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# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DIVISION INTERNAL NOTE

## LANDING AIRFIELDS SELECTION WITH IMPLICIT DESIGNS AND OPERATIONS FOR SHUTTLE ORBITERS



[redacted]



MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

May 15, 1970

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LANDING AND RECOVERY DIVISION INTERNAL NOTE

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# 1.0 SUMMARY

The selection of optimum airfields for support of landings from earth orbit of future reusable land-landing type spacecraft, the space shuttle orbiter, is required to aid in design development and operations planning. This paper reports a study resulting in the selection of a minimum number of unique airfields that provide the maximum number of landing opportunities possible and the minimum duration of in-orbit waits possible for the entire shuttle program, as presently proposed. Some design recommendations and an operational philosophy for the shuttle orbiter are also presented.

The airfields were selected from those currently available in the free world. They are the best equipped airfields available and should require no modifications to support shuttle landings. The airfields were also selected to furnish landing opportunities for four distinct types of orbiter landings. The first type of landing considered was the planned end-of-mission landing and was designed to occur at the launch site, Kennedy Space Center, to reduce turnaround time. An airfield which would be built at Kennedy Space Center, therefore, was the first one selected. The second type of landing considered was the once-per-day landing opportunity within the continental United States. Three airfields were selected to provide this coverage--Columbus AFB, Mississippi; Bergstrom AFB, Texas; and Biggs AAF, Texas. The third type of landing considered was the end-of-first-revolution landing opportunity, which resulted in the selection of Biggs AAF to provide the coverage. The fourth type of landing considered was an emergency landing from earth orbit, which resulted in the recommendation that at least a subset out of a set of 15 unique airfields located throughout the freeworld be used. This subset would be dependent upon the specific mission profile flown and the maximum in-orbit wait time accepted. The 15 unique airfields selected were Kennedy Space Center, Florida (to be built); Columbus AFB, Mississippi; Bergstrom AFB, Texas; Biggs AAF, Texas; Darwin, Australia; N Djili, Congo; Honolulu Intl./Hickam AFB, Hawaii; Nandi Intl., Fiji Islands; Lusaka Intl., Zambia; Perth Intl., Australia; La Tontonta, New Caledonia; Andersen AFB, Guam; Ramey AFB, Puerto Rico; Kadena AB, Ryukyu Islands; and San Nicolas Island OLF, California. These 15 airfields comprise all the fields required to support all four types of landings, from missions ranging from 100 n. mi. altitudes and $28.5^{\circ}$ inclinations to 400 n. mi. altitudes and $90^{\circ}$ inclinations.

In selecting these 15 unique airfields, four shuttle orbiter design recommendations resulted. First, since a maximum hypersonic crossrange of only 250 n. mi. was assumed and subsequently shown to guarantee landing opportunities at least once every two revolutions,

it is recommended that the orbiter be designed to possess at least such a hypersonic crossrange capability. Second, since enough usable airfields exist with 10,000-foot or greater runway lengths, it is recommended that the orbiter should be designed to land and take off within 10,000 feet. Third, the orbiter landing gear should be designed not to exceed an equivalent single-wheel loading of about 50,000 lb and a tire pressure of about 155 psi, which is the average minimum runway surface strength possessed by the selected airfields. Fourth, the orbiter automatic landing system should be designed to interface with the standard instrument landing system or ground-controlled approach system currently possessed by the selected airfields or under present planning to be installed by the time of shuttle operations.

Three general levels of operational support also resulted from this study.

First: All normal end-of-mission landings would be designed to occur at one airfield, the launch site. Therefore, the highest level of approach, landing, and postlanding operational support should be concentrated at this one location.

Second: At least a medium level of operational support (less than that provided at the launch site) should be provided at the end-of-first-revolution support airfield, Biggs AAF, which is also one of the alternate continental United States airfields. This operational support is required not only for approach, landing, and postlanding operations, but also for atmospheric self-ferry, pre-ferry operations, and take-off, and is based upon the following assumptions. The occurrence of a landing one revolution from the launch site is a significant possibility because the planned shuttle insertion orbit has a low perigee (approximately 50 n. mi.), because an abort-to-orbit with an end-of-first-revolution landing is the preferred launch abort mode, and because an alternate to the launch site landing airfield on which a landing could be made one revolution later is desired.

Third: Since a remote possibility exists for landings at the remaining 15 airfields, no operational support should be provided at these airfields prior to a mission, but will be supplied on an "after-the-fact" basis after a landing has been designated to occur at one of these airfields.

As the space shuttle program develops, the assumptions used for this study will no doubt change; but even so, the airfields selected provide a maximum coverage, using a minimum number of the best available airfields for any mission profile in the range from 100 n. mi. to 400 n. mi. altitudes and $28.5^{\circ}$ to $90^{\circ}$ inclinations constrained only by the minimum crossrange of 250 n. mi. The orbiter design requirements developed are a minimum, and the general operational support concepts developed should change very little as the shuttle program develops.

