

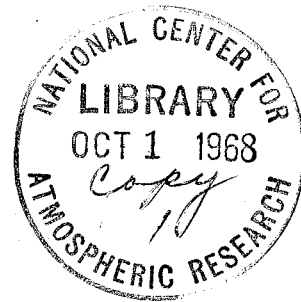
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NCAR-TN-30

Operational Lessons of the Line Islands Experiment

Line Islands Critique
5 May 1967
Pineapple Research Institute
University of Hawaii

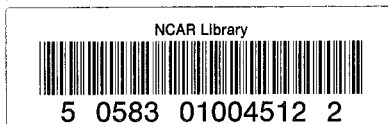
August 1967



NCAR Technical Notes

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
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- To ascertain the feasibility of controlling weather and climate, to develop the techniques for control, and to bring about the beneficial application of this knowledge;
- To bring about improved description and prediction of astrophysical influences on the atmosphere and the space environment of our planet;
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University of Colorado	University of Minnesota	University of Utah
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PREFACE

During March and April 1967, field parties from NCAR and other meteorological research organizations, universities, and governmental agencies established research bases in the Line Islands, a group of small atolls more than 100 miles south of Hawaii. Some 80 to 100 people -- scientists and construction and support personnel -- were in the Line Islands during the period of the Experiment. Quarters were established and research facilities set up in World War II barracks on Palmyra Island, in a recently abandoned Air Force camp on Christmas Island, and on Fanning Island in an old cable station now leased for a research base by the University of Hawaii.

From these three islands and from aircraft and ships in the vicinity, observation groups collected one of the most comprehensive sets of meteorological data ever obtained in the tropics. These data are tied in with photographs taken by NASA's ATS-1 satellite, in synchronous orbit almost directly above the Line Islands; they include observations of standard meteorological parameters, made with conventional instrumentation, and a great abundance of still and motion photographs. Data are now being catalogued and will be made available to interested scientists as soon as possible.

Because the Line Islands Experiment was in many ways a pilot program, and because participants felt future large field experiments, particularly in remote areas, could profit from their experiences, representatives of the groups involved met in Hawaii on 5 May for an introspective review of their venture. The Hawaii discussion was recorded by stenotypists, and is reproduced here with paraphrasing necessary for clarity, and deletion of repetitive or unrelated material. It is hoped that the meanings of the various speakers have been clearly expressed.

In order to release this material rapidly, not all speakers have been consulted about changes in wording. If meanings are significantly changed, and speakers will notify those responsible for this publication, correction sheets will be circulated.

SUMMARY

Because of the desirability of carrying out the Line Islands Experiment during the functional lifetime of the ATS-1 satellite, many aspects of the Experiment were organized in haste. The most salient points brought out in the discussion revolve around the desirability of more lead time and more careful basic planning. Those involved in support activities felt that greater advance warning, and more exact planning on the part of the scientific participants, would enable support groups to function more efficiently. Military groups expressed the need for several months of firm advance plans in order to obtain necessary clearances. However, it was brought out that scientific procedures, by their very nature, require a large degree of flexibility in operational planning, and emphasis was placed on the importance of keeping the scientific purpose of the Experiment always uppermost.

Support groups felt that their personnel were overworked, and suggested a one-third increase in number. The scientific groups felt that an increase in personnel relative to purpose would have been appropriate, as recreation and rest time were minimal.

The desirability of careful site evaluation was pointed out. It became clear in the discussion that use of pre-existing facilities, even if they need thorough rehabilitation, can often be advantageous. An evaluation survey team should go carefully into the effects of decay and neglect, especially of vital power, water, and communications systems. Obviously, pre-established, functioning quarters are desirable when available.

It was recommended that construction or rehabilitation of living sites should precede arrival of scientists, but as soon as accommodations are ready, scientists should be brought in to advise in siting and setting up scientific equipment.

Line Islands personnel emphasized the importance of labeling all equipment and materiel packages as to contents and destination. They pointed out that time should be allowed to load barges and aircraft carefully so that first necessities -- particularly those needed for unloading and building -- would be available first. A time and budget planning network such as "Critical Path Method" (CPM) planning was strongly recommended as a means of obtaining estimates of both time and cost for logistic phases of an experiment. The logistics group felt that the frequency of supply trips could be reduced by such planning. The use of professional planners and contractors with experience in the area involved was also recommended.

Communications, although adequate for the basic needs of this program, left much to be desired. It was thought that communications between remote groups and headquarters, and with aircraft, should receive greater emphasis. The logistic community felt they could have functioned more advantageously if they had been kept completely informed of scientific aims and of changes in any phases of the program.

Heavier aircraft were recommended, and it was suggested that an operative standby plane be available at all times when other research or support planes were in the air, in case of emergency. The use of professional navigators was strongly recommended for experiments in remote ocean areas, as was the use of more powerful homing devices and associated aircraft instrumentation.

The need for a staff doctor was recognized and a doctor joined the expedition early in the program. In spite of the tropical environment and some doubts as to water supply, the health of the group remained excellent.

It was brought out that the effects of salt spray on instruments had been underestimated, and that constant efforts to protect instruments would be well advised.

Although participants noted these various ways in which the program could have been improved, the overall scientific goals of the Line Islands Experiment were attained. Each group fulfilled its responsibilities and all were pleased with the results. The success of this pilot program was due in large part to the great degree of flexibility of the many individuals involved, and to their ability to apply hard work and ingenuity to the tasks at hand.

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I. GENERAL SESSIONPARTICIPANTS

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Joseph Abreu (Holmes and Narver)
Ray Belknap (ESSA, Weather Bureau)
Robert Berg (Holmes and Narver)
Cleon Biter (NCAR)
William A. Bonnet (Atomic Energy Commission)
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- Charles T. Leeds, Jr. (Holmes and Narver)
- Maj. J. Misterly (Air National Guard), not present
- Loyd Newcomer (NCAR)
- Dr. James W. Osmun (ESSA, Weather Bureau)
- Lou Owen (Holmes and Narver)
- Col. William Pendleton (Air National Guard)
- Dr. Colin S. Ramage (University of Hawaii)
- Meridith C. Riddle (Hawaiian Tug and Barge Co.)
- Lcdr. W. S. Riley (USN, CINCPACFLT)
- CMSgt. John T. Schumacher (USAF Air Weather Service)
- Paul Sears (NCAR)
- Gerald E. Shafer (University of Hawaii)
- Maj. Arthur Streim (Air National Guard)
- Ronald Taylor (University of Hawaii)
- Jack D. Tefft (NCAR)
- William Thoene (Naval Supply Center, Pearl Harbor)
- Lt.Col. James E. Thompson, Jr. (USAF Air Weather Service)
- Dr. Henry van de Boogaard (NCAR)
- Dr. Martin Vitousek (University of Hawaii)
- Capt. Daniel M. Whipp (U.S. Coast and Geodetic Survey), not present
- Dr. Edward Zipser (NCAR)

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DISCUSSION

Dr. Daniel Rex (NCAR), after calling the meeting to order and expressing his gratitude and that of Dr. Roberts and UCAR, narrated briefly the history of the Line Islands Experiment:

REX: A little less than nine months ago a group of university scientists got together quite informally at Boulder, Colorado, to discuss some of the missing links in atmospheric knowledge. They were particularly looking ahead to a program called GARP, the Global Atmospheric Research Program planned for the mid-1970s. We hope that GARP will provide some of the building blocks for a utopian weather system, in which everything is known and everything falls into place, and generalized worldwide forecasts can be made quite far in advance.

The Line Islands Experiment has been the first exercise formally associated with GARP. The scientists meeting in Boulder nine months ago organized themselves into three committees or working groups. The group headed by Colin Ramage laid ground plans for the scientific objectives of the Line Islands Experiment and produced an outline which formed the basis for a request for National Science Foundation supplementary support.

This support was granted and made the Line Islands Experiment possible, but it was not until early in September 1966 that we got the go-ahead to "plan." This gave us only five months' lead time, for the field operations were to be conducted from the middle of February to the middle of April 1967. It would take something like a minor miracle to accomplish our objectives. However, we got the project together, with extensive help and excellent support from the military services, the AEC, our contractor Holmes and Narver, ESSA, and the university community.

The catalyst, the peg, let's say, that made the timing critical was the appearance of the ATS-1 satellite, which is stationed over the Line Islands area and which can take cloud pictures about once every

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twenty minutes. This series of cloud pictures is one of the most spectacular parts of the data. Both the satellite and the camera worked beautifully. A major purpose of the field exercise was to produce data to allow better interpretation of the satellite pictures.

So much for the history. We are all pleased with the results as they look from here. Ed Zipser has agreed to give us a run-down later on what we came back with; indications are that the data are excellent.

* * * * *

The purpose of this critique is to give us a chance to relate in one piece the support story of the Line Islands. We are going to be calling on most of the participants to say something about their part of the exercise. This is an opportunity to say what happened, and to point out what was right, and what was wrong, and how we might do things differently in future field experiments. Various groups are already looking ahead and planning more field work, associated again with GARP. Some groups will be starting this summer, in fact, working in the Caribbean area. Others are planning for 1969 and 1972 and perhaps 1975 -- the last two exercises will again be in the Pacific, probably further west, out in the Marshall Islands area.

With no further ado we can jump into the description of support activities of the Line Islands Experiment, and I will call on Sgt. Harrison to tell us something of the Army program.

HARRISON: The Director of Defense Research and Engineering, DOD, forwarded the National Science Foundation's letter of 3 November 1966 to the Assistant Secretary of the Army (R&D), who determined that the experiment was applicable to Southeast Asia problems and would contribute valuable information to the Army's program in tropical research. Thereupon the Commanding General, U.S. Army Materiel Command, requested the Director of the Atmospheric Science Laboratory, U.S. Army Electronics Command, Fort Monmouth, New Jersey, to provide the assistance requested by NCAR.

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The U.S. Army Meteorological Support Activity, Fort Huachuca, Arizona, was designated to furnish the necessary personnel and equipment for the project. This group established direct contact with NCAR on 20 December 1966. They provided 12 meteorological observers and one project officer, plus equipment and expendable supplies, for four surface observation sites and one double-theodolite site. NCAR's earlier request for a weather radar set was withdrawn, so this was not provided.

Army personnel left Fort Huachuca for Hawaii on 8 to 13 February. Three men went immediately to Palmyra by sea, as did four to Fanning (one of these later went to Christmas), and the project officer and five men stayed in Honolulu waiting for air transport to Christmas Island. While in Honolulu, Army personnel assisted NCAR by standing radio watches and helping procure support equipment. They also attended training in the special observational procedures to be used during the Experiment. The Christmas team left Honolulu on the Coast Guard C-130 aircraft on 27 February.

Surface weather observations began at Palmyra on 21 February, at Fanning on 27 February, and at Christmas on 2 March. An approximate total of 3864 hourly weather observations was obtained from the three islands. At least that many supplementary convective cloud observations were made to assist in interpretation of the satellite photographs and to aid in understanding the energy balance of the tropics.

Army observers also serviced and maintained automatic weather stations (Meteorological Research, Inc.) provided by NCAR, and various other meteorological instruments provided by the University of Hawaii and NCAR. Three of the MRI stations were installed and maintained on Christmas, and two on Fanning. Most sets were located to provide easy servicing, but the sets on Christmas Island required a 108-mi round trip every other day. The observers' vehicle used for changing shifts and bringing in observations for radio transmission averaged 120 mi a day. Trips to the most distant observing site were sometimes quite a

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feat, what with numerous flat tires and mechanical failures -- land crabs took the greatest toll of tires.

The MRI equipment performed in an excellent manner. There was some corrosion due to high salt spray levels, and some difficulty in removing yoke caps from anemometer heads. All other meteorological equipment held up well too, except some of that used on Christmas, where virtually constant 15 to 20 mph surface winds blow in large quantities of salt spray.

Installations for the double-theodolite boundary-layer study, on Christmas Island, were completed on 3 March; observations began on 5 March. The baseline established was 1000 m long rather than the desired one mile because of rough terrain and lack of a longer line of sight between the theodolites. Five-hundred-one observations were obtained, with angular readings every 20 sec during balloon ascent, to altitudes of 7000 ft except where clouds interfered. Serials, conducted for eight hours each, were scheduled to provide an equal number of day and night observations.

In addition to taking observations, Army personnel assisted in site operations and support functions on Christmas. They became quite proficient in operating various types of heavy equipment, loading, unloading, and refueling aircraft, operating radios, helping the cooks and medics, and even guiding visitors. There were more than a few of these on most weekends.

In summary, I would say the mission assigned to the Army participants during this program was accomplished. To my knowledge there were no unexpected personnel, health, or morale problems. Many compliments were received concerning our work and extra-curricular activities; these are appreciated by all concerned.

It has been a privilege for myself and my men to be associated with all of you. It is our hope that the Line Islands Experiment has been a successful endeavor and that future experiments in the TROMEX

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program will provide equally satisfactory results in all respects.

Thank you.

REX: Thank you. I wonder if there are any questions or additional information at this time.

LANTERMAN: In addition to the wealth of direct support from Fort Huachuca, we also had considerable assistance from the Army in Hawaii in obtaining field equipment and supplies.

