A Survey of Hawaii for Balloon Launch Sites

JACK M. ANGEVINE

August 1967
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- To bring about improved description and prediction of astrophysical influences on the atmosphere and the space environment of our planet;
- To bring about improved description and prediction of atmospheric processes and the forecasting of weather and climate;
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University of Michigan
University of Minnesota
New York University
University of Oklahoma
Pennsylvania State University
Saint Louis University
Texas A & M University
University of Texas
University of Utah
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University of Wisconsin
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PREFACE

A group under Dr. Luis Alvarez at the Space Sciences Laboratory, University of California, is preparing a balloon-borne particle physics experiment, designed for recovery at sea. Winter flights in westerly winds require a launch site with water to the east, preferably near California. At the request of Dr. Alvarez' group, NCAR carried out the following survey of potential launch sites in the Hawaiian Islands.
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PURPOSE OF SURVEY

The survey trip reported here was undertaken, 23 April through 5 May 1967, at the request of Dr. Luis Alvarez' group, of the Space Sciences Laboratory, University of California, Berkeley. This group is preparing a balloon-borne particle physics experiment, designed for recovery at sea. Summer flights may be made from California, but winter flights in westerly winds require a site with water to the east, preferably near California. Hawaii is an attractive area for such flights. It meets these requirements and avoids complications of customs clearances, immunizations and international cooperation that would be necessary for flights from a foreign country.

On the survey we considered available facilities, weather conditions, logistics problems and living accommodations, and made initial contacts with governmental agencies, such as FAA, which would be involved in any plans for actual launches. We made no commitments relating to any proposed flight program.

PROJECT REQUIREMENTS

Primary emphasis was on finding locations to launch a cable-restrained tandem balloon system initially laid out on the ground to a distance of 450 ft from the payload, then raised to a height of 600 ft before being released. The payload would be handled by the double-anchor-line technique, requiring installation of ground anchors in a circle of 90-ft radius about the payload. An assembly building 35 ft sq and 50 ft high would be needed near the launch area. Projected payloads of 10,000 lb and gross inflations of 17,000 lb would require large heavy equipment, including winch trucks and helium trailers.

The need to concentrate on these heavy-payload requirements kept us from evaluating sites for launching moderate-size payloads by the dynamic
method. More specifically, the need to consider launches from a fixed point away from active runways made it impractical to investigate runways for launching balloons dynamically. However, most of the information presented here should be applicable to both types of launch.

PERSONS CONTACTED

Fleet Weather Central, Pearl Harbor
  Capt. William Hubert, Commanding Officer
  Cdr. Englehart, Executive Officer

Fleet Meteorologists' Office, Pearl Harbor
  Cdr. Tom LeDew, Executive Officer
  Lcdr. S. Riley

Regional Climatologist, ESSA, Honolulu
  Mr. Saul Price, Regional Climatologist
  Mr. Bud Dorr
  Mr. John Lee

Federal Aviation Agency, Honolulu
  Mr. LaBarre, Air Traffic Division, Air Space and Standards Branch
  Mr. Sacks, Air Traffic Division, Air Space and Standards Branch
  Mr. Dau, Honolulu Area Office, Air Traffic Control Branch
  Mr. Richards, Chief, Honolulu Air Route Traffic Control Center
  Mr. Butterfield

6486th Air Base Wing, Hickam AFB
  Lt. Col. Tracy S. Breed, Assistant Deputy Commander for Operations
  Mr. William C. Miller

Wheeler Air Force Base, Oahu
  Lt. Col. James McGovern, Base Commander
  Maj. Dwight Smith, Executive Officer
  CWO Franklin Hodge, Base Engineer

Pacific Missile Range Facility, Hawaiian Area (Kaneohe MCAS), Oahu
  Capt. R. W. Rynd, Commanding Officer
  Cdr. C. A. Carr, Executive Officer
  Cdr. J. B. McKinney, Operations Officer
  Lcdr. J. R. Harrison, Operations Coordinator
  Mr. J. P. Gregg, Special Operations Coordinator
POSSIBLE SITES

We found two possible launch sites for the type of balloon flight required by Dr. Alvarez' group. The best site is Barking Sands Pacific Missile Range Facility on the island of Kauai. An alternate site is Wheeler Air Force Base on Oahu. Each site is discussed in detail later in this report, and is summarized here, along with brief mention of other sites considered.

PMRF BARKING SANDS

The major advantage of this site over others in Hawaii is that the Facility tracks missiles as an everyday activity. Tracking equipment and capabilities assure that balloon flights could be tracked with high accuracy and reliability. Outside users are often accommodated; a routine is established for use of the site; a well-trained tracking crew is available; a resident ESSA weather unit takes observations and maintains forecast facilities; several good communications media are available; air traffic and FAA compliance present no problems; and transportation of equipment should be relatively easy.

To obtain permission to use the Barking Sands Facility, application must be made to the PMR Program Management Office at Point Mugu,
California, by completing a detailed set of documents. To complete the documents satisfactorily might take several weeks of concentrated effort; approval of the completed documents and subsequent approval for support of the program might take several months. Privately sponsored projects, including those of universities, probably would not qualify for support, while those of government agencies, especially the military, would qualify.

There are no quarters available on the base, and very few within reasonable distances. Visitors would have to commute as much as 30 miles one way.

**WHEELER AIR FORCE BASE**

Although the location of Wheeler Air Force Base near Honolulu means better transportation and housing facilities, a number of factors render it less desirable than Barking Sands as a launch site.

