical for items that show promise.

(4) Analyze and evaluate the tests and recommend areas for future emphasis.

(5) State equipment requirements to accomplish the task of jungle field communication, based upon existing and anticipated tactical requirements.

(6) Train the Thai personnel assigned to the Electronics Laboratory so that they are able to utilize the facility, accomplishing this training as a natural course of operating the laboratory.

(7) Aid electronic projects in Thailand as practical, encouraging projects that appear especially useful to the basic objectives of CDTC-T.

(8) Field test selected items of communication equipment in Thailand in accordance with the requirements of the President's Counter Insurgency Committee.

II PROJECT ACTIVITY

A. SUMMARY

Semi-Annual Report 1, for the period 1 September 1962 through 28 February 1963, discussed the initial site survey of Thailand, the establishment and construction of a laboratory facility, equipment shipment schedules, and the initial stages of the testing of man-pack radios, as discussed.

During the period of this report, 1 March to 31 August 1963, all the items above were completed, a United States Army Radio Propagation Agency C-2 vertical incidence sounder was received and SRI assisted in its installation in Bangkok, tests were begun on antennas for field communication use, and a more systematic and objective procedure for evaluating the quality of voice communication by radio was begun.

Also, during this period considerable effort was applied to the development of a proposed integrated program based on the objectives of Projects AGILE, SEACORE, and the SRI contract task statements.

B. SITE PREPARATION

Basic site preparation work was completed during the reporting period. The site chosen was filled and concrete pads were poured for the laboratory complex and for the C-2 sounder. Road repairs were made after completion of the fill operation.

Building modifications were made and the main building occupied. Commercial power and water service were obtained for the main building. Diesel-generated power was chosen for the laboratory complex, due to the availability of generators and the considerable cost of commercial power.

Telephone service could not be obtained during the reporting period, due to the shortage of lines in the area of the laboratory. A temporary radio network was established linking the main building and the laboratory with the office of USAELRDL Contracting Officer's Technical Representative.

Temporary remote sites were constructed for field testing of man-pack radios in the mountains about 100 miles north of Bangkok and in the flat delta area southeast of Bangkok.

C. LABORATORY FACILITY FOR THAILAND

Due to the extensive construction and procurement of equipment required to establish a laboratory facility, the USAELRDL enlisted the aid of the Electronics Defense Laboratory (EDL) of Sylvania to accomplish these tasks. Three separate shipments were made from EDL to Thailand during the reporting period. These shipments included:

(1) T-Van complex for the laboratory;

(2) Power generating equipment;

(3) Test equipment and supplies; and

(4) Portable shelters for field operation.

Basic site preparation was completed prior to the arrival of the laboratory van complex. The van complex was installed on its concrete pad and placed into operation a few days after arrival. A separate building was constructed to house the generators and a heavy maintenance area. A photograph of the van complex and its associated power building is shown in Fig. 1.

Figures 2 and 3 show the headquarters building upon completion of its conversion from a Chinese store-type building into an office and auxiliary laboratory building, with a storage area on the ground floor.