REX: That is right. If there are no other remarks we can move ahead. I would like to ask Lcdr. Riley, USN, to say a few words about the Navy's contribution.

RILEY: I am stationed in the office of CINCPACFLT. The Navy, of course, is very interested in the Line Islands Experiment, as they stand to benefit from it. We were authorized to cooperate in every way we could. We had hoped to do a great deal more than we did. Our somewhat extensive fleet operations in the Pacific removed some of the men and equipment that might otherwise have been available. We had planned to have reconnaissance aircraft available during the entire period of the Experiment. They did start, I think, about 27 February, and were flying every other day, although there were some problems in coordination. On 5 March other commitments came up, and we had to stop flying. We hoped to come back later in the month, but this wasn't possible. There was also some negotiation about landing craft, but most of these are in use in Southeast Asia.

VR-21 Transport Squadron came through near the end of the current phase. They brought back sixty passengers and 49,000 lb of cargo. I am not sure that these figures are current but they were the ones given to me yesterday.

The Fleet Weather Center was also involved, and furnished surface charts on an hourly basis. They had also hoped to make operational use of the Line Islands research data, but the time lag made this impossible.

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This is about the extent of the Navy's participation. I certainly would like to make it clear that we have the authority and interest and eagerness to help in any way that we can.

REX: Thank you, Lcdr. Riley.

VITOUSEK: I would like to add that the Navy collected magnetic tapes of synoptic weather observations for the Pacific region from the middle of February to the middle of April. Copies of these tapes have been given to the University of Hawaii, and will form part of the source material for future analysis.

REX: Thank you. If there are no other comments, I would like to call on the Air Force. Lt.Col. Thompson will describe Headquarters Air Weather Service participation and support.

THOMPSON: I will limit my remarks to the aircraft operators and aircraft operation. Originally we had planned to use WC-130E aircraft from the 54th Squadron at Guam. Unfortunately, at the time of planning we did not know that Southeast Asia commitments would keep those aircraft fully occupied. We had to turn to the 57th Squadron here at Hickam. The 57th has done a remarkable job, I think. I have a member of the staff here who will tell you the details of the operations -- Maj. Chapple.

CHAPPLE: We got involved in operations about 11 or 12 March, via a telephone call from Dr. van de Boogaard. We had a meeting on 12 March to see what we could do to help you with B-47 aircraft. The B-47 is a tired old airplane and it doesn't have nearly the capability of the C-130. It is limited to 30,000 to 40,000 ft of altitude and 2700 to 3000 n mi range. But we did arrange a route to the area that would cover approximately 2700 n mi. We started flying on 14 March, and we are not finished yet: we have one up right now, we have three programmed for next week, and three for the week after that.

The total number of flights will be 28 if we get the other 7 in. To date, we have flown 136 hr and 5 min. Total flying time if we get in all the flights will be about 180 hr.

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We have taken 243 weather observations at altitude, including free-air temperatures and pressure height data. We have also taken over 460 still slides with cameras supplied by NCAR. We haven't seen these slides yet, but I understand that they are quite good. They were taken by the aircraft commander, who sits in the front seat -- if you have seen the B-47 with the circular dome. They are all amateur camera bugs in the front seat and they have had a lot of practice in photography. We also had O-15 cameras on the radar scope operated by the navigator.

The copilot is the weather officer aboard. He is not a qualified meteorologist; he is a copilot trained in observation by me. So if there is anything wrong with the observations come back and see me.

I have enjoyed working with Dr. Zipser and Dr. van de Boogaard. They have devoted a tremendous amount of their time to us; they attended most of our briefings and all of our debriefings to pick up films and observations and to talk to our people and extract every ounce of information that they could possibly get from our crew. Thank you.

FROM THE FLOOR: I might add that I have had considerable experience with research programs which included gathering data, and I thought that the Air Weather Service did an outstanding job of data gathering.

REX: Thank you. I would like to ask CMSgt. Schumacher to tell us something about the Air Weather Service rawinsonde support.

SCHUMACHER: I am with the 6th Weather Squadron, Tinker AFB, Oklahoma, an element of the Air Weather Service, USAF. We provide upper air and rawin soundings. We learned about mid-December that we were to participate in this project. Bob Kubara (NCAR) visited us on 21 January, at which time the complete support program was developed. Final decision was for three upper air sounding stations: one on Fanning, one on Palmyra, and one on Christmas.

A total of 26 AWS personnel participated in this project, with three GMDs and supporting equipment. Nine of our people were at Palmyra, eight at Christmas, and eight at Fanning.

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We took a total of 759 upper air soundings. Two per day at each site averaged approximately 90,000 ft. The rest were cut off at approximately 60,000 ft because of the frequency of our runs.

I was pleased with our part of the operation -- I think our men did a fine job in the Islands. I have enjoyed working with the NCAR people -- I really do believe that I have never worked with more dedicated people. This type of operation is not new to us; we are a mobile squadron and we hope to see you on the next go-around. Thank you.

REX: Thank you. Are there any questions?

ZIPSER: Sgt. Schumacher said that all he was doing was coordinating the program up here at Hickam. Actually, he got involved with just about everything that went on up here. If it hadn't been for him, a lot of things we needed we probably would not have been able to get, but he knew exactly where to go to get what was needed. I am saying these things at this point because I don't want the brevity of Sgt. Schumacher's presentation to mislead anyone. The sounding program is, in many respects, the backbone of the whole Line Islands program. The dedication that all of his men showed impressed me much more than the tremendous number of soundings that were taken and their quality, which were certainly all that we had hoped for.

REX: Col. Pendleton is here to tell us about the Air National Guard support, the backbone, in a sense, of our logistic plan.

PENDLETON: We are delighted to have had the opportunity to support this particular program. Those of us who fly are looking forward to greater and better things as far as forecasting the the weather is concerned. On the trip over here yesterday we had a -5 wind forecast and a +10 wind.

We have also enjoyed sending our crews into areas which are different from those we are used to supplying. As you know, our National Guard program is global in that we are attached to the Military Airlift Command. With today's commitments, we are practically on active duty incidental to our civilian pursuits.

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We flew eleven support missions down into the Islands. Our job is not complete yet. I understand that we have 16,000 or 17,000 lb of cargo that we are still to haul back state-side.

We flew a total of 412 flying hours, covering better than 96,000 n mi, carrying a total of 430,000 lb of cargo. We carried 400 passengers; passenger miles were in excess of 465,000.

Again I want to say that we have been delighted to support this program. Of course, a lot of our success in our mission was primarily due to Mr. Tefft. He met every aircraft that landed at Hickam, no matter what time of morning, night, or day. He did a tremendous job. Thank you.

REX: Thank you. Mr. Belknap will say a few words about ESSA participation.

BELKNAP: I am Executive Director of the Pacific Region of the Weather Bureau, part of ESSA. Our participation consisted of several efforts -- not commensurate in scale with our interest in the results of the studies and the data collected.

During the Line Islands Experiment, the Coast and Geodetic Survey ship Surveyor I was cruising in and around the Islands. There were Weather Bureau observers on board taking rawinsonde observations. I have no figures on the quantity of observations; I am sure that such information can be made available if you desire it.

It turned out that a Navy ship was going to be cruising through the Line Islands area at the right time and we managed to get a Weather Bureau observer on board. He made the cruise from Honolulu to Pago Pago and back, taking radiosonde observations every day.

We also made an effort to get some of the observations into meteorological channels in real time, as a cooperative effort between NASA and the Bendix people and our office on Canton Island. We tried to work in radio links so that some data would flow to Canton and then feed into the FAA circuit from Canton to Honolulu. I got the impression,

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from something said earlier, that some of these data did not get out in time to be used. I don't know where the difficulty was, but if there are future experiments of this type we should try to ask FAA for direct real-time communication for the observations. They have the facilities and equipment. I think that sums up what we tried to do.

REX: Thank you, Ray. Are there any general comments?

FROM THE FLOOR: The forecasting office at the International Airport gave us all sorts of maps as well as weather information. They did everything possible to make things easier for us.

REX: Thank you. Any other remarks?

We hoped to have Capt. Whipp here from the U.S. Coast and Geodetic Survey ship Surveyor, to say something about the Surveyor's part in the Line Islands Experiment, but he cannot be with us. Ed Zipser, as a participant on the Surveyor at one time, would be the best person to tell us a little bit about it.

ZIPSER: I have to disclaim participation in the Surveyor program, except that I walked on and off the ship and talked to people there. My job was overall scientific coordination of the program, and so I have had numerous contacts with the Surveyor.

We first got in touch with ESSA about the Coast and Geodetic Survey ship Surveyor's participation in mid-November, in Col. Cartwright's Liaison Office near Rockville, Maryland. We had more detailed contact in Seattle in mid-December, and this gave us about six weeks, including the holiday season, to arrange for the ship to leave Seattle on 1 February, and Honolulu on 13 February. This schedule of the Surveyor, which could not be changed, was a continuing prod to us not to allow our 15 February deadline to slip, as we wished to integrate our observations with those of the Surveyor.

The Surveyor made two cruises, leaving Honolulu on 13 February and returning on 5 March, leaving again on 9 March and returning on 31 March. A total of, I believe, 160 soundings were taken: two a day in

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Honolulu, four a day throughout most of the program, and one every three hours for something like 15 or 18 days. Standard marine radio-sonde sets were used with a marine theodolite for balloon tracking purposes; the soundings were made by three observers from the Weather Bureau. The Surveyor also accepted, for the cruise, a student to help with weather observations. The Coast and Geodetic Survey assigned an officer trained in meteorology, to guide and supervise the surface observing program on board, which was of course far greater than normal. They took hourly observations so we would have data compatible with that from the Islands, and obtained hourly cloud photographs also comparable with those from the Islands. Once an hour two people handled all of these chores in addition to supervising the instrumentation that we put on board. So we have a rather complete record from the Surveyor during the period of these cruises.

I believe the total time spent on station, anchored northeast of Fanning (about $6\frac{1}{2}^{\circ}\text{N}$, 158°W) to form a synoptic-scale triangle with Palmyra and Fanning, was 13 or 14 days. The ship spent about five days on a cruise south of the equator.

Some University of Hawaii oceanography people spent the entire cruise on board. One of their particular interests was detailed sounding south of the equator to about 3°S , made during the first half of the program. They also made oceanographic soundings on the north-south line between the Line Islands area and Honolulu.

One further contribution of the Surveyor, which was no small part of its total contribution to the Experiment, was to take down some thirty members of the Island contingent. This help came at a critical time, when we had no other means of transportation. The flexibility of the Surveyor group in accommodating us in this way, not part of their official duties, is very commendable; they certainly helped us a great deal.

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REX: Thank you very much. We hope Capt. Whipp will be here this afternoon to give us more details. Moving on, we have both Bill Bonnet and Mr. Finuff from the Atomic Energy Commission. I will call on Bill Bonnet at this time.

BONNET: As manager of the AEC office in Honolulu, I think that it would be appropriate to tell you why the AEC is here and what our interest is in this program.

Of course, our prime function in the Pacific now is to maintain a readiness to resume atmospheric testing should national interests require it. We are therefore interested in weather observations, particularly high-altitude weather observations. On Kauai, at Barking Sands, we are right now in the process of firing a series of rockets. The purpose is primarily to study the characteristics of the rockets, but we will also get information on high altitude winds -- 50 or 100 mi high.

We also have an interest in participating with and helping other agencies of the Federal Government. I sometimes think there is too little of this throughout the country.

I do want to compliment the NCAR people. They moved in here with both a long-range objective and a short-range, two-month objective. They were flexible enough and worked hard enough to reach their objectives. Hard work and flexibility are a combination difficult to beat. I hope that NCAR can maintain their flexibility in their operations. It is essential, in that type of operation, to try to keep from getting too hide-bound by manuals and directives. I was somewhat surprised when NCAR first came out to learn how wide their charter was -- all the different kinds of things they were going to do. However, I must say that I was even more surprised to learn from reading in the newspaper that this charter included rescuing tourists from some of the islands and bringing them back to Honolulu!

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Ben Finuff was designated as our liaison man in AEC and he has functioned in that capacity very helpfully. He will say a few words now. Thank you.

FINUFF: I am with the AEC in Honolulu. The AEC office out here participated only a little in your program. We would like to feel as the old lady did when she poured a cupful of water into the ocean: "Every little bit helps." So we were instrumental in helping you just a little bit.

Our first knowledge of the Line Islands Experiment was through exploratory communications with the Boulder people. In early January Mr. Tefft and Mr. Greenwald came out from Boulder to investigate the feasibility of using some of our facilities for a staging area. We met with them then, and incidentally with the General Services Administration (GSA) who had a lot to do with obtaining the excess materials. After Mr. Tefft and Mr. Greenwald returned to Boulder, Mr. Bonnet received a letter from the Boulder office asking if we would participate by giving all the support within our capability. We then asked Holmes and Narver, our prime contractor in the Pacific Division, to provide logistic support for NCAR. We designated 26 pieces of major equipment which could be loaned to NCAR, to be returned to us afterward because we need them in our long-range plan.