There are no active Air Force operations on the Base at present, and the runways are leased to the Army. As a result, little if any support equipment is available. Virtually everything needed for a balloon flight would have to be brought to the base, as was done for the Alvarez flight series from Chico, California. Tracking would have to be arranged with other agencies, and FAA compliance would be much more difficult to obtain because Wheeler is close to the high-density traffic area around Honolulu. An existing paved area could be used for launching, but a large number of antennas on the inactive runways restrict the available room.

Despite these difficulties, permission could probably be secured to use the Base and balloon flights should cause little interference with existing activities. Wheeler should be considered as a possible alternate site.
OTHER SITES

Two other airfields were considered but were not visited because of their obvious shortcomings. The first, Ford Island, has higher average winds than Wheeler, and is in the high-density traffic area around Pearl Harbor. Access is restricted both for military reasons and by the capacity of the scheduled ferry service.

The other site, Dillingham Air Force Base on the north shore of Oahu, lacks space and is subject to trade winds.

Barbers Point Naval Air Station, west of Pearl Harbor, is a potential site, although it was not surveyed since it appeared that winds there would be similar to those at Ford Island. Barbers Point is also near the high-density traffic areas and is an alternate field for a number of commercial airlines. Nevertheless, if neither Barking Sands nor Wheeler is available, this location should be investigated more thoroughly.

The other airports on the Islands are either too small, too remote, too busy as commercial fields, or exposed to trade winds. However, several of these might be acceptable for a nighttime dynamic launch during lightest wind and least traffic.
PACIFIC MISSILE RANGE FACILITY, BARKING SANDS

Barking Sands Facility, formerly Bonham Air Force Base, is operated by the Navy as part of the Pacific Missile Range. It is equipped for tracking missiles of virtually every type, launched from a wide variety of vehicles and locations. Within a few months the Facility will also operate an Underwater Test Range offshore which will further broaden the scope of testing activities there.

ORGANIZATION

Headquarters, Pacific Missile Range, is at Point Mugu, California. Barking Sands Facility is one of several in the Hawaiian Area Command of the Range. Others are located at Wake, Midway and Johnston Islands. The Area Commanding Officer and his staff are headquartered at the Marine Corps Air Station, Kaneohe Bay, Oahu.

PMRF Barking Sands is operated under an Operations and Maintenance contract by Kentron-Hawaii, Ltd., under the officer-in-charge and a small staff. A vertical diagram of the organization as it affects Barking Sands is shown in Fig. 1.
Fig. 1 Organizational diagram, Pacific Missile Range, as it pertains to PMRF Barking Sands.
QUALIFYING FOR PROGRAM SUPPORT

A military program requiring the facilities available at Barking Sands would almost certainly be approved for support. Programs of civilian government agencies such as NSF, NASA, and AEC can be supported under certain circumstances, while privately funded or university programs would undoubtedly be turned down.

We did not learn the exact ground rules for determining whether a program may or may not be supported. However, the procedure to be followed by a group seeking support is to visit the Program Management Office at Point Mugu. If the general support requirements seem compatible with PMR policies, a staff member will be assigned to assist in filling out the Program Requirements Document. Approval of this document by Pacific Missile Range constitutes authorization for Barking Sands to provide the requested support.

The Program Requirements Document provides for a detailed description of the program and its objectives, and also includes such items as:

- Ordnance -- specifications, use, handling procedures, storage procedures.
- Electronic equipment -- frequencies, spectrum analysis reports.
- Personnel, experimenter and contractor -- names, assignments, dates of arrival and departure.
- Trajectory.
- Tracking accuracy requirements.
- Telemetry requirements -- channels, storage, display, time correlation.
- Aircraft, other than military, that will use the airfield.
- Recovery requirements.
- Facilities requirements -- assembly buildings, shops, ground anchors.

Range support which is unique to an approved program is reimbursable, while items of general utility are provided without cost. However,
overtime pay for range employees may be charged to the program unless the overtime is scheduled for the convenience of the range rather than that of the experimenter.

LOCATION

Barking Sands is on the western tip of Kauai, approximately 129 airline miles west-northwest of Honolulu International Airport at latitude 22°01'N, longitude 159°47'W. Lihue Airport, the terminal for scheduled commercial air traffic and rental car services for the Island, is 35 miles from the Facility, by road along the south side of the Island.

Figure 2 is a map showing the location of Kauai in the Hawaiian Islands. Figures 3 and 4 show the island of Kauai and the location of Barking Sands (Bonham AFB) in more detail.

A comprehensive geographic report on Kauai and Barking Sands, prepared by J. K. Prince at the Naval Missile Center, should be available soon and will be of great interest to any group contemplating an operation from Barking Sands (Ref. 1).

CLIMATOLOGY

Climatological data have been gathered at Barking Sands since 1942. A Technical Memorandum prepared by the Sandia Corporation in 1963 is probably the best available study and may be sufficient to determine the suitability of Barking Sands for balloon launches (Ref. 2).