## 2.0 INTRODUCTION

This paper discusses the findings of a study designed to select specific airfields to support landings of the space shuttle orbiter and to determine the implicit orbiter design characteristics and the implicit operational philosophy. This space shuttle orbiter is planned to be a single-unit vehicle similar to a jet transport aircraft in appearance, size, and landing characteristics. As such, it will require modern, well-equipped airfields for landings.

The rationale for the selection of specific airfields is discussed. First, one general guideline and 10 assumptions are stated. This is followed by a discussion of the systematic selection of airfields to support the normal end-of-mission landing, the once-per-day landing within the continental United States (CONUS), the end-of-first-revolution landing within the CONUS, and the short-time emergency landings within the free world from earth orbit. Next, the shuttle orbiter design characteristics required to use the selected airfields are discussed. An operational philosophy associated with the use of these airfields is then developed; and, finally, some recommendations are made on the exact usage of the selected airfields.

## 3.0 GUIDELINE EXPLANATION

The airfield selection procedure followed the guideline that a minimum number of unique airfields be selected that will provide the maximum number of landing opportunities and the minimum duration of in-orbit waits possible. Such a unique set of airfields will provide coverage for the entire range of mission profiles assumed applicable to the shuttle program.

# 4.0 ASSUMPTIONS EXPLANATIONS

## 4.1 Mission Profile

To limit the number of mission trajectories studied for this paper, it was assumed that the shuttle orbiter would return from only earth orbital missions with inclinations ranging from 28.5° to 90° and from circular orbits having altitudes 100 n. mi. to 400 n. mi. This range of missions includes most of the missions presently considered for shuttle reentries. To represent this mission range, three specific mission profiles were selected for detailed analysis. The first profile analyzed was a 28.5° inclination, 100 n. mi. altitude mission, which allowed the shortest longitudinal spacing between two groundtracks traced on the earth's surface by sequential shuttle revolutions (22.5°). The second profile was a 90° inclination, 400 n. mi. altitude mission, which was slightly beyond the presently designed shuttle orbiter reentry heating load capabilities and provided a reasonable maximum spacing between sequential shuttle groundtracks (25°). The third profile was a 55° inclination, 270 n. mi. altitude mission, which is the present design reference mission for the shuttle support of the space station and is of primary interest. All three mission profiles were simulated on an 1108 Univac computer by using the Lunar Trajectory Program (LTP) No. E020. Each simulated mission trajectory was then applied to the Airfield Accessibility Program (AIRAC) No. E021 on the Univac 1108 to determine the frequency of landing opportunities provided by the selected airfields. All the data generated and analyzed from these three specific mission profiles represent data for the full range of missions assumed applicable to the shuttle program.

## 4.2 Launch Site

Kennedy Space Center (KSC) was assumed to be the launch site for the space shuttle. The location of the launch site determines, in part, the location of the airfields required.

## 4.3 Shuttle Crossrange

The original design estimates of the shuttle orbiter indicated an achievable hypersonic crossrange of about 250 n. mi., which was assumed usable for this study. It is highly desirable for the shuttle to be able to reach a safe airfield using only this hypersonic crossrange instead of providing the shuttle with in-orbit phasing or atmospheric jet cruise capability. This alleviates the operational problems associated with powered maneuvers and additional fuel. This paper will show that such a small crossrange is adequate for landings by using optimum-located airfields. Reference 1 also develops the small crossrange requirement.

## 4.4 Free World Airfields

Selecting airfields from only those in the free world is assumed because of possible political and military implications. The free world excludes all countries which, under present conditions, would not be likely to cooperate with the United States in this type of program.

## 4.5 Runway Length

The assumption of using only airfields with runway lengths of 10,000 feet or more was derived from analyzing the number of airfields of various lengths available within the free world.

The number of free world airfield runways with lengths of 8,000 feet and above are tabulated in table I. The largest number available, naturally, have runway lengths of 8,000 feet or more; but, those currently available runways in excess of 12,000 feet in length are very few. As can be seen, though, a significant number of airfields exist with runway lengths of 10,000 feet or greater. This information indicates it should be possible to select airfields from those with 10,000 feet or greater runway lengths to provide an acceptable and reliable support concept.

### 4.6. Runway Surface

Constraining the airfields used to those having runway surfaces of only concrete or asphalt results from the fact that these surfaces are usually strong enough to sustain the landing weights expected for the shuttle, which is similar to the landing weights exerted by large jet transport aircraft. Some asphalt runways, though, are not strong enough to support such weights and are eliminated from consideration. Other surfaces that are used for runways under most circumstances will not hold up to such weights and are not considered in the selection process. From table I, most of the runway surfaces for runways ranging in length from 8,000 feet to 14,000 feet are of either concrete or asphalt construction.