We also had excess properties from the Johnston Atoll project. NCAR was able to obtain \$112,000 worth of these at no cost. We asked Holmes and Narver for office space for NCAR people, a staging area, repair and rehabilitation of equipment that was going to be sent to the Line Islands, and teletype service back and forth to the mainland. As of last Friday evening, the Holmes and Narver teletype room had dispatched 370 NCAR messages, as well as 239 Holmes and Narver-NCAR messages.

We at AEC have done nothing actively in participation, but we have guided when necessary. Holmes and Narver worked without guidance,

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and without additional personnel, although there was some overtime involved, when time was short, as in loading the barge. Every weekend we loaded the plane that went out to take food and mail and so forth. Holmes and Narver provided dock-side service to load the ocean barge, and they provided transportation later for picking up excess materiel that was available from the Naval Supply Center and from Schofield Barracks. Mr. Crouch was instrumental in scrounging and getting a lot of stuff, so the program out here, as far as we are concerned, has cost you almost nothing. We do expect that any damaged equipment will be repaired and put back in the same condition that it was in when received.

I went down to Christmas on 25 April, and talked to Commissioner Cook, who is the British Commissioner there. He volunteered that the conduct and activity of all the people on Christmas Island were satisfactory to him.

In view of the fact that our scientific laboratories are interested in atmospheric conditions, the AEC office here in Honolulu would like to be placed on the mailing list to receive reports or data developed from this experiment. Thank you.

REX: Thank you, Ben. Particularly, thank you for recognizing GSA and their important role in our experiment.

I would like to call on Mr. Ed Bowen, who is Senior Vice-President and a member of the Board of Directors of Holmes and Narver.

BOWEN: Thank you very much. (Mr. Bowen expressed regret over the absence of Jim Holmes and Chuck Kelly.) We at Holmes and Narver were very glad to participate in the Experiment. Many programs that we have had, in different parts of the world, start out to be economical programs. More often than not, they end up with a big bill that no one has any money to pay. The success of this Experiment was due, primarily, to the spirit of the men and to their attitude. This has been a low-budget job and it took a lot of doing, for the people of NCAR who participated in the field and in the planning, to keep it a low-budget

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program. I think more was done per dollar here than I have ever seen done before, with men like Bill Lanterman planning and figuring out ways and means of getting things done with the fewest possible dollars.

If I may, Mr. Chairman, I would like to introduce the project manager, Chick Leeds. Chick was with you and worked hard, and I would like him to say a few words.

LEEDS: I personally witnessed the cooperative spirit that existed throughout all of the organizations that participated here. There was a helping hand from some organization or another every time it was needed.

The charter under which we operated, in the sub-contract with NCAR, covered principally the rehabilitation of buildings and equipment and facilities at the site. It included rehabilitation of the old runway at Palmyra, which hadn't been used since 1962. Without it there was no way of getting into Palmyra except by PBY. We were also requested to provide, prepare, and serve the food.

In that connection, Col. Pendleton mentioned the cargo of food he carried down into the Islands. I think I can break it down for you. First we shipped down on the barge most of the dry stores and other equipment that were going to be required -- approximately 997,000 lb. Some of this was transshipped to Palmyra and Fanning on the weekly flights. We shipped about 49,000 lb of freeze cargo: frozen meat, frozen vegetables, and frozen eggs. The cool cargo, which included vegetables, totaled 9600 lb.

The men down on the Islands began calling for fresh milk, which we hadn't provided at the outset because it is hard sometimes to get it down there. But we purchased milk from Foremost Dairies and froze it solid and shipped it on dry ice. In most cases, it came out pretty well. There were a few instances where, apparently, the carbon dioxide got into the milk and it tasted a little bit like a soft drink.

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Holmes and Narver provided power and water. Water was something of a problem. At Christmas Island it had to be hauled from a well. At Palmyra and Fanning it was rainwater collected in cisterns; it was contaminated, and had to be treated. The initial crew went in carrying halazone tablets, which are well known to the military; later the water was treated with HTH, the same thing used in the Honolulu water supply.

The initial crew of eight men and Superintendent Bob Berg went down to the Islands on the first PBY flight. We thought they would arrive at the same time the barge did and would assist with the unloading; unfortunately, the weather prevented this. They couldn't land at Palmyra, and had to go to Fanning, where they were pinned down for three days until the Palmyra weather cleared up.

The PBY also brought down a second contingent of ten men; other personnel went down on the Surveyor.

The initial group from Holmes and Narver were construction people; there were just enough support people to feed them. They took emergency rations or Navy combat rations. The group that landed at Palmyra and Fanning on the first trip had to subsist on emergency rations for three days. Later, as things came in and the generators were hooked up, the Air Guard got in the frozen food and they ate a little better. Morale is very important in the Islands, especially when living under extremely difficult conditions and working long, hard, backbreaking hours. Good food helps. Recreation is important too. After consulting with NCAR, we sent down recreational equipment -- fishing rods, volley balls, ping-pong sets, and playing cards. Surprisingly, practically no one had time to use them.

Medical facilities are also important and kits of medical supplies and equipment were sent to each island. NCAR provided a doctor, who was based at Palmyra but made trips to the other islands also. The job of aideman was picked up by whoever wanted to volunteer or was capable. Sgt. Harrison was the aideman at Christmas, and Bob Kubara at Fanning.

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We didn't have a regular storekeeper, but the foreman or cook at Palmyra acted as camp storemanager and provided shaving soap and toothpaste and toothbrushes and so on.

At Palmyra we had no native personnel. All of the work had to be done by scientists, military personnel, and Holmes and Narver. At Christmas and Fanning, native labor did much of the heavy work. We could not use them as food handlers, because of health problems; however, they could wash dishes with rubber gloves, and help in moving things, and rake and burn rubbish and trash. (The undergrowth was very conducive to insects and it was difficult, at times, to get sufficient insecticide at some of the sites.)

At each of the sites there were two 30-kw generators which supplied the main camp power. There were additional installations, in some cases, for the radios.

That is, I think, the story. If there are any questions, I will be glad to try to answer them. Thank you.

REX: We certainly, on our part, appreciate Holmes and Narver's can-do, their attitude, and the many things that they did above and beyond the tasks stated.

There were other participants in the Line Islands Experiment, and certainly the first to come to mind are those involved in the "barge act." Mr. Riddle is here and I wonder if he would say a few words about the tug and barge operation.

RIDDLE: Thank you very much. I am with the Hawaiian Tug and Barge Co. (Dillingham Enterprises). We met, initially, with Bill Lanterman and Mr. Greenwald to discuss what we would do and how we would do it.

From the standpoint of a critique, we obviously all learned a lesson. I feel we had a real break in the weather during the entire program. When a commercial organization undertakes a somewhat amphibious landing, the weather is, certainly, the main criterion. Navigation in the Islands can be difficult. Fanning, particularly, has strong

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currents. We actually unloaded the barge while under way, not being able to get into the Fanning lagoon because of the current and insufficient swinging room. Boats came alongside and 90 tons of cargo were off-loaded into them, with some assistance from the local people in Fanning. It certainly does require good weather to undertake that type of off-loading. Although our cargo load was much greater than expected, we feel we completed the operation rapidly and safely. We were fortunate in that no major injuries occurred.

Throughout the entire operation, Bob James rode the tugboat. After the operation our Dillingham people wanted to know how they could get Bob James into their corporation. Thank you.

REX: Thank you very much. I might say that when it turned out we couldn't charter a cruise ship, and we mentioned a tug and barge, we lost a lot of volunteers for the exercise!

I would also like to recognize Tom Kendall. Tom was one of the first participants in the LIE. He piloted the PBY, as many of you know, on the scouting trip. The PBY is the bird affectionately known as the "Leaky Tiki." It has become one of the legends of the Line Islands Experiment.

Tom, would you say hello, and introduce your son and daughter-in-law, who also ran the big bird for us?

T. KENDALL: This is my son Bob, and his wife Inge, who did all the work.

R. KENDALL: Our PBY operates out of Palm Springs, California. We were called on in November for the survey trip to the Line Islands, arrived here on 22 November, and took down the group of scientists and construction foremen to survey the Line Islands. We returned to Honolulu and stood by until 13 February, when we started moving personnel, tools, and supplies between Honolulu and the three Line Islands. We continued support flights through 26 April.

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During the Line Islands Experiment, we flew 123,695 passenger miles, carrying a total of approximately 32,720 lb of cargo. Of the 60 flights in the Central Pacific area, 27 flights carried mail for the various groups.

We wish to thank Bill Lanterman and the NCAR personnel and Bob Berg of Holmes and Narver for their assistance beyond the call of duty, and Col. Pendleton of the Air National Guard, who brought us a tire when we needed it most.

We appreciate having been able to participate in the Line Islands project and look forward, very much, to the scientific results as they gradually become available.

REX: Thank you, Bob. I haven't had an opportunity to fly with you yet, but I'm looking forward to it.

You all know that there were, in addition to NCAR, a number of participating universities in the scientific program. The University of Hawaii was a primary participant. We are most appreciative for all sorts of assistance from Professor Ramage and his team, both here in Honolulu and on Fanning Island, where we were their guests.

Professor Ramage has asked me to introduce Dr. Martin Vitousek, who, I hope, will tell us about their participation and their plans for Fanning.

VITOUSEK: I am with the University of Hawaii Institute of Geophysics. The Research Association has assumed the management of the facilities on Fanning Island, under the capable leadership of Frank Callendar. The scientific direction of Fanning Island, at least in the interim planning stage, falls to me.

I want to express my gratitude for the start that NCAR has given Fanning Island. I think you who have been there realize its potential as a future research establishment located near the equator in an excellent geophysical position. We hope to develop this facility to a

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smoothly running, comfortable spot for scientists, be they biologists or geophysicists or astronomers. (It is a good spot for a radio telescope.)

The facilities, as you know, are in a state of partial rehabilitation now. NCAR has supplied generators and has done quite a bit to get things started. Participation by NCAR, of course, is participation by the National Science Foundation, who have indicated a strong interest in supporting the Fanning Island facility.

Your NCAR program was the first program for the Fanning Island facility. The second one, an aeromagnetic survey, will be started in August. We hope that an extensive hydrographic program can start next year. We will have a ship and six men there for the full year.

I hope that when NCAR plans another project you will keep Fanning in mind and be our guests. It will then be a more comfortable spot for you. Thank you.

REX: Thank you very much. I don't think there is a representative here from NASA. We want to acknowledge their participation. It was more than successfully flying the satellite. The picture readout system and the picture data-handling system were set up partly to meet our requirements. Picture scheduling was set up to accommodate our intensive observing period and to give us adequate picture coverage during the entire LIE period. Of course, as I said before, in a sense the ATS-1 satellite put the whole show on the road.

I should also mention that there is no one here from Woods Hole Oceanographic Institution. Their aircraft did participate, and they made several research flights.

ZIPSER: They are still flying out of Canton Island. I believe there are to be 12 flights in all.

REX: Their research aircraft is heavily instrumented, and I am sure will provide useful data.

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Jack Hinkelman, the Manager of our Aviation Facility, asked me to call on Loyd Newcomer to tell you about NCAR aircraft participation.

NEWCOMER: Somebody said the Pacific is a four-engine ocean. We had more success, I believe, with a light twin-engine aircraft out here in the Pacific than we had anticipated. We ferried it out by way of Alaska, the Aleutian Chain, and Adak, then down to Midway, Honolulu, and to Palmyra. Just getting the airplane through in the dead of winter was quite a feat. In fact, they tell me that when they flew into Adak there were much larger twin-engine planes that had been sitting there for ten days waiting for a break in the weather. The ferry pilots started to chuckle, and thought that at least they would have some company at the club, but the next day our plane was on its way.

Our plane left Jefferson County Airport, near Boulder, on 14 February. It got to Honolulu about a week later, stayed about three days for some maintenance, and continued on, arriving at Palmyra on the 27th. It operated there for 53 days, excluding the day it flew in and the day it flew out. It flew one or more flights on 49 of the 53 days, flying 265 hr, averaging 5 hr a day. We had it grounded twice, a day each time, for the 100-hr checks on the engines. A few days after it arrived, there was a moratorium on science at Palmyra while we put our house in order; we skipped a day there. Then one day, after a long night rescue flight, we didn't volunteer to fly, and Dr. Zipser didn't have enough nerve to ask us to. So there were four days that we failed to get into the air. A great deal of credit is due the Beech Aircraft Corporation, who built a very reliable, very sound aircraft. I believe that is all I have to say. Thank you.

ZIPSER: First credit for keeping the aircraft in the air for the 53 days doesn't go to Beech Aircraft. It goes to one of the most hard-working and dedicated groups that was in the Islands!

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REX: Thank you, Ed. I would like to ask each of the site managers to tell us something about the Line Islands Experiment as viewed from the island stations themselves. Bob James, will you start out with the story of Palmyra?

JAMES: We approached the Line Islands expedition knowing that we were sending some 80 men to the Islands to an isolated environment. We felt that performance had to be perfect. I will not say that it was perfect. Due to limited time, money, and manpower, many mistakes and omissions occurred.

The first people from the NCAR Field Observing Facility arrived in Honolulu about mid-January, and by February many, many tons of equipment were accumulated -- enough to fill two barges. One barge was 175 by 45 ft. We scrounged, and Leo Crouch and Jim Butler came through with equipment.