The data in Ref. 2 will be analyzed when the copy on order is received. The information in Table 1 was transcribed from the copy at Barking Sands.
Table 1

BARKING SANDS CLIMATOLOGICAL DATA

Years of Data: Surface Observations 1942 through 1946
Upper-Level Winds 1942 through 1946; 1950 through 1961

Hourly Surface Observations: 29,000
Sampling of Surface-Wind Data: 6 pm to 6 am

<table>
<thead>
<tr>
<th>Surface winds (mph)</th>
<th>Percentage of Observations</th>
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<tr>
<td>1-3</td>
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</tr>
<tr>
<td>4-7</td>
<td>38</td>
</tr>
<tr>
<td>≥7</td>
<td>87</td>
</tr>
</tbody>
</table>

^a number of observations
Fig. 2 Map of Hawaiian Islands
Island of Kauai

Kauai is the smallest and oldest island of the Hawaiian chain and boasts its rare tropical beauty. Its coves and coves have been worn away by its tides—resulting in soft, rolling green hills that McKenzie, the Hawaiian word for "beauty," named the "Garden Island." Deep colorful ravines, cascading golden beaches, winding rivers—largest in Hawaii—add to its wealth of beauty. It has many important historical points, but it is its principal central town of Lihue and locale of its modern airport.

Fig. 3 Island of Kauai
Fig. 4 Island of Kauai showing location of Barking Sands (Bonham AFB)
Table 1 indicates a reasonably good chance of encountering acceptable inflation conditions during nighttime hours in winter. When Ref. 2 is received, we will make a detailed study of surface conditions, sky cover and trajectories.

Winds at 600 to 1000 ft, a consideration for cable-restrained balloon launches, have not been measured at Barking Sands. The Regional Climatologist has undertaken an informal study of this problem to determine what conclusions may be drawn from available data or from subjective observations of weather unit personnel at Barking Sands.

Additional climatological data and analyses can be provided by the Geophysics Division, PMR Range Operations Department, Point Mugu, after a user contacts the Program Management Office at Point Mugu.

**METEOROLOGICAL SUPPORT**

The weather unit at Barking Sands is operated by ESSA under contract to PMR and manned by four technicians and a technician-in-charge. The unit takes hourly surface observations and fires one ARCAS rocket daily at noon. This unit is also equipped to provide rawinsonde soundings according to user requirements.

The weather unit office has a teletype circuit (351) and a facsimile receiver which accepts maps from the regional Weather Bureau forecast office in Honolulu.

Regular Weather Bureau services available in Lihue on the opposite side of the Island include two rawinsonde soundings daily, and teletype and facsimile services. Sea-state forecasts and data have been offered to the Project by the Commanding Officer, Fleet Weather Central, Honolulu, and this information can be made available at Barking Sands, either through Weather Bureau communications or through Navy channels.

A meteorologist familiar with ballooning requirements should have no difficulty forecasting from Barking Sands with the available facilities and the proffered sea-state data and forecasts.
LAUNCH AREA

An unused ramp area west of runway 19 appears to be the only possible location for launch of a cable-restrained balloon system. With modest improvements, this area could easily provide a semicircle 500 ft in radius in which to maneuver a winch truck. With more extensive improvement a 1000-ft diameter circle could be laid out in the area, if allowed to encroach slightly on the runway. If this larger circle could not touch the runway, additional work would be necessary on portions of the track crossing unimproved territory.

The required angular coverage of the winch track cannot be determined until prevailing wind directions are analyzed.

Barking Sands runways are shown in Fig. 5. The ramp area under consideration for the launch site is visible west of runway 19/1.

Figure 6 is an aerial view of runway 19 and the ramp. The beach is on the west and the Facility boundary is shown as a broken white line to the east.

Figure 7, scale 1 in. = 144 ft, shows the types of surfaces on the ramp and the surrounding terrain and also shows the positions from which Figs. 8, 9, 10, and 11 were taken.

The surfaces labeled "1" and "2" in Fig. 7 are sealed asphalt. Surface "3" is paved but has not been sealed recently and some grass is established in the cracks, as shown in Figs. 8, 9, and 11. Surface "4" is cement-stabilized soil which is well graded but has been allowed to support a considerable amount of grass and short brush. This surface can be seen at the right and left in Fig. 10 with an unsealed asphalt strip down the center leading to an old revetment, area 7 in Fig. 7. Surface "5" is graded but overgrown, as seen at the right in Fig. 9 and in the background of Fig. 10; the dark line running through this area in the aerial views may be a drainage concealed by the undergrowth.
Fig. 5 PMRF Barking Sands Runway Layout. (Illustration only -- not to be used for navigational purposes. Copyright 1966, Jeppesen & Co., Denver, Colorado.)
Fig. 6 Aerial view of runway 19.
Fig. 7 PMRF Barking Sands runway 19 and ramp area
Fig. 8 Ramp looking south.
Fig. 9 Ramp looking north
Fig. 11  Ramp looking west
All prepared surfaces, "1" through "4", would support heavy equipment such as helium rigs and winch trucks needed for a heavy-load launch. Surface "5" would have to be investigated more thoroughly and the undergrowth removed before moving equipment on it. The general character of the soil suggests that even this area might support heavy equipment with minimum preparation. The relatively arid character of the local climate also suggests few problems with wet or boggy soil; this assumption should, however, be checked carefully with the base engineer and contractors before relying on using the area unimproved.

Figure 12 shows some possible 500-ft radius winch circles which do not intersect runway 19.

FLIGHT REGULATIONS

Launches from Barking Sands would be made under one or more of the restricted airspace areas assigned to the Facility. By winter 1967-68 an additional restricted area extending to unlimited altitudes will be designated for Barking Sands to supplement the present restricted areas. A hot line between FAA Air Traffic Control Center in Honolulu and Barking Sands allows Barking Sands to invoke the restricted areas as needed during an operation.

With restricted areas invoked, FAA would have no authority over the height or proximity of tethered balloons to the runways; these matters would be the concern of the local operations personnel. As soon as a balloon left the restricted area FAA would again require compliance with Part 101 of FAA Regulations. Compliance would mean, among other things, that a tethered balloon used for wind measurements should have the required quick deflation device, even though it were tethered in a restricted area.