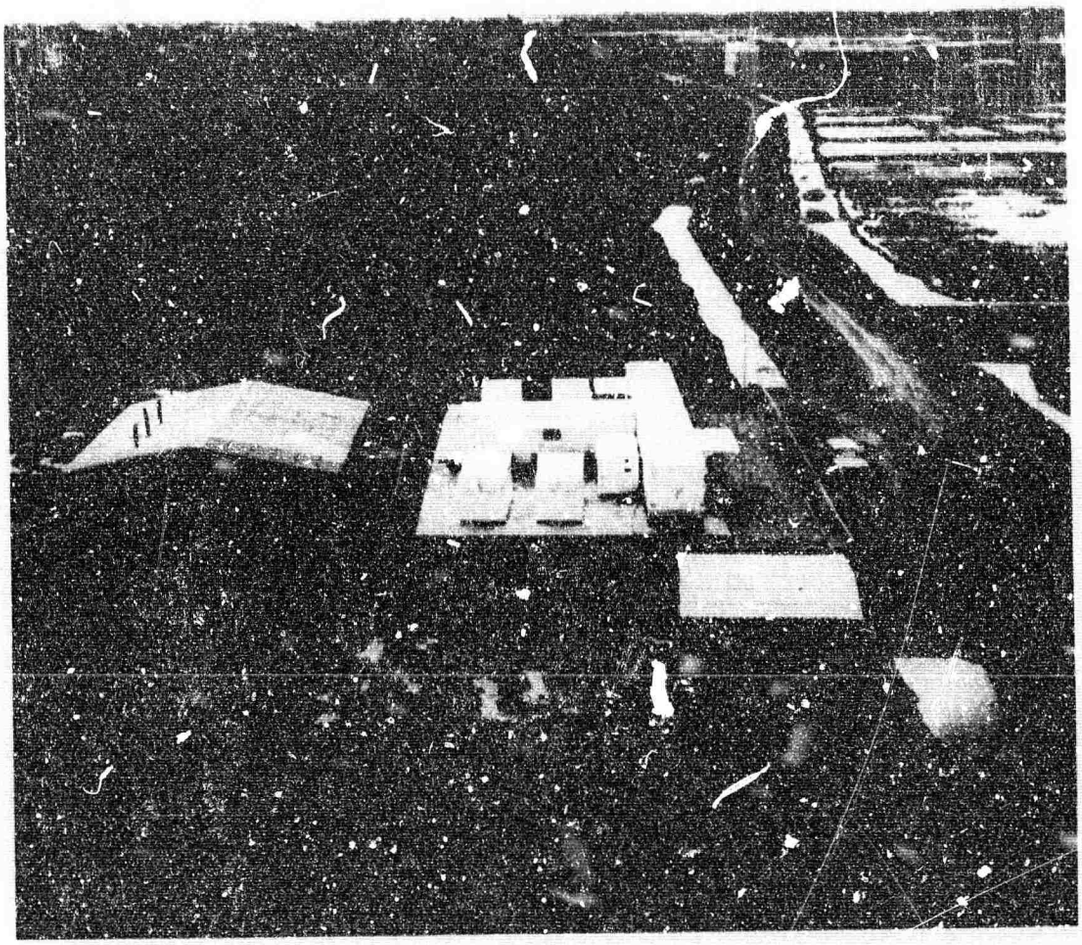

FIG. 1 PHOTOGRAPH OF T-VAN COMPLEX AND POWER BUILDING

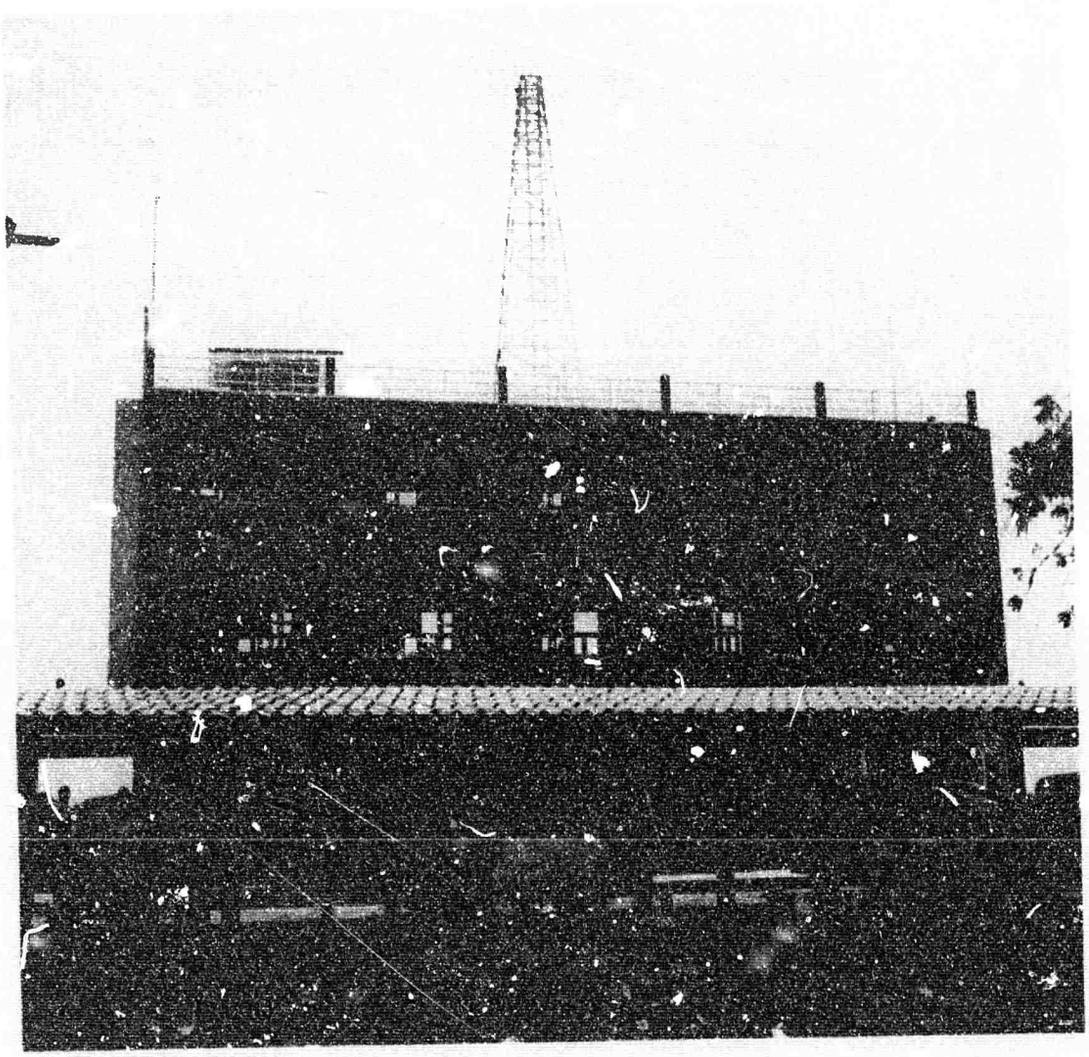

FIG. 2 PHOTOGRAPH OF MAIN BUILDING – FRONT VIEW

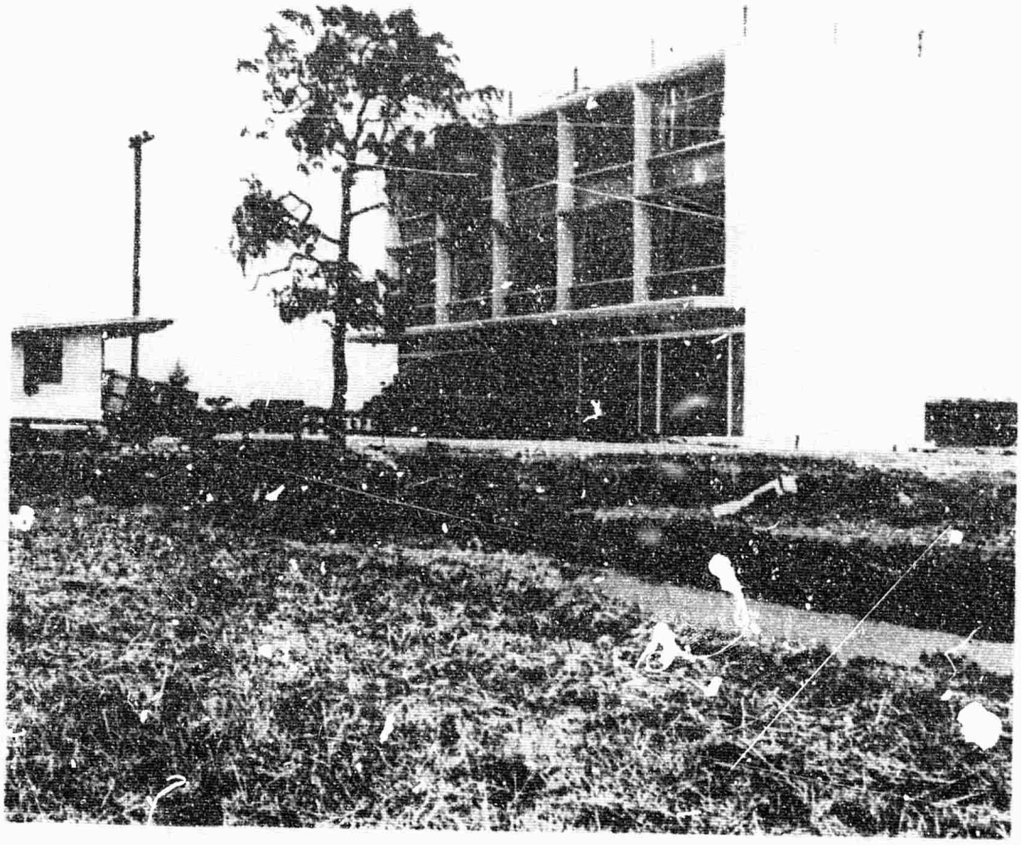

FIG. 3 PHOTOGRAPH OF MAIN BUILDING – SIDE VIEW

D. INSTALLATION OF THE C-2 SOUNDER

During the first reporting period arrangements were made by the United States Army Radio Propagation Agency to supply a C-2 vertical incidence sounder to Bangkok along with operating personnel. A site was selected near the T-van complex. The area was filled and a concrete pad poured to support the semi-van housed sounder. A pier was poured for the antenna tower. (See Fig. 4.)

Two staff members from the United States Army Radio Propagation Agency arrived in Bangkok prior to sounder arrival to erect the antenna tower and plan other site details such as power, water, transportation, film processing, etc.

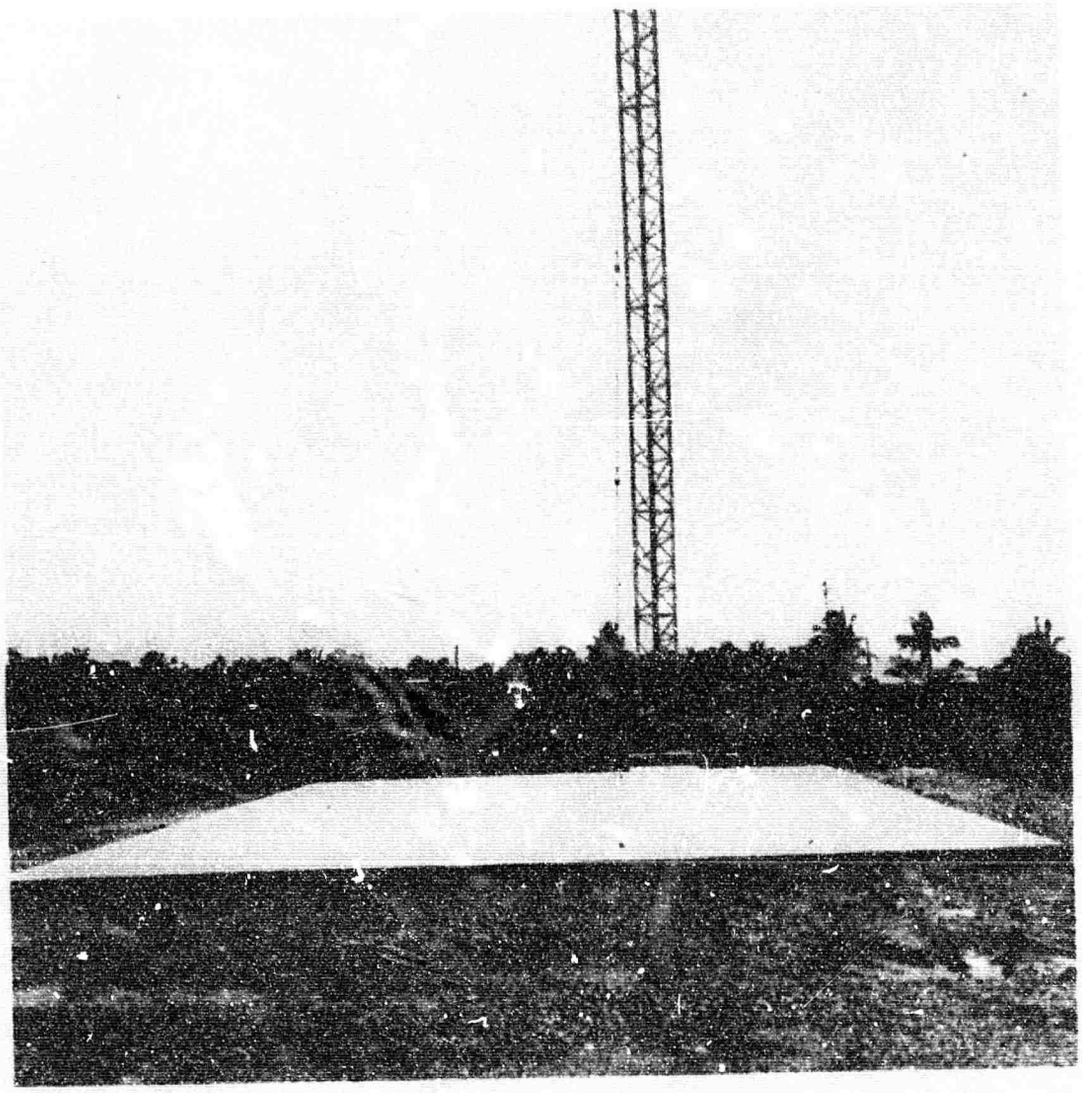

FIG. 4 PHOTOGRAPH OF C-2 SOUNDER PAD AND ANTENNA

The sounder also arrived during the reporting period. It was immediately installed on its pad and initial checkout of the equipment completed. Partial operation was started and complete operations planned during the first part of the next reporting period.