The Navy made an LCM available. (The closest M-boat was supposedly in Vietnam.) We borrowed kitchen equipment from the Army at Schofield; sheets and refrigerators were borrowed. Holmes and Narver of course furnished a lot of this equipment, and a lot was sent in by the military. In fact, when we began loading our barge it became obvious that all of the equipment was not going to go aboard; the barge was completely inundated with cargo.

We took our first people into the Islands on 14 February. Due to the weather and a radio malfunction, we had to divert to Fanning, where we remained four days. So right at the outset we were four days behind schedule.

Upon arrival at Palmyra, we started off-loading equipment, not only Palmyra's equipment, but also Christmas Island's equipment, because the way the barge was loaded, Christmas cargo had to be removed to get to Palmyra cargo.

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Our main emphasis was to open the runway. Bob Berg and his crew of eight, using a grader, opened about 5300 ft of runway, 150 ft wide, in two days.

We went to Palmyra intending to set up a tent city. After examining the tent frames, we found this was completely out of the question; wherever a nail had been driven in, the wood had rotted. So we attempted to rehabilitate the old barracks there. The situation improved and people stayed dry when we got the roof fixed and screens in the windows and generators going.

Later in the program, we set up one tent. It took 72 man-hours to erect it. I think that gives you an idea -- we would still be building tents down there.

We were also eager to establish communications with Honolulu and the research vessel Surveyor. Brian Lewis, of the Field Observing Facility, went to each of the Islands on the first wave. He established communications at Palmyra on the afternoon of the 17th; by the evening of the 19th we had a homing beacon working. This beacon, by the way, puts signals out to 50 to 75 mi at an altitude of 7000 ft for aircraft navigational purposes.

At Palmyra, we wanted to establish a weather radar. This necessitated a good horizon. A 42-ft tower was constructed on top of the block house; it gave us an unrestricted horizon. Weather radar went into operation on 21 February and pictures of the scope were taken every 12 to 15 sec from then to 21 April. It worked perfectly throughout the operation.

We had an APT and it automatically took pictures so that we could review the photographs from the Nimbus and ESSA satellites. We didn't receive good ATS-1 pictures in the Islands, however.

The Air Force team went into an old blockhouse and set up a very creditable observing facility.

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There were problem areas in the Island operations. If I had it to do again, I would try to establish a firm chain of command. Too many people were giving orders. The re-supply, though good, was always a problem. Also we were undermanned. Some of us worked seven days a week, and 17 to 23 hr a day. This is documented. I would suggest that we have at least a third more men in any future operation. Each scientist that came to the Islands brought additional requirements to an overtaxed situation. A real effort should be made to firm up the programs in advance and to install needed equipment at the outset.

There has been some reference to morale. There was routine unhappiness at the stations. I believe if there had not been such a demand on the men's time, they would have gotten along much better.

The roll-up phase at Palmyra, and I think on all of the Islands, worked very smoothly. The efforts of Jack Tefft, Bill Lanterman, and the Air National Guard stand out in my mind. This was the smoothest part of the entire operation. Some delay time was necessary to schedule aircraft into the Islands. In the future, if we can control this delay, we could probably speed up the off-island phase.

REX: Thank you, Bob. I'll move right along and ask Mr. Kubara to tell us how things looked from Fanning.

KUBARA: I represented NCAR at Fanning Island. We enjoyed, I think, very good facilities compared with Palmyra. The station that the University of Hawaii has leased was quite comfortable. We had problems in the beginning with electrical power and pumps, but it all straightened out.

We had 23 people on Fanning. (We should count Jerry Shafer three times because of the hard work he did on the island getting us started.) Fanning's isolation was our biggest problem. We relied on the Air National Guard airdrops and PBY flights. The longest period we had without flights was twelve days. But we were well fed, and though we got our equipment a little late, it all worked out.

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The island itself is small -- 10 mi around. We had one remote site on the southeast corner of the island. We had an MRI site next to the lagoon, and one radiosonde station.

Holmes and Narver personnel did all the camp jobs on the island, freeing the technical and scientific personnel and giving them additional time to concentrate on their activities, which I think was a great help. The morale and health of the personnel were good; the data they obtained will also be good. That is about all I have to say.

REX: Thanks, Bob. Sgt. Harrison, will you tell us something about Christmas Island?

HARRISON: Christmas had the least activity in the operation. At first we were under the direction of Capt. Don Frazee; he departed at the end of March and Dr. Julian Pike from NCAR took over, a very able man. I led the Army team on Christmas, and supervised the Army operations on the other two sites. I had six men on Christmas, three for the double-theodolite operation and the other three for surface observations. The upper air observation program was run by the Air Weather Service team, commanded by TSgt. Coleman (USAF).

Holmes and Narver had Mr. Clardy and four men down there at the beginning; they built up toward the end to help us get out.

Bob James gave us a great deal of assistance when we arrived on the island. Of course, we had a small group and adequate facilities; very little reconditioning had to be done. Bob had pre-positioned our equipment -- it was all off-loaded and ready to go. This perhaps is the reason we got into operation so quickly after our arrival on 28 February; we were in operation on 2 March.

I should give credit also to the assistance of Mr. Dudley Cook, the District Commissioner for the British on Christmas, and Mr. Ron Summers from Tarawa. With their assistance, we scrounged many pieces of equipment and odd repair parts to keep our equipment going.

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We employed four Gilbertese; one worked in the kitchen and the others assisted in off-loading and on-loading, aircraft refueling, washing down the PBY, etc.

Our operation started out with about 21 men and built up to 25 at the end. We provided accommodations for visitors -- on one occasion we had 36 visitors, which was getting close to the breaking point. On 1 April, the Geodetic Survey Satellite tracking party came in with four men, and they fitted in marvelously -- you couldn't ask for a better group. The first or second week of April the Woods Hole Oceanographic Institute C-54Q came with 16 people. They were very well briefed and forewarned about the supposedly austere living and operating conditions at Christmas. They fitted in well and gave us a big boost.

Our daily operations were quite similar to those at the other two islands insofar as routine observations were concerned. On weekends, we continued our routine observations, and also cleaned the aircraft and showed visiting scientific personnel around. Some of the men were a little jealous of a couple of us that got to tour the island every other day; it was some weeks before they had a chance to see what the island looked like.

I feel the food was outstanding. I think I tipped off the milk supply the second week we were there; I felt that fresh milk would be a great morale factor. We did notice that the consumption was pretty good. We had the best water of the three islands. It came from a well 8 or 9 mi away and didn't need to be treated. It didn't taste the best but I don't think anyone became ill from it.

Recreation was minimal. In line with Mr. James's comments on the number of personnel, I think that if we could increase our next operation by close to a third, it would be better. We had one opportunity to go swimming, legally that is, with shark-watchers out. There were many sharks in the area, as Bob Kendall will testify, I am sure. Some

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people who went into the water during their spare time to spear fish experienced cuts from the coral, and "Dr." Harrison had to do a suture job on one occasion.

The medical portion was not too strenuous. We had a round of GIs that ran through eleven people, lasting 24 to 48 hr and leaving us a little weak for a day or two. We had the usual number of cuts and bruises and a couple of sprains.

The back-up labor was very good. All the Holmes and Narver personnel should be complimented. Overtime was kept to a minimum, but most or all of the personnel couldn't have cared less about being paid for overtime. They worked many, many hours over and above what was required. The Gilbertese labor, contrary to what we had been led to expect, was outstanding also.

Communication with the other islands was good. We were a little short on equipment, but we made do and it worked out well. Transportation equipment was lowest. Without the Air Force vehicles we would never have been able to operate. Then Mr. Cook came through with a couple of their left-handed vehicles for us, and we all learned to drive all over again.

If anyone is going to write a book about the Line Islands Experiment, Capt. Frazee has a very extensive diary on the first half at Christmas Island. He thought the program would be a great study and good for a paper on psychology.

REX: Thank you, Frank. I would like to ask Dr. Zipser to give us a thumbnail sketch of how the data look and what the plans are for archiving them and making them available. Perhaps Ed can also tell us about university research participation, and make a few comments from his viewpoint as scientific coordinator.

ZIPSER: There are many things that should be said at this time in regard to the operations, in the spirit of this critique, which actually no one group seems able to make. Each group was responsible

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for a particular piece of the operation, and only a few of us, mostly NCAR, had responsibilities extending over the entire program. So I will push my luck and make a few comments. However, first I will discuss the current status of the data.

First, we had hourly surface observations -- the standard parameters from the three islands -- courtesy of the Army group.

In addition, we had narrative cloud observations from the observers, and complete sky-cover pictures taken once an hour at each site. One of the purposes of the program was to focus attention on clouds, which are extremely important in the tropics.

A lot of emphasis has been put on interpretation of satellite photographs, both the routine type and the more revolutionary ATS-1 pictures. One reason why extensive data collected in the past could not be used is that corresponding surface photography was lacking. This time we have surface and aircraft photographic data for virtually every time and place in the program.

The Army's theodolite program was carried out by Sgt. Harrison's group from Fort Huachuca. As a unit, these data are unique. Dr. Estoque, formerly of the University of Hawaii and now of the University of Miami, is immediately responsible for their reduction.

We have an excellent collection of rawinsonde data from the Islands and from the Surveyor and the Eastman. Serials were taken on about 17 days of the program; on those 17 days we had soundings every 3 hr -- 8 per day. To my knowledge, this is the largest organized collection of such data in the tropics. I think that our program here equalled or exceeded our best hopes.

We had two completely instrumented aircraft in the program when we began. The Queen Air, of course, led the field with 58 research flights from Palmyra, all within the primary operations period. We also had ten or twelve C-54 flights, which will certainly be a useful supplement. Some of these were run concurrently with the Queen Air,

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and I believe will give us opportunities to compare temperature and other readings. Then we also had B-47 recon pictures and wind data from the upper troposphere. We'll have enough of these slides to tie in upper troposphere with middle troposphere.

I have purposely put satellite data low on the list because, although the timing of the program was influenced by the launch of the satellite, and evaluation of ATS-1 data is an A-1 item, I want to make it very clear that this is a research program of tropical meteorology rather than of satellite meteorology. Quite frequently during the program the pictures from the ATS-1 were continuous all day long. These will be the most interesting days, because we can make movies of these pictures and actually look at the motion of the clouds. We also have, as part of the backbone of the program, two or three operational satellite pictures per day, even for days when the ATS was not functioning.

We had time-lapse photography from all research aircraft whenever they were flying, and from the ground at all times, and still pictures from the ground once an hour, or more frequently if anything looked unusually interesting. NCAR will have the dubious privilege of plowing through these pictures.

* * * * *

Now, turning to a summary of university research participation: the University of Wisconsin can take a bow for the heaviest participation in the program proper. At one time, there were ten University of Wisconsin people on Palmyra, the largest single group. They are responsible for a number of programs. In cooperation with the Air Weather Service crew, they released ozonesondes from Christmas and Palmyra at 06Z each day during the last half of the program, for a total of 60 soundings. Pete Kuhn's group from Wisconsin was in charge, with Steve Cox and Jim Maynard as assistants.

Both ground and airborne radiometric equipment were operated by Wisconsin. Maynard and Cox, under the direction of Professor Suomi

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and Dr. Kuhn, carried out most of the work with the ground-based radiometry. Airborne radiometry, primarily for temperature measurements, was carried out on board the Queen Air by a graduate student, K. Menon, under Professor Ragotzkie's direction. Menon flew at least half of the Queen Air missions collecting sea temperature data. He got north-south profiles extending from about 2°S to 8 or 9°N . The Woods Hole aircraft brought in radiometric data less frequently, but covered a wider range of latitudes.

Verner Suomi, Fritz Hassler, and many from NCAR were involved in a very extensive stereo-photography program on Palmyra, with a 3000-ft baseline. The number of pictures obtained runs into the thousands. The University of Wisconsin will analyze these.

Texas A & M was responsible for contributing the services of Capt. Frazee, and of Dr. A. H. Thompson, who helped us get pictures from the Navy reconnaissance aircraft and from the Air National Guard flights to and from the Islands.

Saint Louis University contributed Paul Hwang, a graduate student who, I think, should be singled out. He pulled about three times his weight. He helped to run the APT system, and took over the photography program from time to time. Saint Louis also sent down Dr. A. J. Pallman, who spent three weeks helping with calibration and servicing operations, and Dr. C. J. Murino.

* * * * *

A data catalog is the very first of our goals. It will make available to everyone a complete listing of what we have obtained, what format it is in, where and how they can get it, when they can expect it, and so forth. It will include an evaluation of the various instruments, so that no one will ask for something we can't provide. This we consider our first job; the catalog will be produced with all possible dispatch.

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Second in priority will be a summary of basic data, data which are considered to be so interesting that many different groups will want them. It will include, for example, summaries of the hourly observations, and rainfall observations, and the print-out from the rawinsondes. We will send out letters shortly, soliciting requests, to get a feel in the scientific community as to which data should be included in this category.