We do not know at present whether it would be necessary to comply with FAA cloud cover and visibility requirements for a launch from a restricted area. Further study of climatology of Barking Sands should show if launch under less than FAA minimum conditions might be necessary.
Fig. 12 Possible locations of 500-ft radius winch circles
Cloud cover and visibility are apparently usually satisfactory at Barking Sands, and questions of jurisdiction and need for FAA waivers may not arise.

**TRACKING**

Tracking from Barking Sands should present no major problem, excepting possibly in identifying a slow-moving balloon with equipment set up to track rockets. With a radar transponder aboard the experiment, such tracking should not be difficult, but thought should be given to tracking the lighter-weight tracer balloons to be flown prior to the scientific flight.

Instrumentation at Barking Sands, including tracking equipment, is described in the Appendix.

Barking Sands is bounded by cliffs and mountains to the east, which cause a blind spot in that direction. The blind spot is reduced when utilizing the tracking station on Makaha Ridge to the north-northeast. FAA radar on Mt. Kaala on Oahu would supplement the Barking Sands radar and provide a useful check.

Beyond line-of-sight the experiment could be tracked and controlled by a PMR Super-Constellation which is outfitted with complete tracking gear and based at the Marine Corps Air Station, Kaneohe. An S2F aircraft is also available for tracking, but lacks the range and capability of the Super-Constellation.

If a PMR ship were used for recovery, tracking equipment would be already available at the recovery location. One such ship, the Wheeling, is completely instrumented with command/control transmitters and FPS-16 radar. If a PMR ship could not be used, tracking from the recovery location would have to be handled either by the balloon operations contractor or by the experimenter.
TELEMETRY

A considerable amount of telemetry equipment is available at Barking Sands for the experimenter who wishes to use it. This equipment is also described in the Appendix.

Any radio equipment brought on the site by the experimenter must have been tested for emission spectra and must be operating on FCC-approved frequencies. These characteristics are included in the Program Requirements Document, and PMRF Barking Sands is equipped to monitor radio usage to assure that there is no interference with their own equipment.

RECOVERY

Recovery services might be provided by PMR if requested by means of the Program Requirements Document and approved. At least one large ship, and possibly two, are operated by PMR. The Wheeling is said to have equipment to handle missiles and launching platforms for surface launches, which might make it possible to retrieve a large heavy experiment unaided. Another ship, the Norton Sound, may also be available. Details of equipment, capabilities and schedules of these ships are not known.

In support of the new underwater range facility, PMR has recently purchased two 85-ft torpedo recovery boats of 50 tons displacement and 18-ft beam. These boats can carry eight torpedoes, which are loaded through the stern and winched forward over rollers mounted in the slanted aft deck. At present, these boats can load only torpedoes, but with modifications such as special cradles, they might be able to handle equipment larger than a torpedo. If not, they might still be useful as auxiliary tracking ships.

SHOP FACILITIES

No working areas are available at Barking Sands for use of a large customer group. The site contractor could, with little difficulty,
erect pre-fabricated buildings for shops and offices, and could readily erect an assembly building with dimensions of 35 x 35 x 50 ft.

A number of sites close to the launch area are available for buildings. One of the parking spots inside an old revetment might be used for an assembly building. A concrete bunker covered with 6 to 8 ft of earth is associated with each parking spot, and might provide storage for emulsions and for hazardous items such as squibs and mild detonating fuses.

Dust and salt would be a problem at any location on the Barking Sands Facility. Design of shop, assembly and office spaces should take this environment into account.

TRANSPORTATION

Good air transportation for personnel is available between Honolulu and the island of Kauai. Aloha Airlines and Hawaiian Airlines provide a total of eight flights from Honolulu to Kauai and ten daily return flights, as well as additional flights with modified schedules on Friday, Saturday and Sunday. These airlines use DC-9, BAC-111, Viscount, F-27 and Convair 640 aircraft. Average flight time on the jet flights is about 30 min. One-way passenger fare is $12.57 and there are several special fare schedules for families, youth, off-hours, and direct connections to the mainland. Free baggage allowance for mainland passengers with tourist tickets is 44 lb. (Free baggage that can be brought on a jet from the mainland may exceed that amount.)

Reservations should be made well in advance during the months of heaviest tourist travel -- June, July, August, December and January.

Heavy equipment and scientific gear can be transported between Honolulu and Kauai without major problems. At least one inter-island barge line, Young Brothers, operates regularly scheduled barge services to Port Allen on the south coast of Kauai. Commercial arrangements for shipment by barge may be made through the Dillingham Corporation's
Marine Services Office in Honolulu, who are also agents for States Line. A shipment on a through bill-of-lading between San Francisco and Port Allen via States Line and Young Brothers would take about nine days. To assure arrival on schedule, shipping arrangements should be made as far in advance as possible, since military requirements frequently pre-empt commercial shipments.

General Services Administration Transportation Offices could be of real assistance to a government-sponsored project in arranging shipments. Freight charges might be less on government bills-of-lading than on commercial.

Since Port Allen can handle ships to 500 ft with a draft of 35 ft, direct shipment from the mainland might be arranged rather than transshipping at Honolulu.

The road from Port Allen to Barking Sands is two lanes of asphalt with minimal shoulders. It is rough in places and needs to be resurfaced. The State Highway Department has a budget item for improvement of this road in the coming year. Even in its present condition there would be no difficulty in moving tractor-trailer rigs from Port Allen to Barking Sands. Commuters to and from accommodations on the south coast might be annoyed by the rough road and the hilly twisting route; however, the greatest hazard would be cane-haul trucks crossing the road and leaving coatings of red clay which are slick when wet.