E. FIELD TESTS ON MAN-PACK RADIO

1. General

Field tests on man-pack radio sets were started during the first reporting period and completed during this period. Test areas are shown in the maps given in Figs. 5, 6, and 7. Field tests were made comparing the performance capabilities of the AN/GRC-9, HC-162, AN/TRC-88, 77 AM, and the AN/TRP-4 HF radio sets. The AN/PRC-10 and AN/PRC-25 VHF sets were also field tested.

Test conditions, performance details, and results have been discussed in separate reports, a list of which is given in Sec. IV. The conclusions reached in Research Memorandum 3, "Field Tests on Man-Pack Radios in a Tropical Environment," are repeated here to summarize the results of the field tests.

2. HF Radio Sets

(1) The HC-162 and AN/TRC-88 sets have demonstrated a superior performance level over the other sets tested.

(2) The AN/TRC-88 set is simple and easy to tune and from this standpoint superior to the HC-162.

(3) The HC-162 has frequency flexibility not found in the other sets, which can be used to dodge interference. In the crowded spectrum of Southeast Asia, the frequency flexibility is a definite advantage.

(4) The HC-162 frequency flexibility makes it possible to reach any assigned frequency without crystal changing and subsequent alignment.

(5) The antenna tuning mechanism of the HC-162 is unduly complicated and difficult to adjust. It has three controls that interact, compared to two controls that do not interact for the other sets. Also, the adjustment of the HC-162 set requires an increased time factor of three to five for tuning when compared to the other sets. This results in waste of battery power.