The University of Hawaii has assumed primary responsibility under the direction of Colin Ramage, for doing much of the work involved in the production of the catalog and the data summary. They have an NSF grant for this. They are also accumulating synoptic data from all over the Pacific so that they can produce analyzed maps of the general circulation. They are working with NCAR but have primary responsibility for all of the standard synoptic data.

NCAR is going to catalog and distribute information on the photographic data. Those who are interested in working extensively with the photographic data will almost have to come to NCAR; there is too much of it to distribute. We will endeavor to fulfill limited requests, however.

Satellite data also fall into this category. At least one satellite picture per day during the Line Islands Experiment should be a part of the basic data summary.

* * * * *

Lastly, I should like to offer a few general comments on the LIE. This operation was conducted for the purpose of collecting scientific data. The program was very ambitious, and was done on a very close time schedule, and has had an astounding degree of success. I would like to remind you never to lose sight, during this critique, of the overall scientific purpose of the operation. During future programs we should continue to keep in mind the relationship between scientists and operations people. It is the job of the scientists to devise a

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scientific plan, and to present it to the operations people, whose job it is to carry it out. By a great combination of ingenuity and hard work -- I mean the sort of work I have already described, sometimes at three o'clock in the morning, or all night, and seven days a week -- the Line Islands plan succeeded.

It succeeded because, even after the plan was devised, there was continuous input from the scientists as the program developed. The nature of the relationship of scientists and operational personnel is one that will always lead to conflict. It is a great temptation to want to set up future programs to lessen such conflict. But we should not dwell on this conflict: it is necessary. It is the job of the operational personnel to carry out the operation with all dispatch. It is the job of the scientists to update it, to feed in new ideas, to see what is going wrong, to change it. A good sense of humor and sense of accommodation are absolutely necessary during the entire program.

One thing I want to caution against is adopting some of the very logical recommendations that have been made. For example, it has been suggested that we start our planning a year earlier, develop a more concrete plan, and be in a better position to carry out the operation "neatly." I am not against prior planning, but I think that if it results in a neater, more hidebound operation we would be on the road to failure. Our success resulted from our being able to make changes. Some of the very best features of the program were the radar tower and the way in which it was constructed, the mercury barometer shipment down to the Islands, and the idea of the C-54 research plane basing on Christmas. (This last idea didn't work out the way it should have, but the point I am making is that they were accommodated, and accommodated well, in spite of the last-minute nature of the program.) When these items were suggested, the people in charge of operations could have said, very easily and with complete justification, "This wasn't in the original plan," or "There is no money appropriated," or "You can't do that because we have to get 25,000 cans of beer out to the

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Islands," or something like that. But they didn't. These are all instances in which the success of the operation depended on frantic additions to the plans.

If I had known of the difficulties involved in the program before it started, I doubt that many of the things that we eventually got would have been asked for. Somehow, you people pulled rabbits out of hats, and made a lot of miracles come off.

The panic squeeze on people at the beginning scared away many scientists who wanted to come and would have contributed greatly to the program. The site manager feels that the operation work force could have been expanded by about a third. I feel that scientific participation could have been doubled. The reason for the squeeze was obvious: money and arrangements. Sometimes the scientists down on the Islands did not have transportation to get around to see what was going on, so scientific data were not as well coordinated as they should have been, and in some cases were lost. This is an example of what can happen when scientific effort has to take second seat. A few more people available would have resulted in a better job of coordinating the scientific part of the program. Most of the lack of coordination was unavoidable, this time.

What does our effort really mean? It means that we can present 10 to 25 days of complete, comprehensive data coverage. What are these days worth? They are worth the total investment in the operation divided by the number of such days. This comes to something like \$40,000 to \$50,000 a day for those days in which everything worked. Every day that the barge did not proceed on schedule was therefore \$50,000 lost, if you want to put a dollar value on things. Aside from the money, it meant a day of lost time, a day of lost data, if we measure it with the overall scientific goal in mind.

I think the moral is fairly clear: there is going to be conflict between the people speaking for the scientific community and the people

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doing the dirty job of carrying out the operation, and this is inevitable and even desirable. When conflict arises, the operational people should be quite prepared to give in, because the scientific objective is the main objective.

Obviously, the operational people sometimes have to stand up and say "No, it is impossible; you cannot do it." But if possible, the need of the scientists should be accommodated, even at the risk of a very messy logistic operation and increased cost. The percentage of cost increase is almost always infinitesimal; the scientific gain is usually fairly great.

So again, I would urge for future operations a little greater scientific manpower force, even though it doubles logistic problems by asking operations to cover odd and curious suggestions. If you continue as willingly to accommodate us as you have during this program, the operation will be a scientific success, and it will be a logistic success. That is all I have to say.

REX: Thanks, Ed. You all realize that this afternoon we will break up into four groups: Shipping and Transportation, chaired by Jack Tefft; Government Coordination, which I am supposed to chair; Site Operations, which Bill Lanterman will chair; and Air Operations, chaired by Jack Hinkelman. We will reassemble here at 2 o'clock and go to our respective committees.

(Recess)

II. SHIPPING AND TRANSPORTATION COMMITTEEPANEL MEMBERS

Jack D. Tefft (NCAR), chairman
Joseph Abreu (Holmes and Narver)
Al Carter (Holmes and Narver)
Leo Crouch (NCAR)
Ben Finuff (Atomic Energy Commission)
Maj. J. Misterly (Air National Guard), not present
Meridith C. Riddle (Hawaiian Tug and Barge Co.), not present
Maj. Arthur Streim (Air National Guard)
Ronald Taylor (University of Hawaii)
William Thoene (Naval Supply Center, Pearl Harbor)
Dr. Martin Vitousek (University of Hawaii)

..... Shipping and Transportation

DISCUSSION

TEFFT: Our subject has a slightly broader scope than just "Shipping and Transportation." We want to consider a lot of logistics problems too, while we are talking. We should try to come up with some recommendations as to what might be done to make life a little easier during future programs similar in size and scope to the Line Islands Experiment. Probably the three main items to be considered, in the light of the experiences we have had and what we have learned from them, should be (1) planning and schedules, (2) manpower, and (3) budgeting.

TAYLOR: I want to refresh my memory about the original idea of a Liberty Ship. At one time wasn't NCAR going to get a Liberty Ship for one dollar?

TEFFT: We thought of such a ship, but at the standard rate that anybody pays, military or otherwise. The bill was just too high.

ABREU: Besides the cost factor, there were none available due to Southeast Asia commitments.

FINUFF: Well, in contrast to the statement of the last speaker this morning, I will say you have to plan transportation and logistics well in advance. You cannot establish a budget unless you have a base. You have to figure out the transportation before you can establish a budget. If you do not have a budget all of the things in the world are not going to make the transportation work.

TEFFT: Right.

FINUFF: You need to determine as far in advance as possible what you want to ship, where you want to ship it from, and how you want to ship it -- by airlift, or by surface transportation. If you anticipate that your people will continue to use the islands of the Pacific for future experiments it might be to your advantage to pick up small craft and store them.

TEFFT: We ended up shipping a lot of the research equipment by air, because it was procured and delivered too late to meet any surface

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ship. It isn't too costly to ship research equipment by air, because it is usually lightweight.

FINUFF: Do you have a continuous requirement for all your scientific gear on the mainland?

TEFFT: Yes, we have 75 to 80% utilization of all our equipment the year around.

FINUFF: I was thinking of possibly storing some.

TEFFT: We couldn't do that right now because we are preparing for a rather large experiment near Galveston starting 1 June, and we have to get everything rehabilitated and calibrated and shipped by 18 May. Most of the weather equipment from this experiment has to remain available. Now, generators and possibly vehicles are in a different category; it may well be best to store them in a central area like this.

FINUFF: In the future you might not be quite as fortunate on generators as you were on this expedition. I can assure you that within another year or two there will not be a surplus of generators. The federal agencies out here are picking up any generator that is any good. Motor vehicles, with a maximum of \$250 rehabilitation necessary, are plentiful; you can pick them up any time you want to.

VITOUSEK: It is difficult to make many comments about shipping because we had essentially no planning program. To expedite shipping for future programs we should contact all shipping agencies and get their schedules, so as to make use of commercial shipping possibilities, perhaps diverting a ship that happens to be going by an island. It takes somebody that knows shipping.

TEFFT: I did quite a bit of that work last fall. It turned out that there were two commercial freighters we could use. One backed out because of the problems of getting into the Line Islands -- they were concerned about the weather down there at that time of the year. The other -- our equipment wasn't ready to go at the time that they were coming through. We had space reserved up until the last minute.

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ABREU: You have to guarantee commercial freighters a certain cargo to make a port-of-call.

VITOUSEK: Either that or pay a diversion fee -- \$2,000.

Getting back to shipping during the Line Islands program: there was a great lack of coordination in the planning. Fanning Island was run for 60 years, quite comfortably and quite well, with a ship once every three months. Having to have airplanes coming in every two days with something that someone forgot could be alleviated by people who are expert in planning, like Holmes and Narver.

THOENE: MSTS has 2000-ton government-owned covered barges and at certain times of the year you can get them for a fair rate because Dole Pineapple Company is in off-season. Right now for an ordinary trip to Johnston Island and back, the tug costs about \$18,000 a trip. The cost to Christmas should be in the neighborhood of \$19,000 to \$33,000. It depends on the time of year, however. These barges are very satisfactory for about anything you want to ship -- even 600-kw generators.

CARTER: They would be good for an operation like this. They are half covered and half open?

THOENE: A 155-ft covered portion plus about four storage lockers for small stuff, security cargo or liquor.

TEFFT: That is interesting to know. Do they stay here in the Pacific area?

THOENE: They are always at Pearl Harbor or Johnston or Midway. You can contact them through Capt. Price, MSTS local office.

TEFFT: We talked with them in Washington and San Francisco, primarily about a freighter.

THOENE: I don't have any idea about how much tonnage you required; was it over 2000?

TEFFT: 2500.

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ABREU: About 2200.

THOENE: Well, for that much you should probably have used two barges, one open and one covered. Naval Base controls open barges. The largest they have at this time is 500 gross tons. They can haul about 700 or 800 measurement tons of high-volume cargo. You could put the remaining 1800 measurement tons on a 2000-ton barge. You can get lots on these barges if you plan the loading carefully. And they are shallow-draft; you can put them almost up on the beach. It is no problem to move them around in the lagoon.

TEFFT: Planning and scheduling certainly appears to be the way to set up the next program.

CARTER: Any schedule you make you always leave room to slide; but if you have a good firm schedule you will get out sooner. We had a firm commitment worked out to our schedule for every one of the aircraft.

TEFFT: Even the loads came out well.

CARTER: I brought down some of the schedule charts that we made from just the information from the reconnaissance trip. The procurement and loading of the barge -- we beat that time quite a bit. Our gain about made up for the lost time that you had on Palmyra. And debrushing the runway on Palmyra -- I had it scheduled for one week. We got that done, including the area where the Queen Air and other planes parked. We had one week to get the camp going, so you could start to house personnel. That worked right on time. Down on Fanning it came out on time, too; Christmas went ahead of schedule.

TEFFT: More now about the budget and budget planning. We couldn't really move at all until final approval of the overall budget came through from Washington. But studies of barge availability and procurement were going on. Things finally came together on 1 February.

CARTER: When you are planning a schedule you can come up with answers of how many dollars are needed. Maybe one of your scientific

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groups has so many dollars in the budget. You can let that group know far in advance if it has enough money, or if it has too much money and can do something extra. As Dr. Zipser was saying, you can never depend on scientists; they change their minds every two minutes. But even if you have to do extra things within the same time plan, you have the schedule, and you can still give them a firm dollar estimate.

I went to "Critical Path Method." I am a firm believer in it. I have used it so much that now I can sit at my desk and lay out, in my mind, the various jobs that we are going to do. I find it is an advantage to do that. I don't think there is any job that I have done out in the Pacific that I haven't done ahead of schedule. With firm planning in locating your critical path, you will always come out ahead of schedule.

In this type of planning, each item has a network all its own, and you can get a firm dollar estimate for it. You net each additional need separately, through the entire operation, and then you put it in one master net.

You will find that you will save money. I brought the book down to show you. When Boeing first started making missiles, they wanted a foolproof system for their planning. They got Remington Rand to set one up, and that is how the method came into being and was first used. It worked so well that the Polaris project was 18 months ahead of schedule. Eighteen months is a big saving in dollars. But you can save by proper planning and scheduling. You can work with a plan and schedule to follow when talking to the contractor. Make him give you a schedule; make him tell you how much it is going to cost. It can be done and come out on time and save you money.

TEFFT: We only tried it twice on parts of the Line Island project. It worked out well.

We have been kicking around transportation and shipping. You know a lot of our problem is air transport.

Shipping and Transportation

STREIM: It might help you to know what our problems were in air transport. When it comes to scheduling the crews, most of our people are weekend warriors -- they are available from Friday night to sometime Monday morning. They can take a trip from California to Honolulu and get back by Monday morning, but it takes longer to get clear to Christmas or Palmyra, and we needed crews from Friday through Tuesday at least. So advanced plans were absolutely necessary.

Our schedules usually come out three months in advance. In other words, in the next few weeks we will plan all our trips through July, August, and September. We will put them up on the board and wait for volunteers. We have trouble when we get into a frantic operation like this where we have to fill in trips right now.