ACCOMMODATIONS

Housing and meals for project personnel on Kauai may be a problem although other large groups working at Barking Sands have solved similar problems. Most transient groups stay at the Prince Kuhio Hotel and Apartments near Poipu Beach on the south tip of the Island, 30 mi from Barking Sands.
Some hotel rates and locations:

<table>
<thead>
<tr>
<th>Hotel</th>
<th>Single</th>
<th>Double</th>
<th>Location</th>
</tr>
</thead>
<tbody>
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<td>Prince Kuhio</td>
<td>$8.75</td>
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<td>Poipu Beach</td>
</tr>
<tr>
<td>Poipu Beach</td>
<td>7.00</td>
<td>10.00</td>
<td>Poipu Beach</td>
</tr>
<tr>
<td>Kauai Surf</td>
<td>12.00</td>
<td>16.00</td>
<td>Kalapaki Beach, Lihue</td>
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<tr>
<td>Poipu Shores</td>
<td>7.00</td>
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</tr>
<tr>
<td>Menehune Manor</td>
<td>5.00</td>
<td>7.00</td>
<td>Waimea</td>
</tr>
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</table>

We visited the Kauai Surf and Menehune Manor and found them both to be quite satisfactory. The Kauai Surf is a resort hotel with a wide range of recreational facilities, including a beautiful beach. Menehune Manor is a modern apartment with nine units, half a block from the black sand beach on which Captain Cook landed, in the small, quiet town of Waimea -- a completely different environment from the Kauai Surf. Furnished kitchen, living room and two bedrooms make up each unit, and would be suitable for families, but reservations would be difficult to get.

Other hotels and motels on the south side of the Island are listed below. No information was obtained on any of these.

- Jerves Motel
- Green Garden
- Garden Isle Beach Apartments
- Wai-o-hai Resort Hotel

Noon meals are available in the base cafeteria at Barking Sands. We did not eat at any of the other locations, but we noted that prices at Lihue Airport were comparable to prices in medium-size cities on the mainland.
WHEELER AIR FORCE BASE

Wheeler Air Force Base is the site of several Air Force Headquarters, none of which use runways or flight facilities. Runways are leased to the Army, which uses them for touch-and-go training flights, and for its helicopter and courier services.

The Base is located on the central plateau of Oahu at an altitude of 840 ft. It is near the town of Wahiawa, 17 mi northwest of Honolulu International Airport.

ORGANIZATION

Wheeler is operated by the 6486th Air Base Wing with headquarters at Hickam Air Force Base. We obtained access to Wheeler Air Force Base and introductions to the Base Commander and Executive Officer, through the Assistant Deputy Commander for Operations at 6486th Headquarters.

CLIMATOLOGY

Russell Dorr in the office of the Regional Climatologist, ESSA, Honolulu, has made a preliminary summary of the surface wind conditions at Wheeler. Table 2 summarizes his study. The left-hand column for each month shows percentage of observations less than or equal to 3 kt, the right-hand column shows percentage of observations of 11 kt or greater.
Table 2

FREQUENCY OF LIGHT WINDS, WHEELER AIR FORCE BASE
JUNE 1939 THROUGH MAY 1949;
JULY 1963 THROUGH FEBRUARY 1966

(Anemometer height varied, 15 or 30 ft)

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<td>19.7</td>
<td>21.8</td>
</tr>
<tr>
<td>12-14</td>
<td>6.6</td>
<td>29.4</td>
<td>14.5</td>
<td>26.0</td>
</tr>
<tr>
<td>15-17</td>
<td>17.7</td>
<td>12.4</td>
<td>29.9</td>
<td>9.7</td>
</tr>
<tr>
<td>18-20</td>
<td>48.2</td>
<td>3.0</td>
<td>58.4</td>
<td>3.4</td>
</tr>
<tr>
<td>21-23</td>
<td>58.0</td>
<td>1.2</td>
<td>68.2</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Table 2 shows a significant diurnal effect; lighter winds are more frequent in late evening and early morning, as might be expected. Evidently, a reasonable percentage of days would be suitable for inflation. However, we know little about the other necessary conditions for a balloon flight of this type. In particular, winds from 600 to 1000 ft have not been measured. There may be some data in archives for these levels, but the only reduced data seem to be for 1500 m and upward (Ref. 3.)

Cloud cover is a significant factor at Wheeler. Even on "clear" days trade winds crossing the Koolau Range cause some cloudiness. Whether
cloudiness exceeds FAA minimums is not known, but data are likely to exist on this subject.

The climatological data presented here are inadequate to allow conclusions about the suitability of Wheeler as a launch site. We are not working on this subject at present, but if Wheeler becomes a primary location for other reasons, a more rigorous study will have to be made. The first step should then be to query the National Weather Records Center in Asheville, North Carolina. If records are inadequate, a special study will be needed. On Oahu the means for making such a study are limited, since the local ESSA group does not have the people or facilities to make a special survey. Consequently, an outside group from ESSA, NCAR or some other agency would have to make the survey.

METEOROLOGICAL SUPPORT

The weather station nearest to Wheeler is the Weather Bureau office at Honolulu International Airport. There are no weather facilities on the Base, although a meteorologist could be stationed there without difficulty.

Upper-level winds are available only from Lihue, 90 mi northwest, and Hilo, 220 mi southeast. ESSA meteorologists believe Lihue winds are probably representative of winds over Wheeler. We could not locate any GMD equipment on Oahu.