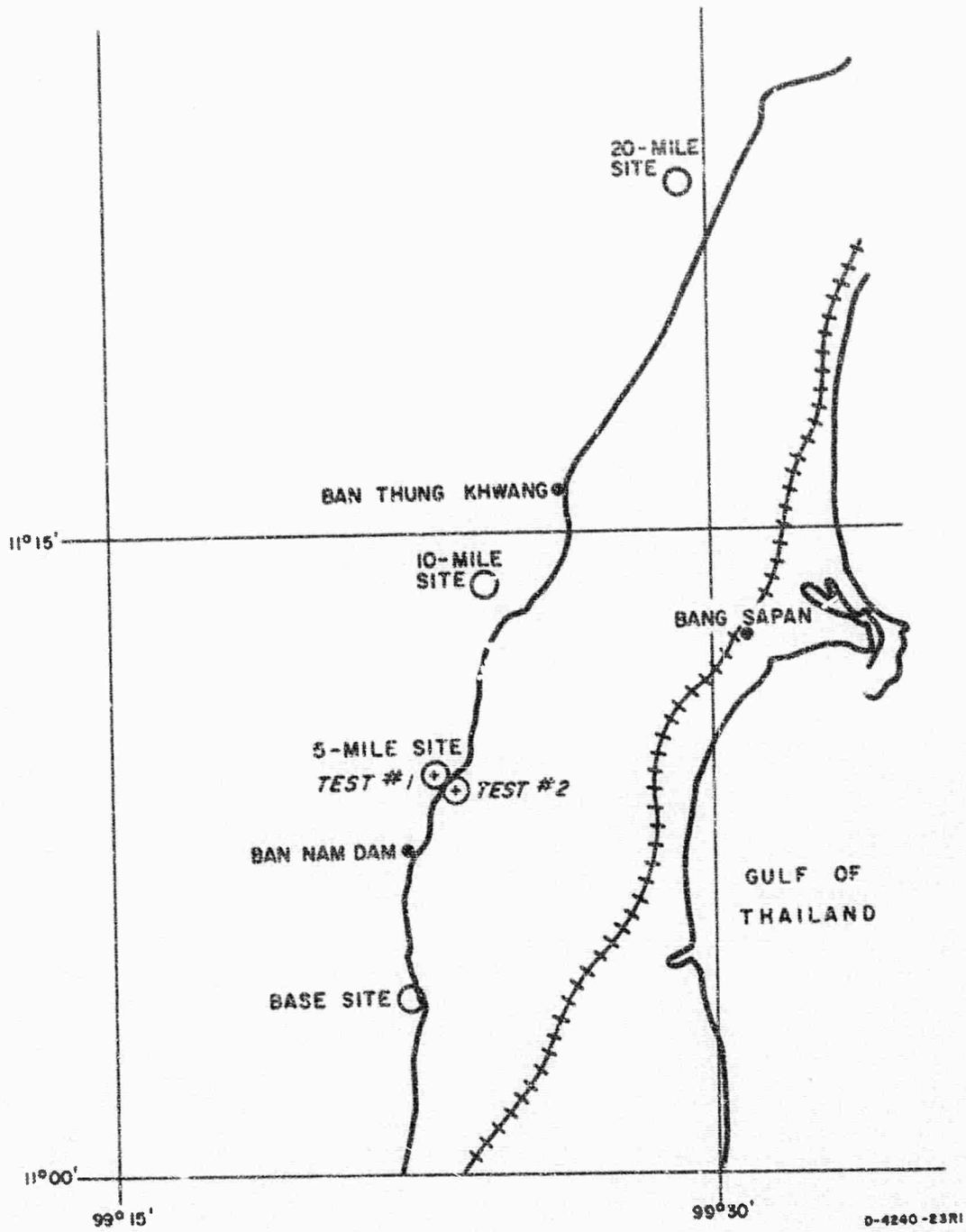

FIG. 5 MAP SHOWING LOCATION OF TROPICAL FOREST AREA SITES

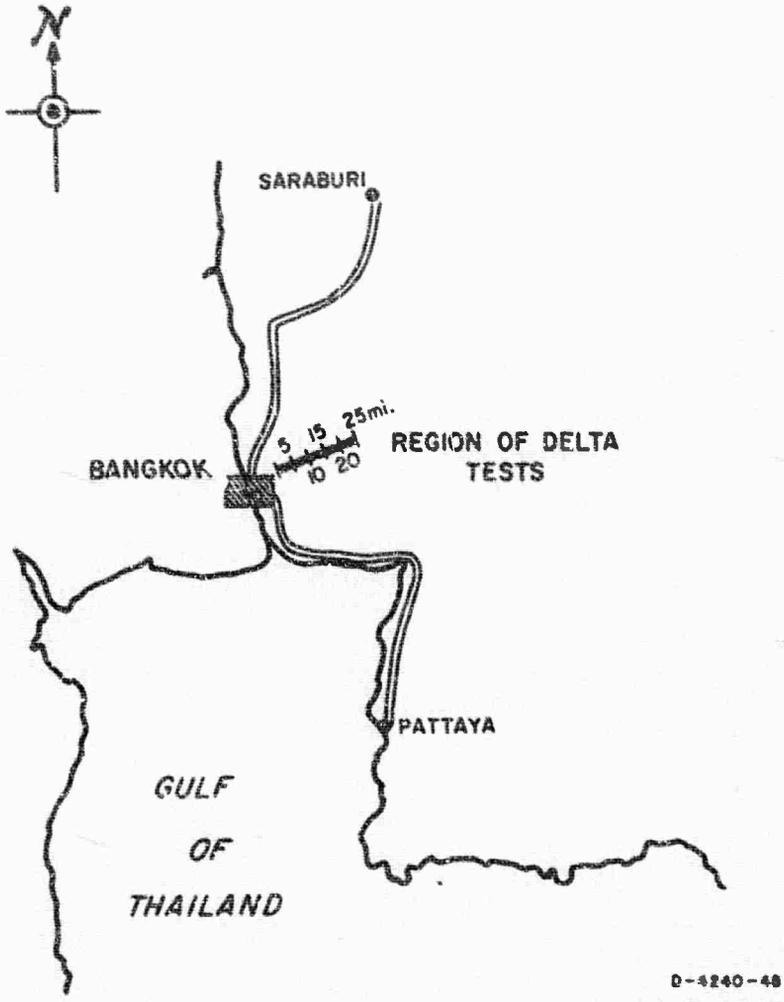

FIG. 6 MAP SHOWING LOCATION OF DELTA REGION SITES

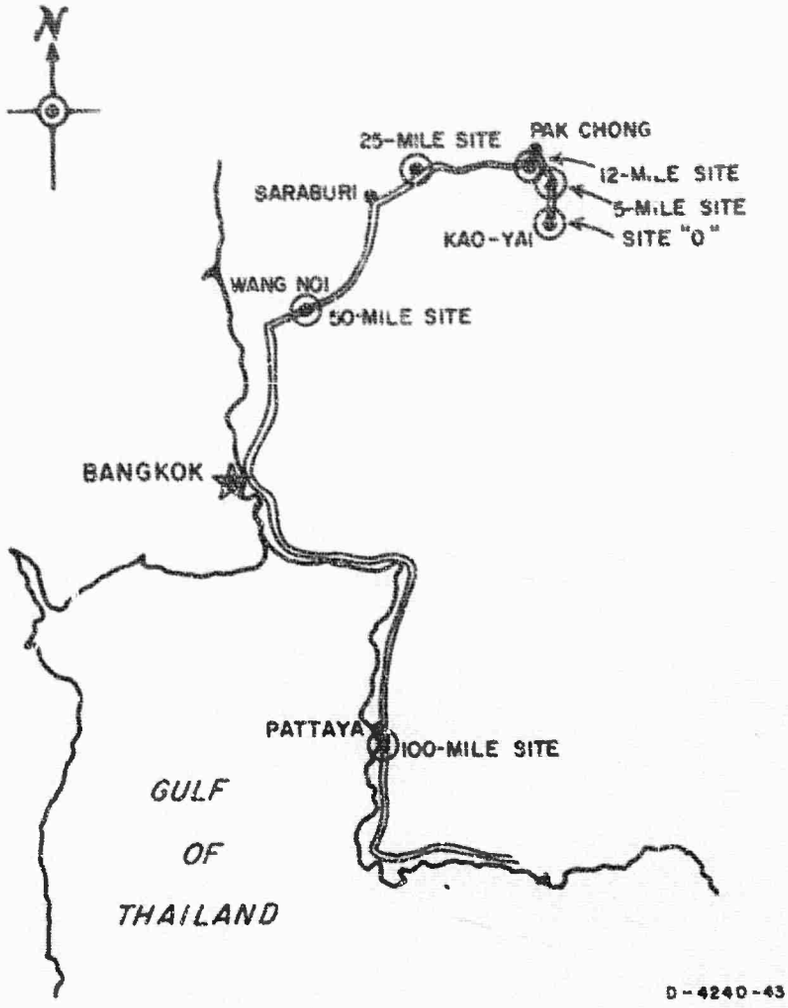

FIG. 7 MAP SHOWING LOCATION OF MOUNTAIN AREA SITES

(6) Doublet antennas gave the best performance. Slant-wire antennas were considerably lower in performance and whip antennas very poor in performance.

(7) The nature of terrain between sites is not a significant factor.

(8) Terrain features and vegetation near an antenna are probably important. (More detailed investigation of this factor is required.)

(9) Propagation via the ionosphere was the major mode observed on all tests. No ground-wave signal could be identified with certainty, even at 5-mile ranges.

(10) The HF spectrum is crowded in Southeast Asia. From the test conducted, it appears impossible to guarantee interference-free channels. While it might be possible to clear a channel in Thailand, most of the interference observed originated in neighboring countries.

(11) Radio propagation predictions, such as those developed and distributed by the United States Army Propagation Agency, can be altered to apply to man-pack radio sets and can be used to predict their average performance.

(12) All man-pack sets can be monitored from long distances. The manuals contain no precaution concerning potential monitoring action. The inclusion of such a warning in the manuals and in a sign on the side of the set seems advisable.

(13) The tests clearly indicate that antenna and propagation characteristics should be given more consideration in deriving the design specifications for new equipment.

3. VHF Radio Sets

(1) Using their long whip antennas, both the AN/PRC-10 and AN/PRC-25 sets generally worked well at ranges up to 3 miles in moderate forest areas.

(2) Elevation of one or both whip antennas above ground gave decided range improvements. With both whip antennas 70 feet above the ground and lashed to the tops of trees, 5-mile range was established 24 hours a day. With both antennas elevated 30 feet above ground, 5-mile communication through moderate forest could not be established.

(3) On one test conducted through extremely dense undergrowth, with a long whip on the base station set and a short or long whip on a hand-carried set, total loss of signal occurred at less than one-half mile range. Only one such location was found in the test area.

(4) Little difference could be found between the capability of an AN/PRC-25 and an AN/PRC-10 to establish a useful voice channel. No range difference was noted.

(5) The AN/PRC-10 drifted in tuning with time. This resulted in speech distortion, which was corrected by occasional retuning. Drift rate tests on several units would be required to establish the magnitude of this problem.

F. ANTENNAS FOR FIELD COMMUNICATION

Field tests on man-pack radios showed large performance variations with type of antenna. The radiation patterns of vertical whip antennas and dipole antennas are quite well defined and performance seemed consistent with the relationship between radiation patterns and the predominant propagation mode.

A search for measured or modeled patterns of the slant wire antenna was unsuccessful. Since the slant wire antenna is included as a standard item in many field radios, it was considered important to understand its radiation pattern. A partial model measurement of its radiation pattern has been completed. (See reference to Research Memorandum 4 in Sec. IV.) The results show a null in the vertical direction for most of the configurations possible. Certain azimuth and elevation alignments provide the desired vertical lobe; however, the use of these observed lobes would require that unusual antenna orientation restrictions be placed upon field installations.

The orientation of linearly polarized antennas for ionospheric propagation over short ranges near the geomagnetic equator has been examined. The Appelton-Hartree equations for this particular case take on a singular form on account of the horizontal magnetic field. This results in a magnetic north-south antenna orientation being preferred for all linearly polarized antennas, regardless of the location of the terminals. United States military documents on field communications state that a broadside orientation is proper. This appears to be incorrect. (See Research Memorandum 5, referenced in Sec. IV, for further details.)

It has been observed that considerable confusion regarding antennas for field communications exists among United States military personnel. Wide distribution of small, concise, cheap booklets, such as the United Kingdom publication "Signal Training Volume II, Wireless Pamphlet No. 2, Aerials," seems appropriate.

Instrumentation for field experiments to investigate the magnitude of antenna orientation effects on the propagation path has been assembled in Thailand. Field tests are planned using both experimental and standard communication equipment.

G. VOICE COMMUNICATION TESTING AND EVALUATION

In the voice communication tests of man-pack radios in Thailand (see Research Memorandum 3 by W. R. Vincent) radio operators were used to modulate the transmitters and record the received messages manually, and the messages were not necessarily typical of military message structure. Thus the test results contained three undesired variables due to differences in operators, test conditions, and messages sent. To provide more accurate and valid tests, equipment has been procured to transmit pre-recorded messages and to record the received messages, and procedures are being developed for using intelligibility tests for comparative evaluations. Rhyme Test master intelligibility test tapes (English version) have been recorded and analyzed for appropriate signal strength, noise level, and distortion characteristics, with satisfactory results. The English version tapes will be used, both in the U.S. and in Thailand, to test and evaluate the intelligibility of military radio equipments and other voice circuitry in English, and also to provide a base for comparison of intelligibility of such equipments when the Thai language is used.

An acoustic coupler matched to a condenser microphone of known characteristics for use with radio/telephone handsets was fabricated. This coupler will greatly enhance the validity of the test to be performed as well as decrease the difficulties of recording transcribed Rhyme Tests.

H. COORDINATION WITH THAILAND MINISTRY OF DEFENSE PERSONNEL

Long-range objectives of the CDTC program require close coordination and working arrangements with Ministry of Defense personnel in Thailand. General agreement has been reached on program tasks and specific measurements programs to be undertaken. In addition, the Thailand Ministry of Defense has

assigned personnel to work on certain of the tasks considered important to them. Thai personnel who have been assigned to work in the Laboratory are as follows:

Capt. Prapat (RTN)

Lt. Kitti (RTAF)

Capt. Udom (RTA)

Lt. Termpoon (RTAF)

Lt. Paibul

Master Sergeant Sathorn (RTAF)

3rd Class Petty Officer Chalerm (RTN)

Airman 1st Class Sopin (RTAF).

III PROGRAM FOR THE NEXT REPORTING PERIOD
(1 September 1963 to 31 March 1964)

The program to be followed is dependent on guidance and priorities received in the field. On the basis of present information, it is expected that work will be performed under the following subtasks during the next reporting period.*

Task I

Subtask 1. Small Unit and Patrol Communications

Observe and study operations and communications of small Thai military and police units of patrol, squad, platoon, and company size, as well as related base stations and networks, and determine the adequacy of existing pertinent communications equipments and practices.

Subtask 2. Survey of Existing Communication Systems

Prepare a concise description of existing Thai communication systems, including military and other government agencies, and covering,

a. Fixed police and military communications networks

b. The T.O.T. system

c. Other fixed systems

d. Vulnerability of systems to sabotage

e. Possibilities for reserve and alternate circuit planning

f. Tactical military communications resources (units, personnel, and equipment).

Task II

Subtask 4. Noise Measurements

Determine the mean and diurnal variation of local noise in Thailand.

*The Tasks and Subtasks are outlined in the SRI Work Program, dated 8 October 1963.

Subtask 5. Antenna Orientation

Determine effect of the earth's magnetic field on orientation of field communication antennas near the magnetic equator.

Subtask 6. Ground Constants

Obtain direct measurement of ground conductivity and ground dielectric constant.

Subtask 7. Earth Potential

Employ earth potential devices to obtain indications of magnetic and ionospheric instability coincident with radio field tests.

Subtask 8. Frequency Prediction

Examine noise and ionospheric factors in connection with the procedures used for frequency prediction in equatorial regions.