Another problem that we had: it is pretty difficult to get an overloaded airplane off a 5000-ft runway on a hot day. Our first take-off at Palmyra was rather shaky. Our engineer and Anderson and I sat out there for more than half an hour going through our books, trying to determine whether we were going to get off the ground in 5000 ft. We had gone into Palmyra first, and when we went out the freight was still pretty heavy. In future operations it would behoove you people to give us your requirements; we will tell you whether we can make it that way or not, safely. We are not trying to compromise on safety. But that first trip was an experience. We got off the ground, and I guess you know the sensation of going off a carrier deck: you disappear below the deck and dip into the water. That is the way we felt. All you have to do is give us your requirements and we will tell you whether it can be done.

The other thing is that if you get plans firmed up far enough in advance, we can work through MAC Headquarters and get all kinds of support, right here or from any base that you are operating out of.

TEFFT: We started through Air Force Headquarters. Then one day I got a call from MAC Headquarters and they said that our request for

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National Guard support had been granted. So we immediately called the National Guard people in Washington, and they were already working on the setup. It came down to you as the supporting wing. But the Saturday morning that the first flight out of here was due, word had not arrived at Hickam that the airplane was on its way from Van Nuys. Given another two weeks on the pre-planning and this kind of thing could have been worked out better.

STREIM: Our operations are really global. We fly to Rio, South Africa, Australia, Southeast Asia, Norway, Alaska. Every Friday is frantic day in Van Nuys. These missions have to get out. We plan an itinerary, and we try to follow it right down to the letter. We have to abide by our own crew requirements, which are normally 15-hr maximum crew duty time. Out here it is 20 hr. Then the crew must be allowed 15 hr off duty. Sometimes on these islands you get only 12. If you have a delay, the crew can be sleeping or flying all the time.

What you want to do, of course, is get the maximum in tonnage-miles out of us. This requires coordination.

TEFFT: Did you have any problems getting crews for our trips?

STREIM: No. We advertise. You cannot force our crews; they are not military. So I have a couple of public relations men in there and they try to sell the trips. We have to take them ourselves sometimes, but we like to come out and fish and skin dive. I also waved the flag in the NCAR operation.

TEFFT: We ran into a bottleneck with the regular Air Force. They didn't have people available to help us at all. They are all tied up.

STREIM: We try to do the job that we are supposed to do. But when a man has had five or six long trips in a year it is pretty hard to break him away from his civilian obligations.

The way this operates, when you make your request, MAC schedules one wing to supervise and take care of all of the schedules. Our schedules show that only Utah, Arizona, and California aircraft participate.

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TEFFT: The Line Islands airdrops are the first in history that have been made by C-97s. We had it all set up with the people in Hickam to help us. The third week we had two big boxes rigged and ready to go and two volunteers from the airdroppers were to go along. But MAC wouldn't let them because it was beyond MAC's control. They would have been willing to cooperate if we had worked out the details in pre-planning.

We went ahead anyway and made the drops, because they seemed the best way to service Fanning. We had all the help we needed, but we couldn't get the approval.

STREIM: Air drops at best are kind of hazardous. Normally they are made at about 1000 ft, and that was impossible. The second drop -- the one when the mail was dropped into the ocean -- was lost because they were not briefed on how to use quick-release. The chute opened and the airplane dragged it out. They tried to hold on to it but the wind was dragging it out, and them along with it.

TEFFT: Well, the big package went down all right. It was a four-ton box. They dropped it lower than normal (400 ft), but there was enough time to slow it down. They said that the chute landed on top of a palm tree, and that the box hit the ground about the same time that the chute opened. It only broke half a case of eggs and half a case of tomatoes.

STREIM: When we came to make the drop on Fanning we tried to find some people. We didn't realize that everyone was hiding under trees -- they were not taking any chances of getting hit!

TEFFT: Well, they didn't put up the smoke. They were supposed to put out the smoke pot.

STREIM: Of course, we had the pre-planning part of going to look at each operation and each site. Fortunately, the strip at Palmyra was solid enough to support the aircraft.

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TEFFT: I think that everything worked fine. There were no major maintenance problems that I know of on the trips that I made out there. Everything seemed to run well. What is your hourly cost?

STREIM: We figure about \$500 an hour. The airplane burns approximately 3000 lb of fuel an hour. It is an expensive plane but it is a safe one. And any time that you want to use the airplane just for passengers we could make it a lot more comfortable. But again, we have to know in advance what is going to happen.

TEFFT: It was originally scheduled that one of the roll-up flights would be for passengers only. But it turned out that we got the extra passenger flight from the Navy and we utilized your aircraft for cargo. We did not need to add more than the normal number of seats that you carried all the time.

STREIM: Well, if details of future experiments could be worked out in advance, so we know where we are going, and how we are going to get in and out, we will be happy to give you all the support we can.

TEFFT: That sounds just fine. In the next couple of years you will be competing with Pan American and some of those people in Barbados.

THOENE: I think you should have a general funding code for transportation. This would take the confusion out of whether or not an agency could come to your support, and whether they would be paid for it. I think that you could get a lot more support from the military if you did. We have certain regulations imposed on us and we must work within their framework.

TEFFT: They probably should have given us a funding number when they set the thing up in Washington.

THOENE: I think you save yourselves money in the long run. I think we are the cheapest service in the Pacific.

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VITOUSEK: There is one comment I would like to make. I still think that the plans for air transportation should have been in charge of a planning officer who knows which aircraft can do what, how they should or should not operate. We should have professional planning, for safety's sake.

TEFFT: I think we have covered everything. Thank you, gentlemen.

III. COMMITTEE ON GOVERNMENT COORDINATIONPANEL MEMBERS

Dr. Daniel F. Rex (NCAR), chairman
Ray Belknap (ESSA, Weather Bureau)
William A. Bonnet (Atomic Energy Commission), not present
Edwin G. Bowen (Holmes and Narver)
James F. Butler (General Services Administration)
Dr. James W. Osmun (ESSA, Weather Bureau)
Col. William Pendleton (Air National Guard)
Dr. Colin S. Ramage (University of Hawaii)
Lcdr. W. S. Riley (USN, CINCPACFLT)
Lt.Col. James E. Thompson, Jr. (USAF Air Weather Service)
Dr. Henry van de Boogaard (NCAR)

. Government Coordination

DISCUSSION

REX: I think we all feel that if we had had more time we could perhaps have made things more specific and direct insofar as commitments from the government were concerned. In the light of comments or criticism of the Line Islands Experiment, we also want to look into the future and discuss what might be planned for later experiments. Does anybody wish to comment about government coordination during the Line Islands Experiment?

RAMAGE: If we consider the Line Islands Experiment as a pilot exercise, it will serve as a reference by which we can measure individual responsibility or capability. Our experience has shown that the Experiment placed a tremendous strain on the NCAR organization, a strain which, if continued for a longer period of time, could have caused permanent damage. Consequently, I feel that in any future planning there must be an operations committee which will include NCAR as an integral part but will also include, for obvious reasons, ESSA, the Air Force, the Navy, etc. Right in the initial planning each one should be assigned certain responsibilities within the overall schedule.

I think that this study has shown that no single government organization can handle a sizable meteorological experiment such as this. There is just not enough staff, not enough real backup, not enough existing facilities power within any one organization. Future operations must take account of this. I don't think it is a question of NCAR trying to build up. I think it is really a question of inter-agency support. There must be some form of affiliation to handle large programs.

REX: Although I share Professor Ramage's feeling of uneasiness as to the depth of NCAR's abilities in the field of future large-scale field operations, I haven't much affection for the "committee approach." Current efforts to define and assign responsibilities for the GARP program (which will be on an even more extensive scale) do not seem to be converging very rapidly. ICSU and WMO are planning these activities,

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and I hope that some clear understanding of who has what responsibility will come out of their planning. Meantime we, meaning the organizations concerned with the Line Islands Experiment, ought to begin putting together some kind of plan to work with. I don't believe that by so doing we would be pre-empting anyone's prerogative or responsibilities. We simply ought to look ahead and develop an informal organization with internal communications, that can follow up whatever plans come out.

In the way of plans, I don't know whether all of you have heard of the meeting in Stockholm in early July, for the purpose of developing GARP plans.

VAN DE BOOGAARD: A special subcommittee of IUGG (International Union of Geodesy and Geophysics) has invited scientists, including some from NCAR, to discuss GARP and sub-GARP programs.

REX: This meeting will involve some fifty people, all working scientists concerned with meteorology.

VAN DE BOOGAARD: The meeting will have essentially the same purpose on an international basis as TROMEX has on a national basis. We hope that some concrete proposals will be forthcoming.

And, of course, there is a big general IUGG meeting in Switzerland in September.

REX: The same TROMEX planning group that met last year will meet again in Boulder in September, to discuss the objectives of a further tropical experiment. I mention both of these meetings simply to say that this fall recommendations for further experiments should emerge. I hope that we can assemble an operations group to look into the related logistic and operational problems. I would like your reactions. Should we go ahead and call a group together informally to begin to look at the problem?

OSMUN: Why can't NCAR, with its ideal structure, invite to such a meeting all those it thinks should participate. You know the capacity, capability, and interests throughout the whole national structure --

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Army, Air Force, ESSA, Navy -- as well as among scientists in Europe and elsewhere. Then we could study the special problems of such an operation, and move along a little bit faster than we did the last time.

BUTLER: I think we can propose this. It may end up that ESSA could draw together all the strings.

(In the ensuing discussion it was brought out that recognition of the gap in meteorological knowledge in tropical areas, such as the area around and south of Hawaii, had resulted in the positioning of the ATS-1 satellite and the development of the Line Islands Experiment.)

RAMAGE: It becomes pretty obvious that what we figured almost a year ago, when we began this project, has come to pass.

Let's face it, this international program, from TROMEX on, is really largely an American program. If we gather our ideas together and present them, probably scientific groups from other countries will trail along. This is fair to say, I think. This country is going to be the effective one out of the hundred or so participating. Therefore, I feel that we should start the ball rolling. We should not wait for other gatherings to tell us what to do because they're waiting to be told what to do. This is where we push the button.

I very strongly support the idea that NCAR has put out that there should be a planning meeting. I'm also particularly impressed by the possibilities of getting very significant information from the meeting in Stockholm.

REX: It is hard at this early date to talk at all about the requirements that may arise. But one thing that I think would be beneficial would be to figure the Army, Air National Guard, Coast Guard, Air Force, Navy, etc. right into the project at the outset. If they knew what was expected of them in the beginning, planning problems would be greatly simplified.

Government Coordination

RILEY: I agree, so far as the Navy is concerned. I now fully understand the problem of trying to get something done in a hurry, although this time we came in sort of late. CINCPACFLT helped in the areas we were told to, and we'll cooperate wherever we can to this extent. I am sure that the purpose in the Navy is to contribute to the whole program. If there is a real possibility of an extensive field program, we could get some sort of clearance to help you more.

THOMPSON: It is our intention that the Air Weather Service support you as much as possible. If you go to the Air Force first to get the help, and your request comes back to us, we come up as best we can and will continue to help you as long as we can. Unfortunately we were caught a little short this time.

REX: Do you think the Air Weather Service should be included in initial planning meetings for future field projects?

RAMAGE: Yes, definitely.

VAN DE BOOGAARD: The Line Islands Experiment is essentially a pilot program, on the experience of which future programs can be built. The Barbados experiment in 1968 is likely to be the next large tropical project. It is a continuation of a previous project, and is controlled and conducted by Florida State University; the NCAR Field Observing Facility will hopefully play a significant role in it.

A research project in the Marshall and Gilbert-Ellice Islands area of the Pacific, around 1971 or 1972, has been suggested by one of the TROMEX working groups. It will be at least two orders of magnitude larger in scope than the Line Islands Experiment, and will demand a certain amount of international cooperation. The World Meteorological Organization (WMO) working group on tropical research has proposed a really international field research project in the area between the 180th meridian and the Philippines, and between about 30°N and 25°S, during the entire year of 1969 -- 1 January to 31 December. This area would include the Marshalls and the Gilbert and Ellice Islands. Obviously,

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time discrepancies are involved. It looks now as though technological developments necessary for this project, particularly satellite technology, will not be available before 1971. And as these experiments are prerequisites for GARP, they necessitate a shift of the date of GARP to 1973 or 1974.

REX: In Boulder, about three months ago, we thought that the most realistic date for the Marshall Islands experiment was 1972 or 1973. This is the date that we have all been working toward.

RAMAGE: I would like to bring up one point. This is the desirability of establishing and maintaining the satellite read-out station on Fanning Island, particularly since the ATS satellite is still operating, and particularly since it looks as though there will be a large experiment in five years. We've talked about this, of course, with ESSA Honolulu. We're thinking of the possibility of establishing a permanent rawinsonde station on the island. Now I feel that this may be the time to recommend a semi-permanent satellite station on Fanning. At this time, it is not very high-priority, but I think there are pretty good scientific reasons for changing the priority of the Fanning station: the Line Islands Experiment, continued operation of the ATS-1, and the continued interest in the Pacific. So I propose that such a recommendation be made a part of our proceedings. The University of Hawaii is building up the Fanning Island facility, through the cooperation of NCAR, which is moving equipment from Palmyra. We are building an air strip near the Cable Station, which will be the scientific headquarters. ESSA is also interested in this scientific facility.