Sea-state data and forecasts are available from Fleet Weather Central, about 15 mi away at Pearl Harbor.

LAUNCH AREA

Figure 13 shows the runway layout at Wheeler Air Force Base. Figure 14 is an enlarged layout of the potential launch area at the northwest end of abandoned runway "C". Symbols on this figure show position and direction from which Figs. 15, 16, and 17 were taken.

A large antenna farm covers all of abandoned runways "B" and "C",
Fig. 13 Wheeler AFB runway layout. (Illustration only -- not to be used for navigational purposes. Copyright 1965, Jeppesen & Co., Denver, Colorado.)
Fig. 14 Wheeler AFB partial layout
Fig. 16 Wheeler AFB runway photograph
excepting the portion of runway "C" shown in the photographs. The ramp area and end of the runway are in relatively good condition, with some weeds growing through cracks in the pavement. The ramp is slightly lower than the runway but not enough to cause any difficulty.

Circles on Fig. 18 indicate area needed for a 500-ft radius winch track which does not interfere with the active runway. A $360^\circ$ track can be drawn, with some small areas extending into unimproved territory. A track covering $215^\circ$ can be laid out completely on pavement. The entire area is downwind from the antenna farm during trade wind periods, and there are no other major obstructions further downwind.

The gulch runway "D" is in good condition and lies approximately 50 ft lower than the active runway. This runway was abandoned because of tricky winds for aircraft. It might be good for inflation of a balloon but, since it lies about $90^\circ$ to the prevailing wind, would not be of much use for a balloon launch.

**FLIGHT REGULATIONS**

Wheeler Air Force Base is an active military airfield, with control tower manned from 0600 to 2200 local time. All FAA regulations pertaining to balloon operations would be in force and waivers would be required if non-conformance were anticipated. Since Wheeler is near the high-density area around Honolulu International Airport, and Barbers Point NAS, the FAA might be reluctant to grant waivers for such items as cloud cover and visibility. Difficulty of obtaining a waiver for operation of a tethered balloon carrying an anemometer would depend on reaction of the local user, in this case the Army.

**TRACKING**

Some tracking services could be supplied by the FAA, which operates a radar station on Mt. Kaala, 8 mi west of Wheeler. Other tracking facilities would have to be supplied by the user, since none exist at
Fig. 18 Wheeler AFB partial layout
Wheeler. We found no other tracking capabilities on Oahu, although there are undoubtedly some military and Air Defense facilities.

TELEMETRY

Before committing a project to using Wheeler, inquiry should be made about radio frequencies and powers of the antenna farm on the Base, to determine whether this array would cause interference with telemetry or command equipment associated with the balloon operation.

RECOVERY

We made no survey of recovery equipment because recovery procedures for the experimental package are still being worked out.

SHOP FACILITIES

A modest amount of hangar space at Wheeler might be available for staging and work space. We did not discuss possible use of this space but did learn that permission to erect a special assembly building should not be difficult to obtain. Several out-of-the-way locations appear suitable for such a building, depending on the availability of utilities services.

TRANSPORTATION

Transportation of equipment and personnel would present no problems because of the short distance between the Base and Honolulu along a major highway. The highway is four-lane part way, but carries heavy traffic during morning and evening rush hours.

ACCOMMODATIONS

The most satisfactory accommodations for a group working at Wheeler would be closer to Honolulu. Two motels near Honolulu International Airport would provide acceptable facilities. These are the Holiday Inn and the International Inn. Rates are:
<table>
<thead>
<tr>
<th></th>
<th>International Inn (commercial rates)</th>
<th>Holiday Inn (no commercial rates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>$10.00</td>
<td>$11.00</td>
</tr>
<tr>
<td>Two in twin beds</td>
<td>12.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Two in one bed</td>
<td>12.00</td>
<td>16.00</td>
</tr>
</tbody>
</table>

To qualify for these rates the International Inn requires only that the group submit a letter guaranteeing reservations; no minimum number or other restrictions are imposed. The Holiday Inn does not charge for children under 12 who use the same facilities as the parents. There are no seasonal rate changes.

Both motels have 24-hr switchboards, and the International Inn has a 24-hr coffee shop. The dining room at the Holiday Inn is open from 6 a.m. to 10 p.m.

Reservations are usually necessary in June, July, August and December because of heavy tourist traffic. The Holiday Inn will soon be connected to the "teledex" reservation service in use at Holiday Inns on the mainland.

Accommodations nearer Wheeler are generally more austere, catering to military personnel on Temporary Living Allowances. A typical example is the Wainani Apartment-Hotel, a short distance from the gate, which has furnished apartments with living room, kitchen and one or two bedrooms for about $5.00 per person per day. There are no telephones in the apartments but they can be installed. The nearest restaurant is about 1.5 mi away.
APPENDIX

INSTRUMENTATION AND TRACKING CAPABILITIES
AT BARKING SANDS, KAUAI

(Adapted from an internal draft paper, provided through courtesy of Barking Sands Operations Personnel.)
INSTRUMENTATION AND TRACKING CAPABILITIES

COMPUTER (USQ-20B)

The Univac USQ-20B is equipped to perform real-time data reduction such as impact prediction and trajectory analysis. From ballistic parameters received via teletype from other tracking stations, the computer derives early acquisition data for the radars at Barking Sands and Kokee. After acquisition, it selects the best radar data source and updates computed ballistic parameters for transmission to the next downrange tracking station.