Subtask 9. Antenna Terrain Effects

Investigate the effects of terrain on the performance of field antennas.

Subtask 10. Flutter Fading

Determine the effect of equatorial flutter fading on field communications.

Subtask 11. Vertical Incidence Ionospheric Measurements

Utilize data from the U.S. Army Radio Propagation Agency C-2 vertical incidence ionosonde in the control and interpretation of data from tests involving high frequency propagation.

Subtask 12. Oblique Incidence Ionospheric Measurements

Using an oblique incidence sounder, examine typical field communication paths and determine the nature and characteristics of the propagation modes and antenna effects and how these affect tropical field communications.

Subtask 13. Technical Assistance

Furnish technical advice and assistance as required and approved.

In support of this program, A. J. Mandelbaum and Dr. Tor Meeland are scheduled for assignment to Bangkok in late October; R. R. Mann, early November; R. E. Morse and J. A. Macleod, in December; H. F. Erickson, early February.

IV PUBLICATIONS AND CONFERENCES

A. PUBLICATIONS

Several publications were issued during this reporting period and are listed as follows:

1. Research Memorandum 1, not published and designation not used.
2. Research Memorandum 2, "Voice Tests on Man-Pack Radios in a Tropical Environment," by W. R. Vincent.
3. Research Memorandum 3, "Field Tests of Man-Pack Radios in a Tropical Environment," by W. R. Vincent.
4. Research Memorandum 4, "Scale-Model Measurements on a Sloping-Wire Antenna," by T. S. Cory.
5. Research Memorandum 5, "Orientation of Linearly Polarized HF Antennas for Short-Path Communication in the Ionosphere Near the Geomagnetic Equator," by George K. Hagn.
6. Measurement Report No. 1, "Measurement of Receiver Bandpass and Transmitter Frequency for Channel One of the AN/TRC-77 Radio," by 3rd Class Warrant Officer Chalerm (RTN), Master Sergeant Sathorn (RTAF), Airman 1st Class Sopin (RTAF), and David J. Lyons, Vitro/Stanford Research Institute.
7. Measurement Report No. 2, "Measurement of Relative Receiver Sensitivity, Transmitter Power Output, and Interference Effects of the HC-162 Man-Pack Radio Set," by 3rd Class Warrant Officer Chalerm (RTN), Master Sergeant Sathorn (RTAF), Airman 1st Class Sopin (RTAF), and David J. Lyons, Vitro/Stanford Research Institute.

B. CONFERENCES AND VISITS

Several conferences have been held between project personnel and other parties. A summary of these conferences follows.

1. On 26 March 1963, Mr. George Watts of Fort Monmouth visited the Institute to discuss project business.

2. On 29 March 1963, members of the senior staff of the Institute and Mr. Watts met with the following visitors from Thailand:

Air Marshall Earn Kemasingki, Commandante
Royal Thai Armed Forces Staff College

Major General Sing Chai Menasuta, Deputy Director,
Directorate of Education and Research

Major General Tarn Singha Thamrong, Deputy
Directorate of Joint Operations

Major General Chote Klongzicha, Deputy Superintendent
of Military Affairs, National Defense College

Col. Thavit Bunyavat (connected with Morse Knutson
Company), Chief of Education Division, Directorate of
Education and Research

3. From 15 to 19 April 1963, Mr. H. L. Kitts of Fort Monmouth, Major John A. Krantz, Project Officer in Thailand, and Captain K. M. Irish, Assistant Project Officer in Thailand visited the Institute to discuss project business.

4. On 29 April Mr. W. R. Roberts visited Dr. P. Le Kawa, U.S. Army Language School, Presidio of Monterey, California, for discussion on the structure and use of Thai language.

5. During 30 April to 2 May Mr. A. J. Mandelbaum attended the 11th Military Operations Research Symposium, Annapolis, Maryland on Limited and Unconventional Warfare; participated in a working group on Special Warfare; attended presentations by Mr. W. H. Godel (ARPA), Mr. R. C. Phelps (ARPA) on Research and Development Problems of Limited War and Remote Area Conflict respectively. He presented a paper by Bruce Clarke, General, U.S.A., Ret'd., "U.S. Relationships with Indigenous Forces."

6. From 4 to 10 May Mr. G. S. Wiley visited Bangkok to discuss an operation analysis program, the requirements for analytic effort, equipment under test, and the Thailand operational environment. This trip was shared with other project business in Vietnam. The following were visited:

Mr. Tom Brundage, ARPA Research and Development
Field Unit

Lt. Col. J. F. Scoggin, USA, ARPA Research and Development Field Unit

Mr. W. Bergman, ARPA

Col. Lua, RTA, CDTC-T

Col. Skul, RTA, CDTC-T

Major T. Kranz, USA, COTR

Lt. Cmdr. Ceoly, USN, USICC

Col. Nolon, USA, JUSMAG J-3

Lt. Col. Snow, USA, JUSMAG J-6

Lt. Col. Vaughn, USAF, JUSMAG J-4

Major Springer, USA, JUSMAG J-6

Capt. Thompson, USA, JUSMAG J-4

Lt. Col. Pitts, USA

Dr. Clark, RAC

Mr. L. G. Sturgill, Jansky & Bailey

Prince Wan Waithayakon, Deputy Prime Minister

7. From 5 to 8 May Mr. A. J. Mandelbaum and Mr. W. R. Roberts visited the Special Warfare Center as well as the Airborne, Electronic and Special Warfare Board, and Materiel Requirements Division, Special Warfare Combat Development Agency at Ft. Bragg, North Carolina. The following were visited:

Lt. Gen. Hamilton Howze, Post Commander, C. G. XVIII Airborne Corps; Brig. Gen. Andrew Lipscomb, Dept. CG XVIII Airborne Corps

Col. J. T. Little, G-3, Special Warfare Center; Capt. D. E. Keen, Signal Officer, Special Warfare Center; Mr. Taylor, Deputy Signal Officer, Special Warfare Center

Major J. T. Bell, Signal Officer, 7th Special Forces Group (Airborne); Captain Ferguson, Signal Officer, 5th Special Forces Group (Airborne)

Sgts. First Class Richardson, Hardin, Noah, McCaskey, Beube, Hogan, Communications Committee, Special Warfare Training Group (veterns with combat experience in Vietnam, Laos, Taiwan, Okinawa, Iran, Philippines, and Burma)

Col. McMillan, Airborne; and Mr. J. C. White, Senior Scientist, both of Electronic and Special Warfare Board

Mr. Charles Sverigan, Materiel Requirements Division, Special Warfare Combat Development Agency

8. During 8 to 11 May Mr. A. J. Mandelbaum and Mr. W. R. Roberts visited the following at the U.S. Army Electronics Research and Development Labs., Ft. Monmouth, New Jersey.

Major General Stuart B. Hoff, C.G., Army Electronic Command, AMC

Brig. Gen. Lotts, Deputy C.G., Army Electronics Command

Col. James Kimbrough, C.O. USAERDL

Mr. Robert Kulinyi, USAERDL

Mr. Howard Kitts, USAERDL

Mr. George Watts, USAERDL

The Annapolis and Ft. Bragg field trips were reported upon; the test program was discussed; the projected psycho-acoustic test program and system evaluation techniques were explained; and characteristics of equipments being developed or considered at USAERDL for tropical tactical use were reviewed.

9. On 26 and 27 May Mr. W. R. Vincent visited Colonel H. E. Tabor at ARPA.

10. During the month of June Mr. W. R. Vincent, Mr. A. J. Mandelbaum, and Mr. W. R. Roberts visited Bangkok on project business and the latter two acted as observers at the SEATO Exercise held in Thailand.

11. From 17 to 21 June H. L. Kitts, and R. A. Kulinyi of Fort Monmouth and Lt. Colonel Jones of ARPA visited the Institute to discuss project business.

12. During 9 to 12 July Mr. A. J. Mandelbaum and Mr. W. R. Roberts visited Hq. Far East Land Forces (FARELF), British Commonwealth, Singapore. Personnel interviewed included: Lt. Col. G. J. Moss, Signal Officer, FARELF; Mr. K. R. Wilson and Maj. N. B. Moss, Directorate of Operations Science and Research.

The experiences of British forces in jungle operations in Malaya, North Borneo and Brunei against communist insurgents and guerrilas, together with associated tactical communications problems and solutions, were reviewed in considerable detail. Classified documents covering British radio communications

research and findings for jungle operations in Malaya, were requested, and subsequently delivered to Operations Analysis Department, Stanford Research Institute.

Discussions were also held with Dr. C. Clark, University of Singapore, on ionospheric and prevailing noise characteristics in tropical areas.