OSMUN: Fanning Island is under the sovereignty of New Zealand. Therefore, if the World Weather Watch and the contribution to science are evenly distributed, New Zealand should get the opportunity to contribute. I think this is important.

REX: Have there been any contacts with New Zealand in this regard?

Government Coordination

RAMAGE: I'm sure, knowing my old friends down in New Zealand, that they would be delighted to have the United States establish a station.

REX: Does the University of Hawaii have a long-term lease?

RAMAGE: Fifteen years, I think, with allowances for renewal.

REX: Does that just involve the Cable Station area?

RAMAGE: The 37 acres of the Cable Station. If we build an airfield, this will be outside the area. However, there has been very, very favorable reaction to the idea of having an airfield. We've had a lot of encouragement and support from Commissioner Cook. I know there will be no problem.

REX: Will the University man the station permanently?

RAMAGE: We plan to have caretakers from now on, as we build it up for a science station. We are trying to get heavy equipment, and hope for National Science Foundation support to get the runway done this current year -- perhaps within six months or so. I think a permanent satellite read-out facility there would be very useful, to NASA as well as to us.

REX: Our report will reflect these comments. Any other comments?

OSMJN: I've already talked with an ESSA representative about a World Weather Watch station. We discussed Kapingamarangi, Woleai, and Pagan as possible sites for observation facilities. The Micronesians are under New Zealand sovereignty also. We don't want to take away the sovereignty from New Zealand. But one possibility would be to consider training capable Gilbertese.

RAMAGE: I agree. This would be a very good way to maintain it properly. We have a very nice relationship developing now with the East-West Center.

REX: Any other comments? Thank you. Thank you all for participating.

IV. COMMITTEE ON SITE OPERATIONSPANEL MEMBERS

W. S. Lanterman (NCAR), chairman
Robert Berg (Holmes and Narver)
Frank Callendar (University of Hawaii)
William Clardy (Holmes and Narver)
MSgt. Frank Harrison (Army Meteorological Support Activity)
Robert James (NCAR)
Robert Kubara (NCAR)
Charles T. Leeds, Jr. (Holmes and Narver)
Gerald E. Shafer (University of Hawaii)
CMSgt. John T. Schumacher (USAF Air Weather Service)
Capt. Daniel M. Whipp (U.S. Coast and Geodetic Survey), not present
Dr. Edward Zipser (NCAR)

..... Site Operations

DISCUSSION

LANTERMAN: Before we can make any specific recommendations, we should try to identify difficult problems. Going over the site operations, I broke our topic down into (1) establishment: the initial phase of getting into place, and (2) operations: food, medicine, recreation, communications, and resupply. Some of you may have other topics. Within these two areas, let's specify the problems and then make recommendations as far as specific problems are concerned. We should come up with something that would be a help in the long run, particularly in the next operation, whatever and wherever it may be. Let's first list some problems which we encountered during the initial phase. I'll ask Bob James first what his problem areas were.

JAMES: A serious problem we ran into was that the equipment was not identified. There were no shipping manifests included. The Air Force boxes were easily handled. I don't know if the Army requests manifests or not; I suspect they were in the boxes. It would pay us to be very precise about what is in each box.

LANTERMAN: Do you recommend that complete shipping manifests be put on each box?

JAMES: Exactly. A detailed statement. Also, when we arrived at Palmyra, we found that all of the cargo was in a warehouse, jammed in so it was impossible to walk through and see all of the items.

LEEDS: May I suggest that, if possible, we have a shipping clerk on each end who would have the manifests?

JAMES: You would need as many shipping clerks as there are people trying to get into the boxes.

LANTERMAN: The gist of it is that we need more complete documentation on each shipment that goes out. As far as shipping clerks are concerned, for an operation of this size I doubt if it would be practical.

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LEEDS: We might have had better control if all the shipments went to a designated receiving point on each island.

LANTERMAN: Leeds recommends that we have complete shipping documentation and someone in charge of receiving at each site. Does that take care of that problem?

JAMES: We had cargo on three islands, and it was a jumble from the time we arrived at Fanning. Much of it had to be sent to Christmas Island and Palmyra.

LANTERMAN: The recommendation would be to load very carefully and to plan and plot prior to loading. Would that do?

JAMES: I will mention another problem. There should be a good delay time for the people setting up the facilities, before the arrival of the scientific people.

LANTERMAN: We had no choice but to take them down when we did -- we couldn't have held them off for another week! The recommendation though would be to phase groups in to use the facilities as they become available.

JAMES: But I think if we fall behind schedule . . .

LANTERMAN: I couldn't agree with you more. But you can't always do it. You have got to keep flexible.

LEEDS: It would have added to the confusion if we had had more scientific people at the beginning than we did. Under the special circumstances of this program, we were forced against the wall.

JAMES: I think we wasted time and lost data by letting scientists arrive so soon.

KUBARA: Many of the scientific people are the only ones familiar with the equipment. Their equipment is delicate, and I think you will have a hard time keeping them away from it. They will want it as early as possible. When you move scientific equipment into a site, some scientific personnel should be present.

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LANTERMAN: I think that the answer to this problem is to phase in the scientists at the first possible moment. Those planning any operation are going to have to consider carefully how to get the scientists in as soon as possible.

HARRISON: Up at Palmyra, while preparing the site, I had to have some of the scientific people in order to know proper siting of all the equipment that we had.

ZIPSER: I waited for the siting of the surface equipment. It is going to be a problem to decide who is going to go and who is not going to go. In our case, the transportation fell apart, and we didn't have a secondary plan. It was only because we had enough ingenious people around using their heads that we did as well as we did, I think.

LANTERMAN: Does anyone care to identify another problem?

JAMES: I think it was unfortunate that we had only four key men who could check out the phases of the operation.

LANTERMAN: Do you think we should vest responsibility in a large number of people?

JAMES: More than one, at least, at each site.

LANTERMAN: This can be carried to extremes, of course. But we did need more personnel. The reasons we didn't have them are, I am sure, obvious to everybody.

Let us go back to the problem of lack of time. The construction group did not have sufficient time to build up the facilities so that everyone else could move in with nothing to worry about.

KUBARA: Existing facilities are a factor here. Fanning had excellent facilities. I don't think it required as much of a buildup period as Palmyra.

LANTERMAN: The time required would be a matter of the individual place -- 30 days for Palmyra, perhaps two weeks for Fanning, and for

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Christmas you would probably say "Give me a week." So I think that this is again a matter of not getting the scientists in too soon, but phasing them in as the facilities become available.

KUBARA: I believe many of our problems were due to our failure, on survey trips, to spend enough time on questions like where to locate each piece of equipment, and what equipment was required. This was probably due to factors beyond our control. I know I wasted many man-hours on arrival at Fanning. Perhaps if we had had someone that knew something about the refrigerators, he could have told us much earlier what problems we should be prepared to attack. Also, the 220-v AC lines and fuse boxes were just cut right out. This left us with a serious and unforeseen power problem.

It seems a lot of material destined for Fanning Island, that would have taken care of these items, never arrived there. I think this was one of the big problems -- control on the shipments to the various islands was not close enough.

LANTERMAN: This comes right back to the first problem. I think the second problem is more difficult to solve because it would require taking about a 40-man survey team if we had a refrigerator expert, an electrical engineer, and everything else that we required.

SHAFER: There was no electrician to change the refrigerator plug, no evacuation system down there. There were no miscellaneous cars, helicopters, etc. These are things that could have been determined during the survey trips.

LANTERMAN: Let us stick to the location of the equipment, and recommend that any survey trip determine actual sites. Although these may be changed, we should go in on the basis of this early information. Do you have anything else to add to that?

SCHUMACHER: The essence of the solution is that everything in a good logistics plan must have a certain amount of flexibility to it. These are basic problems. You will run into them anyplace.

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KUBARA: I think we would reap benefits from having representatives from all participating agencies along with the survey team.

LANTERMAN: All the agencies were invited to send representatives.

HARRISON: This was our big complaint. This was the first time we have ever had so large a group of personnel and equipment deployed without the benefit of a site inspection.

LANTERMAN: I recall that prior to the survey trip the Army was invited to send someone to it. At that time, it was not even known that you were going to be involved.

SCHUMACHER: I would like to recommend that the parties at the working level participate in the survey.

JAMES: One of the serious drawbacks in the off-loading operation was the unreliability of the surplus equipment. We should have it checked out more carefully.

LANTERMAN: The recommendation is either to have new equipment, or to check thoroughly on the surplus.

LEEDS: The equipment was really old, and the things that worked all right at check-out broke down after they got there.

KUBARA: We had a minimum of spare parts. If more effort were placed on providing spare parts, we might have avoided some of these problems.

CLARDY: Obviously there are a lot of things you can't forecast.

LANTERMAN: I think this all ties together into the problem of surplus equipment. There should be a basic supply of spare parts. Let's take up some of the other items which are tied in with the operational phase. Does anyone have anything to say about the food?

KUBARA: I think the food was great.

HARRISON: I will second that. The quality of the food was fine.

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LANTERMAN: No problems in the food area? Let's go to recreation.

JAMES: We should have had more time for recreation.

LANTERMAN: This problem, as it turns out, is one of personnel.

KUBARA: Our personnel worked seven days a week. The Air Weather Service men had twelve hours on and twelve hours off, roughly. I think it involved a tremendous effort on their part to carry out the program.

HARRISON: I know from our initial meeting in January that I should have been a little more insistent about four more people, even though there may have been a logistical problem in handling them. Those four additional people would have allowed the two satellite islands to conduct a much more thorough observation program.

LANTERMAN: The problem isn't as simple as just adding people because every time you start adding four people for logistics another three or four scientists are going to come in. I think you are probably right. You could have used more people, but you have got to compromise somewhere between getting the program going with what you have or not doing it.

So I think the personnel problem is one that we all recognize. We can only recommend that an adequate ratio of support personnel be used to insure optimum scientific success.

I am not sure how many more areas we can cover. Certainly there was difficulty in communications and the only possible recommendation is to have more operators, more equipment, radios and teletypes.

JAMES: We could talk about the roll-up just briefly. As I indicated this morning, we were ready to come off the island as soon as the aircraft were scheduled in.

LANTERMAN: Initially we were told there would be only one plane, and a crew rest would be needed between flights. We were trying to accommodate ourselves to the availability of aircraft. The roll-up

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was scheduled very closely to the way it worked out. We could, perhaps, have gotten out faster, but if we had tried to do it faster, we might have required two extra flights. I think that it was more orderly and worked more smoothly because it was phased out over an extra day.

There are areas that we have left uncovered. If you have noted any other problems in recreation, personnel, or communications, I would appreciate hearing from you.

V. COMMITTEE ON AIR OPERATIONSPANEL MEMBERS

J. W. Hinkelman (NCAR), chairman

Cleon Biter (NCAR)

Maj. Richard L. Chapple (USAF 57th Weather Reconnaissance Squadron)

Robert Kendall (Catalina Limited)

Thomas Kendall (Catalina Limited)

Loyd Newcomer (NCAR)

Lou Owen (Holmes and Narver)

Dr. Edward Zipser (NCAR)

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DISCUSSION

HINKELMAN: The meeting will come to order. There have been no specific guidelines set as to what we are to do, but I have prepared an outline setting forth topics we might discuss. I think from the overall standpoint we should concentrate on suggestions which might improve future operations.

The areas to be considered are: (1) logistic flight operations, (2) research flight operations, (3) airport operation and control at Palmyra, (4) air operations management (operations center) at Palmyra, (5) navigational and communications facilities, and (6) weather briefings. We might discuss these things from the standpoints of original planning, quality, efficiency, and cost.

Let me review for you the air operations management plan for LIE. We developed a plan which spelled out functional control at Palmyra for operations for the Islands. We set up an operations center at Palmyra in which we could provide everything necessary for total LIE program operations, flight planning, and research support. Loyd Newcomer was manager of the Palmyra operations center and the Palmyra airport operations. As for airport operations, we had a gasoline-driven fuel system and an auxiliary power unit at Palmyra. We utilized a gasoline-driven fuel system at Christmas, but no APU. In Honolulu the logistic air operations support was controlled by Jack Tefft.

For Nav-Com facilities, there were two homers, one at Fanning and one on Palmyra. The Queen Air had Loran C, doppler, and celestial capabilities. Air-to-ground, we had single side band HF and VHF (Unicom) for airborne control at Palmyra. We used HF for long-range communications from air-to-air. We used single side band for point-to-point on the ground, between the Islands and Honolulu.

For logistic support we had the PBY, which made several flights back and forth to Honolulu as well as flights between the Islands, and the Air National Guard C-97s, which made eleven flights to the Islands.

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An Air National Guard C-124 and a Coast Guard C-130 each made an emergency flight. One Navy C-118 and one Coast Guard C-130 flew roll-up flights. The D-18 Twin Beech we had planned on but didn't have. (The D-18 aircraft, which was to be used by NCAR for inter-island transportation, was ditched and lost at sea while being ferried by the contractor from Honolulu to Palmyra. The flight crew was rescued by a Japanese fishing vessel, after the aircraft was located by the NCAR Queen Air.)