The AN/USQ-20B communicates with a Univac 1218 Computer at Kokee Park through the Data Terminal Buffer, the Kineplex Data Modem, and a microwave link between Barking Sands and Kokee.

The data reduction and general computational capabilities of this computer fit the system in the medium-scale class; it is approximately equivalent to the IBM 7040. With the exception of an on-line card punch, peripheral equipment is available for nearly any general computational and data reduction requirement. Available software includes the CS-1 compiling system and AS-1 assembler, trigonometric routines, conversion routines, and Fortran IV.

DATA ACQUISITION SYSTEM

The function of the acquisition system is to allow the site to take the best available data on a target's azimuth angle, elevation angle, and range, on a real-time basis, and make these data available on the acquisition buss for use by the MPS-25, MPS-26, MPQ-38, M-33, Command Control, Agave, Optics, and GMD. These stations will then use the data as an aid in acquiring a target for automatic tracking.

As soon as a station acquires track, the acquisition data are removed from the synchro drive system, and the internal data become prime. The acquisition buss data remain available in the event of a station losing track.
The Agave, MPQ-38, Command Control, and M-33 can accept and transmit only azimuth and elevation data.

The MPS-25 and the MPS-26 systems can accept and transmit azimuth, elevation and range data. The USQ-20B can transmit azimuth, elevation and range data through D/S converters.

**RADAR**

The Barking Sands Radar Complex is comprised of four radars: one each C-band MPS-25 and MPS-26, two S-band MPQ-38, and an X- and S-band M-33 acquisition and tracking radar. The instrumentation radars can: (1) serve redundantly to track the same vehicles in both the C- and S-band, or (2) simultaneously track separate vehicles.

**AN/MPS-25 Radar**

The MPS-25 is a van-enclosed C-band tracking radar with a 10-ton antenna, pedestal-mounted on a 20-ft tower. It can perform skin or beacon tracking to a range of 2000 mi. The tracking accuracy is 0.1 mil RMS in azimuth and elevation, and 5 yd RMS in range.

The MPS-25 is used primarily as a satellite and ICBM tracking radar, but also provides missile trajectory data for many other programs.

**AN/MPS-26 Radar**

The MPS-26 is a van-enclosed C-band tracking radar with a beamwidth of 1.5° and can perform skin or beacon tracking to a range of 2000 mi. It is located at Barking Sands to serve as a long-range tracking radar and to assist the MPS-25 in acquisition.

The MPS-26 is used at this station for satellite and ICBM tracking, and to provide missile trajectory characteristics for development and study programs.

**AN/MPQ-38 Radar**

The van-enclosed MPQ-38 radar is capable of tracking in S-band, both skin and beacon, to a range of 200 mi. Its primary function is to support Target Drone programs; it is also used in area surveillance and as an acquisition aid to assist the U.S. Weather Bureau.
M-33 Radar

The M-33 is a fully integrated dual-van radar, with an S-band 60-mi range acquisition system and an X-band tracking system of 50-mi range capability. A polar-to-cartesian converter, linear time recorders, and an X-Y recorder are incorporated in the van.

During local rocket control launch operations, the acquisition radar assists the Range Officer in performing area surveillance. The X-band tracking radar is used primarily in support of U.S. Weather Bureau Meteorological High Altitude Wind Studies, and secondarily to support Navy Fleet Operations.

OPERATIONS CONTROL CENTER (OCC)

Operations are coordinated and conducted from the Operations Control Center, located in the Range Operations Building. All information relevant to an operations status is relayed to OCC. Instrumentation data from site tracking stations are displayed in the Center, command control signals for drone control originate from a console located here, and all site operational communications are controlled by this station during an operation.

Data display equipment in this facility consists of three radar plot boards and associated converters, a Command Control Monitor Console, status alert monitor lights, one oscillograph, and three strip chart recorders.

A "Fox" Console is utilized by a control operator to pilot the drone on its prescribed flight path.

The Range Facilities Control Officer (RFCO), Instrumentation Coordinator (IC), and the Range Operations Supervisor (ROS) consoles include communications circuits to allow loop conferences within the site and with off-site stations, and monitoring of station communications. The desired communications setup may be selected and activated by depressing a touch-light switch on the console. Monitor status lights, indicating the operational status of each system, are available.
Telemetry data readout is not provided at OCC. However, the telemetry facility, adjacent to OCC, has extensive real-time readout facilities.

**AGAVE (AUTOMATIC GIMBALED ANTENNA VECTORING EQUIPMENT)**

The Agave unit is an automatic angle tracking device with a relatively large antenna beamwidth which enables acquisition of a target within a large angular region. The associated electronic equipment is located in the antenna pedestal housing and in the telemetry facility. The Agave antenna also serves as the primary telemetry system antenna. The unit measures continuously the azimuth and elevation angle of airborne targets, and provides acquisition data (in the form of synchro data) to the acquisition data system. The synchro tracking data are used by more highly directive tracking systems.

The Agave system tracks a space or airborne vehicle in azimuth and elevation by means of the telemetry signal transmitted from the vehicle. It can acquire and track a signal over a frequency range large enough to accommodate transmitter instability and doppler shift within the 215 to 265 MHz range.

The system uses a high-gain "iron cross" antenna consisting of four elements, in conjunction with a receiver and servo-system, to acquire and track the signal source.

**TELEMETRY**

The telemetry facility, located in the Range Operations Building, is equipped for VHF and HF signal reception, demodulation, recording, and reduction of data telemetered from aircraft, missiles, and orbital vehicles.