13. During the week of 22 July 1963 Colonel H. E. Tabor and R. C. Phelps of ARPA visited the Institute.

14. On 3 August 1963, George Watts, USAELRDL, visited the Institute on project business before leaving for Bangkok.

15. During the week of 5 August H. P. Blanchard, A. J. Mandelbaum, and W. R. Vincent visited Colonel H. E. Tabor of ARPA and Mr. Robert Kulinyi and Mr. Howard Kitts of USAELRDL in Washington to present a proposed project program.

16. Mr. Vincent travelled to Bangkok the week of 12 August to coordinate project activity.

17. From 18 to 21 August T. S. Cory visited USAELRDL, Fort Monmouth, Naval Research Laboratory, Washington, and the Office of the Chief Signal Officer, Washington, to discuss antenna work being conducted on the project.

18. On 20 August 1963, R. S. Kulinyi, USAELRDL, visited D. R. Scheuch, H. P. Blanchard, and T. S. Cory at the Institute to discuss project business

V IDENTIFICATION OF KEY PERSONNEL

Mr. Robert E. Leo arrived in Bangkok 15 July 1963 to assume technical direction of the Tropical Communication Laboratory.

For the Period 1 March through 31 August 1963	Hours Charged to the Project
C. Barnes, Development Engineer Communication Laboratory	159
H. P. Blanchard, Assistant Director Electronics and Radio Sciences Division	64
T. S. Cory, Research Engineer Communication Laboratory	466
A. S. Dennis, Physicist Aerophysics Laboratory	39
A. W. Fuller, Development Engineer Support Services Group	1,000
P. H. Gaver, Program Manager Operations Analysis Department	91
G. H. Hagn, Research Engineer Communication Laboratory	229
G. D. Koehrsen, Project Administrative Assistant Communication Laboratory	1,040
R. E. Leo, Technical Director Communication Laboratory	360
A. J. Mandelbaum, Operations Analyst Operations Analysis Department	340
A. J. Peterson, Assistant Director Electronics and Radio Sciences Division	15
E. T. Pierce, Staff Scientist Communication Laboratory	97
R. A. Rach, Assistant Manager Communication Laboratory	275

For the Period 1 March through 31 August 1963	Hours Charged to the Project
W. R. Roberts, Operations Analyst Operations Analysis Department	264
W. R. Vincent, Manager Communication Laboratory	682
G. S. Wiley, Manager Operations Analysis Department	97

Barnes, Cecil, Jr. - Development Engineer, Communication Laboratory

Mr. Barnes received a B. S. degree in Electrical Engineering from Harvard University in 1936. Following service in the U. S. Merchant Marine, and some experience in business and teaching, he served as a Radar Officer in the U. S. Navy from 1942 to 1946. From 1946 to 1950 he was a Radio Engineer with United Air Lines, working on equipment evaluation and modification design.

Mr. Barnes joined the staff of Stanford Research Institute in 1950. His work here has included the design of ADF flush antennas, flame attenuation measurements, radio and radar tracking of earth satellites, and full-scale HF antenna pattern measurements.

Mr. Barnes is a member of the Scientific Research Society of America.

Blanchard, Henry P. - Assistant Director, Electronics and Radio Sciences Division

Mr. Blanchard's work, in addition to his general Division responsibilities, has concerned weapons systems analysis, long-range navigation and guidance systems, low-frequency radio phenomena, low-silhouette antennas, VOR (omnirange) for helicopters, VHF homing systems for small aircraft, intelligence data acquisition and processing systems, technical intelligence studies, field programs involving operations at locations outside of the United States, and the establishment of requirements for command control communications.

For eleven years before joining the staff of the Institute in 1953, Mr. Blanchard taught in the undergraduate and graduate electrical engineering programs, emphasizing communications and circuits, at Stanford University. During this period, he developed a microwave signal generator and directed research on long-range navigation and guidance systems for the Air Force. Earlier, he had been with the Pacific Telephone and Telegraph Company, and with the California Railroad Commission.

Mr. Blanchard received the degrees of B. A. and Engineer in Electrical Engineering from Stanford.

He is a member of the Institute of Radio Engineers, as well as the IRE Professional Groups on Aerospace and Navigational Electronics, Antennas and Propagation, Circuit Theory, and Information Theory, and Sigma Xi.

Cory, Terry S. - Research Engineer, Communication Laboratory

Mr. Cory obtained B. S. and M. S. degrees in Electrical Engineering in 1958 and 1959, respectively, from North Dakota State University. Subsequently, he spent six months at Fort Monmouth, New Jersey, where he attended the basic signal officer school and worked temporarily in the solid-state devices group at USASRDL.

In January of 1960, Mr. Cory joined the antenna research facility of Collins Radio Company in Cedar Rapids, Iowa, where he participated in programs involving the design and development of log-periodic antenna structures. He was instrumental in the development of the Collins vertically polarized monopole array. In the spring of 1961, Mr. Cory served on a study group under the direction of AFCRC which was considering transportable air traffic control systems including HF point-to-point to tie into globecom systems.

In the fall of 1961, Mr. Cory left Collins for graduate work at Stanford University. In June 1962, he joined the staff of Stanford Research Institute. He received the degree of Engineer in Electrical Engineering from Stanford in June 1963.

At SRI, Mr. Cory has participated in programs with NEL and BuShips implementing antenna selections for use with sounders. He has conducted research on the aperture-blocking effect of multiple feeds in the high-frequency Luneberg on HF and UHF antennas suitable for satellites. Currently, Mr. Cory is conducting research to develop a new class of tactical communication antennas suitable for use in jungle environments.

Mr. Cory is a member of the Institute of Electrical and Electronics Engineers.

Dennis, Arnett S. - Physicist, Aerophysics Laboratory

Dr. Dennis joined the staff of Stanford Research Institute in September 1960 on a part-time basis and became a full-time employee in April 1961. He is primarily concerned with the effects of weather conditions on the performance of radar sets and radio communications systems.

In 1955 Dr. Dennis joined the staff of the Weather Modification Company of San Jose, California. He has been a Director of the company since 1956 and was Vice-President from 1956 to April 1961. During this period he was responsible for the conduct and evaluation of the company's rainfall-increasing and hail-suppression experiments, which were scattered over nine states, including California.

Dr. Dennis was graduated from Acadia University at Wolfville, Nova Scotia, Canada, with honors in Physics, in 1949. From 1949 to 1951 he was employed by the Meteorological Service of Canada as an aviation meteorologist at various Royal Canadian Air Force stations. He did postgraduate work in Physics at McGill University in Montreal and received an M. Sc. degree in Physics in 1953 and a Ph. D. degree in 1955. During the summers he did research work for the University in radar meteorology and for Bell Telephone Laboratories at Murray Hill, New Jersey, in transistor development.

Dr. Dennis is a Professional Member of the American Meteorological Society. He has had scientific papers published by the American Meteorological Society and by the American Society of Civil Engineers.

Fuller, Alfred W., Development Engineer - Equipment Engineering Group

Mr. Fuller's early experience included work as an engineer in a broadcasting station, as a foreman in the Exhaust Department of Heintz and Kauffman Company, and as a final test inspector for airborne radar antennas for Dalmo Victor Company. Following World War II, he engaged in design, construction, and installation of mobile transmitter-receivers for police and fire departments and for private aircraft. Prior to joining the staff of Stanford Research Institute in 1949, he had his own company, installing and maintaining communications equipment.

Mr. Fuller's work at the Institute has been concerned with the design and construction of single-side-band transmitters, computers, electronic surveillance equipment, systems monitoring equipment, and equipment for gathering weather information.

Gaver, Pierce H., Jr. - Senior Operations Analyst,
Operations Analysis Department

Mr. Gaver is presently directing a study group involved in research on future communication requirements for the command-control functions of the military services. This work includes communications traffic analysis and operational-communications planning for limited and nuclear war in 1965-1970.

Mr. Gaver has participated on a research team on the future requirements for sea-based deterrence systems of the 1965-1970 era.

As an Operations Analyst for the Management Sciences Department in the Economics Research Division, Mr. Gaver has directed and conducted studies in the evaluation of weapon and environmental communication systems availability, particularly with respect to leadtimes for development, procurement, and deployment of these systems.

Mr. Gaver attended the University of Maryland and received a B. S. degree in Engineering from the United States Military Academy (1948). Advanced military studies have included Russian language and area studies; the Officers' Guided Missile Specialists' course, Fort Bliss, Texas; the Special Weapons course, Fort Leavenworth, Kansas; and the Officers' Advanced Artillery course. Mr. Gaver has done graduate work toward an M. A. degree in History. He is an honors graduate of the Industrial College of the Armed Forces correspondence course, "Economics of National Security."

Before joining the staff of Stanford Research Institute, Mr. Gaver served in the United States Army from 1948 to 1956. His military service included tours of duty as instructor on the Corporal missile and instructor in surface-to-air missile tactics at the Antiaircraft Artillery and Guided Missile School, Fort Bliss, Texas; administrative officer and instructor at the Chemical-Biological-Radiological School in Germany; instructor at

the Mutual Defense Assistance Pact School, Germany; and artillery battery executive and reconnaissance officer.