For research operations, we had a USAF B-47 weather reconnaissance plane from Hickam, the Navy C-121 operated from Barbers Point, Hawaii, and of course the Queen Air based at Palmyra. These planes gave us a total of 60 flights -- 260 hr. We had research support from the Woods Hole C-54Q, too. And photos were taken from an FAA Superconstellation on regular flights.

CHAPPLE: From our standpoint the USAF part of the mission was a success. We had 30,000 to 35,000 ft altitude for the aircraft. We completed 20 out of 21 flights and have 7 to go.

HINKELMAN: How was coordination and control with NCAR?

CHAPPLE: There were no problems. Our crews were briefed. We did not have a qualified meteorologist on board our craft. In spite of this, we can continue to operate for the last seven missions.

HINKELMAN: Did you have any air-to-air communications with anyone else?

CHAPPLE: We normally work through Hickam AFB. Information we could give them was an added bonus to everybody in the field of meteorology. We used our own facilities at Kunia, so the information would go out daily, but I don't believe we got all the information disseminated to everybody. To my knowledge, no contact was made with Fanning by aircraft, and contact with Palmyra was infrequent. We did not particularly need the assistance of Fanning, Christmas, and Palmyra. We had direct control here at Honolulu. Navigation was not a problem.

HINKELMAN: Did you use our homer at Palmyra?

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CHAPPLE: I am sure that some of us tried the homer, but we had radar that picked up Palmyra Island.

KENDALL: You used radar for navigation?

CHAPPLE: We used doppler or celestial or a combination. I talked with the navigators personally, but none of them had problems.

HINKELMAN: The Navy isn't represented today at this meeting. From a logistic standpoint, the Navy provided a C-118 transport during roll-up. I guess you discussed the operation with them.

CHAPPLE: They were operating with doppler and apparently had no trouble.

HINKELMAN: I was involved in setting up the logistics support flights. From what I understand, Lcdr. Lee did most of the work in setting up the Navy flight. He couldn't be here today. But my understanding is that everything came off perfectly.

Next, we ought to ask the NCAR people who operated the Queen Air for comments.

BITER: I have two points that I would like to bring out at this time, more from the standpoint of research than of operations. First, instrumentation on the aircraft: On another project, where more people and more islands are involved, we ought to have some way to carry standard instruments for calibration -- a flying lab to calibrate ground instruments. We should have some sort of standards, particularly in the tropics, to keep our instruments running throughout the entire project.

Second, we felt that we had inadequate communications between our base, wherever it might be, and NCAR itself. We didn't know what was going on at home base and at Palmyra. We would like to have been able to talk to the NCAR scientists to get some of their knowledge over the phone, instead of having to transport them to the field.

HINKELMAN: I understand there were no problems in air operations at Palmyra. We operated regardless of weather.

BITER: The Queen Air operation worked exceptionally smoothly.

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NEWCOMER: You mentioned the operation of the field at Palmyra. This was a relatively easy job because traffic in the area was so light -- mostly our own. The operation involved checking runways, making sure that there were no foreign objects on them, checking the markers along the side, assisting the pilot in landing, and keeping an eye on the wind indicators. We checked the communications, the runway homer, the radio operation provided by Holmes and Narver, and the VHF station used for communications in the vicinity of the field. The flare pots which were provided to mark the airport runway were quite effective.

I don't feel we got much use out of the operations center, except as a planning area where the pilots and navigators could work out details for the flights. The map on the board assisted the scientists in discussing each day's program. But there was no one to man the center during the time the planes were in the air. We sketched our flight paths with a grease pencil on a small, plexiglass-covered map, and left it with the radio operator in the radio room. He kept a record of the flight progress reports provided by the pilot. One could go to the radio shack at any time and get the latest position and intention of the PBV or Queen Air pilot.

The two radio operators provided by Holmes and Narver to man the facilities were very competent and worked long hours.

NEWCOMER: One other item in regard to the facilities in the Islands. At Palmyra one building was used for too many essential activities -- the same building housed the kitchen, mess hall, communications center, medical dispensary, post exchange, administrative headquarters, operational navigation, and records center. Had this building been destroyed by fire, a serious situation would have resulted. In the future, dispersal of essential activities should be considered.

HINKELMAN: As far as the airport operations in Palmyra are concerned, there was no crash equipment except a couple of CO₂ bottles. The flare-pot idea was good, an innovation that really helped. How about better navigational facilities?

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NEWCOMER: For maximum safety, I feel long- and medium-range navigation over the high seas demands the knowledge and skills of professional navigators. Most aviators acting in the capacity of pilot-navigator lack the capability of navigating with a high degree of precision. Several times the need for better navigation skill was apparent; the case of the pilot of the D-18 points this up best. In the future, if we can't afford the services of practicing, qualified, professional navigators, we just can't afford the operation.

CHAPPLE: Coupled with this need for highly skilled professional navigators, we need good terminal navigational facilities on the various islands. We have to consider two things: the transmitters on the islands and the equipment in the airplanes. The two have to work together.

NEWCOMER: We did need better terminal navigation aids. The non-directional homers on Palmyra and Fanning were of limited range, using the equipment we had on the Queen Air. The military planes had greater success, so probably some of the difficulty stemmed from the equipment aboard our own airplane. We would have to go to heavier equipment than we had to equal the ADF success enjoyed by the military pilots, and this increased weight would be almost prohibitive on a light aircraft such as ours.

For future operations in remote areas, thought should be given to using more modern transmitters. Frontier Airlines, for example, operates homing facilities on a need basis throughout the area they serve. They use small, low-frequency transmitters with reasonably good range. VHF DF sets, radar, tacan, and VHF omni should all be considered for terminal navigation aids in planning future operations of this nature.

Before I go into communications, I'd like to talk about air search-and-rescue. I don't feel an airplane should be operated alone in remote regions where air search-and-rescue is not immediately available. At least two airplanes should operate together, flying side by side. Or one should be on a standby basis while the other is aloft. These two airplanes should be equipped to rendezvous at sea by electronic means.

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I realize we planned to have two airplanes in the Line Islands at all times. But this did not always happen.

In addition to having a second airplane for search-and-rescue purposes, it is desirable to have airplanes of the same type based together in remote regions so one can be a source of parts for the other. Cannibalization of parts would enable one plane to continue limited or full-scale operations if the situation warranted the risk of operating without a search-and-rescue aircraft. Keeping one airplane in commission by cannibalizing could prove to be a matter of life or death if the need for a fast emergency evacuation arises.

HINKELMAN: How does this tie in with the fact that we had a complete set of spares on hand?

NEWCOMER: Clyde Hudson and Robert Beabout did a very fine job of selecting spare parts. In operating an airplane in a remote area, you can't always take all the parts in a spare-parts kit. In our case we took along everything that was needed.

HINKELMAN: Did this apply to all the types of aircraft in the area?

NEWCOMER: When operating a four-engine airplane in a remote region the need for a search-and-rescue aircraft is not so important. But I think we can profit from procedures used by the Navy: they will not operate any airplane in an isolated area without search-and-rescue capability nearby.

HINKELMAN: Did you consider the PBY effective in search-and-rescue?

NEWCOMER: Yes. Also the Coast Guard based as far away as Honolulu has been able to help an airplane in trouble while it is still in the air.

HINKELMAN: How about ground logistics support, as in Palmyra?

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NEWCOMER: Quite adequate, and credit goes to the men who supported us. When we needed fuel drums, we got them. There was no problem in this area. They provided shelter for maintenance work.

Another item: overgrossing. Flights should be so planned that, after taking into consideration the payload and the reserve fuel requirements, the maximum allowable gross weight is not exceeded. We operated consistently 300 to 500 lb in excess of the maximum allowable gross weight. This was done to achieve the range desired. Operating the Queen Air at weights ranging from 8800 to 9000 set up a potentially dangerous situation in the event of an engine failure. For approximately the first two hours of each flight it is doubtful if we could have avoided ditching at sea if an engine had failed. The answer to this problem is longer-range airplanes with better engine failure characteristics, such as four-engine or modern twin-engine turboprop planes.

HINKELMAN: Would you characterize the Queen Air operation as a safe operation?

NEWCOMER: Yes, except that we might not have had single-engine performance early in the flights. We lived with this doubt rather than do any testing to remove it.

HINKELMAN: The weight problem came up because on most of the flights we carried more equipment and people than we originally thought we would.

How about communications?

NEWCOMER: They were not always satisfactory. Our SUNAIR, ASB-100 transceiver was not always reliable. It would have been desirable to utilize a more expensive and more reliable type, but there was the weight problem in the light airplane. Weight becomes a big factor, and probably the next set on the market that would have benefited us would be a set weighing 100 lb more than what we had.

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KENDALL: When we used this set, we had excellent reception from Honolulu. The power pack unit weighs not more than 50 lb. If you want to specify a good homing unit for air rescue, we suggest you obtain or build some self-contained 500-kc emergency sets such as are found in all ADF units, standard emergency equipment for operation, 20 to 25 oz. Landing and taking off at Palmyra did not justify putting in a big VHF. In the future, set up a single side band HF system and use that for coordination throughout the total flight. I have not been able to carry Collins single side band. Another set on the market is a quarter the weight of the SSB and will run for hours. Plug it into the aircraft's 12 v and it will give a 1000-mi range adequately, especially with a good antenna.

HINKELMAN: It is true we could have used single side band HF to greater advantage. At NCAR we plan to acquire single side band for research in the Boulder area. This extended-range communication would enable scientific and operational people to talk back and forth.

KENDALL: We feel Unicom on Palmyra was of some use. Civil aircraft flying over the area did not have trouble. Navigation-wise, low-frequency homers were used. From the safety standpoint, they were inadequate. We should look into VHF DF transponder systems. Fred Clark brought one down, and it is my understanding that it never worked. He took the equipment back. But this was a fine idea.

ZIPSER: Do you feel that a transponder system is necessary?

HINKELMAN: We knew before we started that we were going to have navigation problems. We talked with Beech Aircraft about homing problems with the antenna at the low side of the aircraft. We did try radar tracking. Fred Clark operated the radar system. I don't know why it couldn't track the aircraft. But the self-contained systems and low frequency on the ground were not adequate. We did have celestial, Loran C, and doppler on the Queen Air, but I agree that safety could have been improved.

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As regards the Twin Beech ditching: the Queen Air and all aircraft operating out in our area should have been informed of VHF frequencies. The doppler navigation system had no trouble pinpointing the Twin Beech craft that was lost. The Beech pilot was briefed about the facilities that were available on Palmyra.

KENDALL: You could probably pick up a 1600 to 5000-kc medium-frequency broadcasting system operating at 25 kc off the standard band. You would have quite adequate ADF facilities 400 to 500 mi out.

ZIPSER: In large future operations, perhaps in the Barbados program, there will be scientific requirements for vertically stacked, coordinated aircraft missions.

HINKELMAN: I think everything has been covered except the PBY operation and weather briefings. We have discussed logistic support, flight operations, airport operations and control at Palmyra, navigational and communication facilities, and air operation management.

Logistic-support-wise, Lou, your people (Holmes and Narver) and the construction people were extremely helpful. Your operations were well planned, and it showed in the way you had everything set up.

OWEN: The Holmes and Narver group is a service group. We can serve you best when we know what we are serving, what your goals are, and what is expected of us.

HINKELMAN: Some of the goals developed during the program!

KENDALL: Everybody, including Holmes and Narver, should have been kept informed of what your ultimate goals were. Properly informed, we could have functioned more effectively. The scientists should have told us what their objectives were and what they were trying to achieve. You must plan ahead and not go off halfway around the world on short notice.

HINKELMAN: In the future, we should work out plans and logistic support more carefully. Informing people about operations is above and beyond our purpose here. The people concerned with logistic support in

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the operation should know the expected goals. When I was out here in March, I called on the Air Guard and the Navy. I outlined the program, brought out maps of the Islands, listed our facilities, and gave them publicity on the operation. But when I talked to some of the crews later I realized that the people actually involved in the operation didn't understand the problem.

CHAPPLE: Before we start to fly, our signal center informs our crews of our goals and the goals of the total operation. I don't know about the other operations.

HINKELMAN: I think the roll-up ran pretty smoothly. By then the people had been briefed!

BITER: By the last few weeks, things were organized and could have run for a year.

OWEN: My own experience with administrative people is that they can work more effectively if, when they carry the ball, they know which way to run.

HINKELMAN: This comment was expressed in the Islands also. Management is responsible for communications, and I think this is a very important thing.

Let me summarize now: (1) Operationally, the aviation part of the program was a success. (2) From the logistic standpoint, we were undermanned for the kind of operation expected, although NCAR and Holmes and Narver provided adequate general logistic support. (3) The search-and-rescue operation when we lost the D-18 was well executed, but pointed up the fact that navigation capabilities were marginal. I must admit there had been questions raised about our bringing light aircraft to the Islands. (4) Not enough information was put out in advance about the overall plan and information did not disseminate adequately. Most non-NCAR people involved in the operation were not aware of what the goals were. (5) We should have had more time to get ready.