This equipment accommodates FM/FM, PAM-FM/FM, PDM-FM/FM and PCM/FM signal reception. Ten VHF radio frequencies may be received simultaneously. Magnetic tape recorders are used to record either pre-detection or post-detection signals. The Agave system antenna is the primary antenna for this system. All IRIG standard discriminators are available -- narrow-band channels 1 to 18 and wide band channels A to E.
PAM/PDM decommutation is available for decommutation of 30 data channels at rates from 1 to 5000 PPS. Additional modules may be added to accommodate 90 channels. PCM data may be tape recorded only.

Meters, direct writing recorders, and oscillographs are utilized for "quick look" data presentation and documentation.

Video patch bays and extensive rack-mounted test equipment facilitate rapid setup and calibration of the station for operational use.

COMMUNICATIONS

The range telecommunications system at Barking Sands was installed to support operations of Pacific Missile Range, Hawaiian Area. This system provides support to fleet operations, and to orbital, missile, and meteorological programs. PMR services are provided by the Barking Sands facility for various National Range programs. Intersite communications at Barking Sands are also provided.

Microwave links between Kokee Park and Barking Sands provide voice, data transmission, timing, teletype and remote radio transmission. Communications to Kaneohe consist of voice and teletype.

High-level RF interference at the instrumentation site led to establishment of the present remote radio frequency communication facility, situated approximately 0.5 mi north of Barking Sands Instrumentation Complex. The facility consists of a communications underground bunker, a medium-power transmitter van, an all-purpose communications van and an antenna farm.

Landline cable facilities link radio circuits to the range telecommunication center for operational programming and control.

Frequency ranges and mode of operations consist of communications in the AM, SSB, and FSK modes in the HF frequency band, and AM communications in the VHF and UHF frequency bands.

TIMING

The Timing Operations Center (TOC) at Barking Sands generates a series of individual, identifiable groups of electrical pulses held in
an extremely close time relationship. These pulses are used for correlation of telemetry, radar, and other data transmitted to and received from weapon systems, satellites or space vehicles.

TOC includes two identical but completely independent time signal generators, each supplied from separate precision frequency standards and powered by independent power supplies.

The complete system consists of a WWV receiver, two frequency standards, a clock divider, a transfer and alarm panel, time base generators, timing patch panel, line driver amplifiers, power supplies, monitor oscilloscope, recording oscillograph and other components required for a completely integrated and functional system.

The equipment is capable of generating IRIG formats A, B, C, D, E, and PMR timing signals. Any of these signals may be distributed to a maximum of 40 users by line driver amplifiers; 12 are presently being utilized at Barking Sands. The signals are supplied to nominal 600-ohm balanced wire lines at any level between -20 and +12 dbm. Six additional single-ended outputs are available in parallel form for distribution as dc voltage levels on 100-ohm balanced lines. The present wiring to the line keyer pin board allows the selection of any 6 bits of the 17-bit second storage register. However, any function may be rewired to the line keyer.

Present TOC site timing distribution follows:

- **USQ-20B** utilizes IRIG format B only.
- **Telemetry center** utilizes IRIG formats B and C.
- **Radar data from the MPS-25 and MPS-26** is time-correlated via the USQ-20B.
- **Remaining radars** have data time-correlated via strip recorders in the Operations Center of the Range Operations Building.

**COMMAND CONTROL**

The FRW-2 Command Control System transmits high-power RF signals to missiles and target drones to provide: (1) guidance and control, and
(2) destruct signals for range safety purposes. Services of this system are used extensively for drone control during naval fleet training exercises.

The basic system consists of coding equipment which translates command signals into audio tones that modulate an FM transmitter operating in the UHF band. The transmitter operates into a high-gain antenna array, automatically positioned by tracking information from the acquisition bus; or the transmitter may be manually controlled locally. Monitoring and decoding equipment translates the modulation intelligence into visual display which confirms the outgoing commands.

**FREQUENCY CONTROL AND ANALYSIS (FCA)**

Frequency control and analysis equipment at Barking Sands consists of a mobile 20-ft FCA truck and a semi-mobile 40-ft van. The truck has a built-in motor-generator power source and is completely transportable; the van requires an external 208-v, 60-Hz power input.

The truck provides FCA operation support in areas beyond line of sight from the FCA van. The truck and van work in conjunction, using triangulation methods to locate interference signals.

Electronic equipment combinations in the truck and van perform the following functions:

- Spectrum surveillance from 550 kHz to 10.7 GHz.
- Direction finding over most of the RF spectrum.
- Signal analysis.
- High accuracy frequency measurement throughout their operating range.
- Field strength measurements.

The FCA van also provides graphic recording of signal strength and command functions, and tape recording of all types of signal information from 50 Hz to 25 kHz.

The truck and van are provided with their own HF and UHF radio communications equipment so that operations with other stations may be coordinated as a range-wide system. The van is also hard-wired into site communications via the Telecommunications Center.
Much of the van equipment is installed in duplicate for simultaneous operation and to provide back-up in case of equipment failure during an operation. The van has adequate storage space for spare parts and may be made self-sustaining in maintenance. A 5-ton air conditioner and an 18-kw heating system facilitate operation under a wide range of climatic conditions.

**MISS-DISTANCE INDICATOR (MDI) AN/USQ-11A**

The Miss-Distance Indicator, AN/USQ-11, measures the distance between two moving objects in space. Miss-distance measurements are accomplished by detection and measurement of frequency changes due to the doppler effect.

A missile transmitter telemetry signal, a target transponder and ground station receiving equipment are employed in determining the doppler frequency and the resulting missile-target proximity information.
REFERENCES