Hagn, George H. - Research Engineer, Communication Laboratory

Mr. Hagn received a B. S. degree in Electrical Engineering from Stanford University in 1959. While a student, he worked for Stanford Research Institute two summers, becoming a member of the staff in September 1959. He earned an M. S. degree in Electrical Engineering from Stanford University in 1961, under their Honors Co-operative Program. While at Stanford he also participated in a student teaching program. Mr. Hagn attended the 1961 Radio Propagation Course of the Graduate School of the National Bureau of Standards, Boulder Laboratories.

At the Institute his work has involved the measurement and analysis of ionospheric phenomena, microwave diffraction, and the scattering of HF radio waves from the earth's surface. He has also conducted airborne antenna pattern measurement programs at HF and microwave frequencies.

Mr. Hagn is a member of the Institute of Radio Engineers and an associate member of the American Geophysical Union.

Koehrsen, Glenn D. - Administrative Assistant, Communication Laboratory

Mr. Koehrsen attended Iowa State University in 1956-1957 and City College of San Francisco in 1957-1958. In January 1963 he received a B. A. degree in Mathematics from San Jose State College, with work in Industrial Administration. In 1953 to 1956 he had served in the U. S. Navy. During that period he attended a six-month Electronics Technicians School, specializing in communications.

In April 1958 Mr. Koehrsen joined the staff of Stanford Research Institute. Among the projects on which he worked as an Electronics Technician and later as a Student Engineer were one concerned with design and construction of VLF satellite receivers; the construction of a specially designed astrometric camera for Lick Observatory, for which he built the control unit; and the establishment of the data reduction facility for the Communication Laboratory. For the latter project he screened and hired personnel, coordinated the procurement of data processing machines, and established procedures on data handling equipment.

Leo, Robert E. - Project Technical Director
Communication Laboratory, Bangkok

Mr. Leo received a B. S. degree from the California Institute of Technology in 1945 and an M. S. degree from Stanford University in 1955, both in Electrical Engineering.

From 1941 to 1946 he served in the U. S. Navy in the communications field, becoming an Instructor upon receiving his commission as an Ensign. The following year he worked for the Civil Aeronautics Administration, involved with receiver, terminal equipment, and high-power transmitters. In 1947-1948 he was a member of the Gatti-Hallicrafters Expedition in British East Africa, responsible for communications. From 1948 to 1950 he worked for the Arabian-American Oil Company in Saudi Arabia, as a Communication Station Supervisor and as an Electrical Engineer in the Geological Group.

In 1951 Mr. Leo joined the staff of Stanford Research Institute as a member of the Communications Group. Later he was associated with the Digital Group of the Computer Laboratory. Among the projects in which he participated were projects dealing with maintenance minimization for radar equipment, single-sideband equipment, and the ERMA computer program. In the summer of 1957 he made a survey for the Institute of 28 industrial, government, and university computer groups in six European countries.

In 1958 Mr. Leo became associated with the Advanced Development Laboratory of the General Electric Company, Palo Alto, as a Design Engineer for digital equipment. In 1959 he transferred to the G. E. Computer Department in Phoenix, Arizona, where he was a Senior Design Engineer and Project Engineer for special-purpose digital computer controls.

In 1961 Mr. Leo became an Assistant Professor of Electrical Engineering at Montana State College, a Research Associate of Electronics Research Laboratory, and a consultant for Montronics, Inc., Bozeman, Montana. At Montana State, he was project leader for experiments in meteor-burst communications and high-frequency direction finding.

During a year's leave of absence from Montana State, Mr. Leo is directing the technical program at the Communication Laboratory in Bangkok.

Mr. Leo is a member of the Institute of Electrical and Electronics Engineers and the IEEE Professional Technical Groups on Computers and on Communication. He is a registered Professional Engineer in the State of California and a Lieutenant Commander in the U. S. Naval Reserve. He holds three Federal Communications licenses: Radiotelephone First Class, Radiotelegraph Second Class, and Amateur Radio Station K7KOK.

Mandelbaum, Albert J. - Operations Analyst,
Operations Analysis Department

Since his association with Stanford Research Institute, Mr. Mandelbaum has been engaged in research and analysis of requirements, current and future, of world-wide strategic military communications systems with particular emphasis on the technical and military factors, as well as on new concepts in the conduct of future war as these affect future communications requirements and improvements.

Mr. Mandelbaum received a B. S. degree from the United States Military Academy, West Point, New York in 1930. Commissioned in the Signal Corps Regular Army, he served as a Unit Signal Officer until 1936, when he attended and graduated from the Advanced Officers' Course, U. S. Army Signal School, Fort Monmouth, New Jersey. Being retained thereafter in the faculty of the Signal school, he specialized in Signal Corps tactics and mobilization planning until 1940. Upon the outbreak of World War II, he became Signal Officer, Sixth Army Air Force, Carribean Theatre, and planned and directed the installation of a very extensive radio and land-line communications systems connecting all U. S. military airfields from Mexico through Latin America to Peru, and along the Antilles to Dutch Guiana. Subsequent to 1943, Mr. (then Colonel) Mandelbaum assumed command of the 4th Army Airways Communication Wing, serving over 135 airfields and other Air Force installations in the China, Burma, and India Theater. Here, he planned and directed the installation and operation of extremely complex radio communication and radio air navigation systems pertaining to Air Traffic Control especially over the densely travelled "Over the Hump" air routes of the Himalayas traversing India, Burma, and China.

In 1946, Colonel Mandelbaum attended the Command and General Staff College, Fort Leavenworth, Kansas. Upon graduation, he commanded the

Signal Corps Publications Agency concerned with the preparation of technical texts and manuals for new Signal Corps equipment. In 1948 he became Assistant Commandant of the U. S. Army Signal School. During this period he attended the Advanced Management Program Course at the Harvard Business School. He then served in the Office of the Chief Signal Officer, as Chief of Personnel and Training. With the Korean War he was assigned to the Office of the Assistant Chief of Staff for Logistics in the Procurement Division. In 1953 Colonel Mandelbaum graduated from the Industrial College of the Armed Forces. Thence he assumed command of the Electronic Warfare Center of the Signal Corps, where he directed research and military exercises in electronic countermeasures. In 1955 he was transferred to Supreme Headquarters Allied Powers Europe, Paris, to become Chief, Telecommunication Branch of the Signal Division. Here he initiated and monitored the implementation of ACE HIGH, the world's largest forward scatter system, for NATO Europe. Here also he planned and implemented the Alert and Atomic Strike Communications System for Allied Command Europe. In 1958 Colonel Mandelbaum returned from foreign service to become Signal Officer, Fifth U. S. Army, Chicago, Illinois, during which period he supervised the construction of the Midwest Relay Center, a modern, complex, fully automatic switching center. In 1960 he retired from the Signal Corps and joined the staff of Stanford Research Institute.

Mr. Mandelbaum is a registered Professional Engineer of the State of Colorado; a Director, San Francisco Chapter, of the Armed Forces Communications and Electronics Association, and a member of the Society of American Military Engineers.

Peterson, Allen M. - Assistant Director, Electronics and Radio Sciences Division

Dr. Peterson attended San Jose State College from 1940 to 1942. He was a member of the Electronics Group of the Sacramento Air Service Command from 1942 to 1944 and from 1944 to 1946 was on active duty with the U. S. Army Air Force.

From the Department of Electrical Engineering at Stanford University he received a B. S. degree in 1948, an M. S. degree in 1949, and a Ph. D. degree in 1952. Since 1947 Dr. Peterson has been a staff member of the Radioscience Laboratory at Stanford. He is currently Professor of Electrical Engineering, Assistant Director of the Electronics and Radio Sciences Division, and Co-Director of the Stanford Center for Radar Astronomy.

In 1953 Dr. Peterson joined the staff of Stanford Research Institute, where he has been engaged in research on radio propagation, communications, and radio systems design.

He is serving as a consultant to the following:

The President's Science Advisory Committee

Advanced Research Projects Agency

Operations Evaluation Group (Office of the Chief of Naval Operations)

Defense Atomic Support Agency

Air Force Science Advisory Board

Institute for Defense Analyses

In 1959 Dr. Peterson received the Achievement Recognition Award of the Seventh Region of the Institute of Radio Engineers.

Dr. Peterson is a Fellow of the Institute of Electrical and Electronics Engineers and a member of the IEEE Professional Technical Groups on Antennas and Propagation, on Electronic Computers, and on Information

Theory; the Scientific Research Society of America; Sigma Xi; the Society for Industrial and Applied Mathematics; and Commission 3 of the Union Radio Scientifique Internationale. He was a member of a National Science Foundation Panel charged with planning and reviewing auroral and ionospheric research programs conducted during the International Geophysical Year. Dr. Peterson is the author or co-author of over fifty papers in the fields of communications, radio propagation, and upper atmospheric physics.

Pierce, Edward T. - Staff Scientist, Communication Laboratory

Dr. Pierce received a B.S. degree in Mathematics in 1937 and a B.S. degree in Physics in 1938, both from the University of Wales, Great Britain, and with the grade of summa cum laude. He received a Ph.D. degree in Physics from the University of Cambridge in 1950.

From 1939 to 1946 he was an officer with the British Ministry of Supply, particularly concerned with aircraft armament. In 1946 Dr. Pierce joined the faculty of the University of Cambridge; initially, he was at the Observatories, but in 1950 was appointed a University Teaching Officer at the Cavendish Laboratory. At Cambridge Dr. Pierce supervised research in the fields of atmospheric electricity, cloud physics, atmospherics and the propagation of long radio waves, and solar physics.

In 1957 Dr. Pierce joined Vickers-Armstrong (Aircraft) Ltd. Here he worked on problems in atmospheric physics, gas discharges, and high voltage effects. After moving to the United States, Dr. Pierce was with AVCO Manufacturing Corporation from January 1959 as a Senior Staff Scientist engaged in research in various areas of geophysics. In October 1960 he joined the staff of Stanford Research Institute. At the Institute his work has included studies of the lightning discharge as a plasma and as a source of atmospherics; propagation at very-low frequencies; the formation of the ionosphere; disturbances of the ionosphere by natural or artificial agencies, and their influence on communication; and the general geophysical effects of nuclear explosions.

Dr. Pierce has published, as author or co-author, over forty scientific papers.

Dr. Pierce is a Fellow of the Royal Astronomical and Royal Meteorological Societies, having served on the Council of the latter society. He is

also a member of Commission III of the U. S. Committee for the International Union of Scientific Radio (URSI), the American Geophysical Union, and the Scientific Research Society of America.

Rach, Robert A. - Assistant Manager, Communication Laboratory

Mr. Rach received a B. A. degree in Astronomy from the University of California in 1950. He worked at Lick Observatory from 1950 to 1951 as an Observer. From 1951 to 1953 he served with the U. S. Army as a Field Instrumentation Officer and later, in Korea, as Commanding Officer of a Topographic and Meteorological Unit. From 1953 to 1956 he was a graduate student and later Lick Observatory Fellow in Astronomy at the University of California. At Lick Observatory he was concerned with position measurement of stars and spectrographic studies.

In May 1956 Mr. Rach joined the staff of Stanford Research Institute, where he has been engaged in studies of propagation and communication systems and in evaluation of communication networks. Among the projects on which Mr. Rach has acted as leader were projects on telemetry propagation problems connected with missile re-entry, HF propagation prediction by digital computer techniques, digital simulation of the performance of HF communication networks in a normal and jamming environment, and real-time control of world-wide communication networks. Mr. Rach is currently pursuing additional problems in the areas of network vulnerability, planning techniques, network control, HF sounding, backscatter radar, nuclear effects, and satellite communication systems.

Mr. Rach was appointed Assistant Head of the Communication Group in March 1959 and Assistant Manager of the Communication Laboratory in 1962.

Mr. Rach is a member of the Scientific Research Society of America and Sigma Xi.

Roberts, William R. - Operations Analyst, Operations Analysis Department

Mr. Roberts is presently engaged in engineering research directed toward the evaluation and improvement of speech communication systems, with particular emphasis on those systems that are secure voice systems.

Mr. Roberts received a B. S. degree in Mathematics from Trinity University in 1949, with a minor in Physics. After his discharge from the United States Marine Corps in 1954, Mr. Roberts worked for the City Public Service Board of San Antonio, Texas, where, as a Budget and Statistical Engineer, he prepared statistical analyses of various features of electrical utility service with respect to loads, distribution networks, and construction costs.

In 1956-1957, Mr. Roberts spent a year with the Core Laboratories of Dallas, Texas, as a Junior Engineer. His duties included the extensive analysis of rock samples for porosity, saturations, and permeability. He also prepared estimates of the feasibility of oil production at specified sites.

Mr. Roberts joined Lenkurt Electric Company of San Carlos, California in 1957, as a Design Engineer. In this capacity he was responsible for developing the concept and design of packaging plans for active and passive networks on various communications systems.

During 1959, Mr. Roberts was employed by the Boeing Airplane Company of Seattle Washington, as a Design Engineer. At Boeing he specialized in manufacturing and packaging techniques for the Minuteman sequence and monitor launch system. He also worked extensively on the console designs for Minuteman.

At the end of 1959, Mr. Roberts joined the ITT Federal Laboratories of Palo Alto, California, as a Senior Member of the Technical Staff. As Project Manager, Mr. Roberts was responsible for several projects

involving speech communication systems utilizing bandwidth and amplitude compression devices. He was directly responsible for the development and application of psychophysical techniques used for the evaluation of speech systems considered for Project 480L AIRCOM, the USAF Global Communication System. This development included an experimental design such that the obtained results could be reproduced with a high degree of statistical validity. He was also responsible for the development of experimental procedures designed to measure the amount of prosadic information imposed on the phonetic code during speech transduction and transmission, i.e., the amount of information retained by a speech communication system with respect to talker identity, intent of message, emotional status, etc.

He is the author of a paper entitled, "A Judgmental Method for A Voice Communication System Evaluation," published in the 1961 IRE International Convention Record.

Vincent, Wilbur R. - Manager, Communication Laboratory

Mr. Vincent received a B. S. degree in 1947 and an M. S. degree in 1951, both in Electrical Engineering from Michigan State College. He was a Radio Technician in the U. S. Signal Corps, installing and servicing radio-teletype installations in the Pacific, from 1943 to 1946. In 1948 he joined the Electronics Staff of the Bell Aircraft Corporation as a unit leader in charge of missile communication equipment development.

In October 1955 Mr. Vincent joined the staff of Stanford Research Institute. As a Research Engineer he was engaged in work on meteor-burst communication, auroral-zone communication, and associated communication and propagation studies. He conducted extensive studies and field experiments on the propagation path provided by ionized meteor trails and assisted in the setting up of the Stanford-Montana State College meteor-burst communication system, the first such system to operate in the United States.

Mr. Vincent was appointed Assistant Group Head of the Communications and Propagation Group in 1957, Head of the Communication Group of the Communication and Propagation Laboratory in 1958, and Manager of the Communication Laboratory in 1962. He has conducted studies of communication network analysis, optimum utilization of large imperfect communication networks, the use of electronic computers to solve radio propagation problems and communication network problems, satellite communication, improvements in high-frequency radio, and other related problems.

Mr. Vincent is the author of several papers in the field of communication and radio propagation.

Mr. Vincent is a member of the Institute of Radio Engineers and a member of the IRE Professional Groups on Circuit Theory, on Communication Systems, and on Antennas and Propagation.

Wiley, Gordon S. - Manager, Operations Analysis Department

Mr. Wiley joined the staff of Stanford Research Institute in 1954. His work has been concerned with operational analysis of complex systems including military weapons systems, command-control-communication systems, and air-traffic-control systems. He has directed and performed operations analysis on such diverse problems and systems as helicopter navigation requirements, mine field techniques for low-altitude defense, operational environment of U. S. striking forces, and continental air and anti-missile defense systems. Mr. Wiley served as a member of the DOD R and E (communications) panel on Communication Switching. He is currently concerned with study activities of national strategic command-control- communication systems, field army air defense weapons, and interpretive intelligence to provide criteria for system evaluation. As the program supervisor for the SRI Research Office, U. S. Army, CDEC, he provides direction to the scientific design and analysis of field experimentation on advanced warfare techniques.

Mr. Wiley received a B. S. degree in Electrical Engineering from the U. S. Naval Academy in 1941. From 1941 to 1954 he was an officer in the U. S. Navy, attaining the rank of Commander. During this time he attended the Radar Courses of the Radiation Laboratory of the Massachusetts Institute of Technology, the Naval Research Laboratory, and Camp Catlin, T. H., followed by three years as a Radar and CIC Officer. He qualified as a naval aviator, attending the All-Weather Flight School and later the Tactical Air Control School while serving in various aircraft squadrons. He took the Naval War College courses in Intelligence, Logistics, and Strategy and Tactics. He served on the staff of the Chief of Naval Air Technical Training as Training Officer, responsible for instructor training, training methods, and curriculum content involving thirty-two technical schools and the Naval Air Mobile Training Units program. He later attended the

Guided Missile School, Fort Bliss, Texas. Mr. Wiley served with the Operational Development Force as Project and Operations Officer of a squadron performing analysis and evaluation of weapons systems and tactics. He was assigned to the staff of the Director of Guided Missiles, Office of the Chief of Naval Operations, with responsibilities for formulating operational requirements and program management of guided-missile weapon systems.

Mr. Wiley is a member of the Operations Research Society of America, the U. S. Naval Institute, the Scientific Research Society of America, and the California Academy of Sciences and is listed in American Men of Science. He holds a commercial pilot's license with instrument rating.

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