### 4.7 Navigational Aids

In order to make use of available ground systems, the shuttle orbiter should interface with aircraft-type navigation equipment presently available. The preferred ground navigational aid for present-day landings is the instrument landing system (ILS). The second choice is the ground-controlled approach (GCA) system. The third choice is either the precision approach radar (PAR) or the approach surveillance radar (ASR). If an airfield possesses a VHF omnidirectional range (VOR) system, tactical air navigation (TACAN) UHF pulse-type omni range and distance measuring equipment, a combination VOR and TACAN (VORTAC), distance measuring equipment (DME), or direction finder (DF) equipment, some instrument ground assistance from the airfield can be obtained for approach and landing. An airfield possessing none of these aids would require a visual landing which would be totally unaided. This is assumed undesirable for such a vehicle as the shuttle.

### 4.8 Runway Elevation

Airfield runway elevations were assumed limited to 4,000 feet or less above mean sea level because higher elevations require longer runways for landings and take-offs and because airfields at the higher elevations are often surrounded by high mountains that could exceed the shuttle's cruise, approach, and go-around altitudes.

## 4.9 Weather

Even though the shuttle landing may be totally automated, conditions such as high winds, low visibility, low ceilings, thunderstorms, and snow, could dangerously affect a landing. It is, therefore, very highly desirable to use airfields where good weather prevails. In this paper, "good weather" was assumed to exist at an airfield when the frequency of occurrence of instrument flight rule weather minima was below about 10 percent for any month (this weather minima was derived from that recorded at the selected airfields [see the appendix]) The worst minimum was about 10 percent in frequency of occurrence which resulted from the worst minimum available at the airfields considered. This weather criteria was used because of the lack of any firm weather constraints for the shuttle and concerns only visibility and ceiling limits.

## 4.10 Obstruction

Since the shuttle will probably have the capability for a single go-around on the first landing attempt, high obstructions in and around the airfield would be dangerous. Airfields with such obstructions, therefore, were not selected.

# 5.0 END-OF-MISSION AIRFIELD

To delete the necessity for postmission flybacks to the launch site and to provide for quick turnaround and refurbishment of the shuttle, a fully-equipped airfield will have to be constructed at the launch site, assumed to be KSC. This airfield would be the primary end-of-mission landing site, and would require the highest level of approach, landing, and postlanding operational support. The missions would have to be designed to normally end at KSC.

# 6.0 ALTERNATE CONTINENTAL UNITED STATES AIRFIELDS

The airfields to support alternate continental United States (CONUS) landings of the shuttle orbiter are constrained to provide at least one landing opportunity per day within the CONUS. To guarantee the desired quick refurbishment and reuse of the shuttle and to obtain quick access to the returned cargo, landing opportunities within the CONUS are required as often as possible. The possibility of having to use any one of these airfields is low, though, since all normally planned CONUS landings will occur at the launch site. These airfields, in general, will not require installation of special operational support equipment prior to a mission. The constraint of at least one landing opportunity per day within the CONUS can be met, since the relative motion of the shuttle in its orbit and the daily rotation of the earth places the shuttle over the CONUS at least twice per day and at least one of these passes should be within the shuttle's hypersonic crossrange capability to reach an acceptable airfield.

## 6.1 Orbital Considerations

In this paper, it has been assumed that whenever a shuttle groundtrack passes within the shuttle's crossrange capability of an acceptable airfield, the shuttle has an opportunity to land at that airfield. Using this assumption, the general location and the exact number of the alternate CONUS airfields are determined in the following discussion.

For a shuttle flying a mission profile within the range of missions considered in this paper, the longitudinal spacing between the shuttle's sequential groundtracks is, at most, 25°. This spacing is for the 90° inclination, 400 n. mi. altitude mission (see fig. 1); therefore, the groundtrack that follows two sequential groundtracks by about 24 hours will pass somewhere between the two. Thus, at least once per day the shuttle will pass over a specific area on earth that is at most 25° in longitude long. By selecting a group of airfields within this area of passage within the CONUS, a landing opportunity at least one time per day can be guaranteed.

The center of this area of passage should be limited to locations within the CONUS. Its latitude should be below about 33°N latitude to guarantee that the shuttle orbiter can be within range of an alternate CONUS airfield from a 28.5° inclination mission and above about 30°N latitude to remain mostly within the CONUS. Then, the area of passage longitudinal spread, or length, from fig. 2 would not exceed about 620 n. mi. from center to extremity. Its total length, then, would not exceed 1,240 n. mi. when centered at the 30°N latitude limit nor would it be less than about 1,160 n. mi. in length when centered at 33°N. This variation in the area of passage length is due to the fact that the shortest distance between successive groundtracks depends on the latitude of the measurement as well as the altitude and inclination of the mission considered.

Now, considering that the shuttle can fly hypersonically up to 250 n. mi. in either direction from its orbit to an airfield (encompassing 500 n. mi.), only three airfields will be necessary to cover all of the area (1,240 n. mi. divided by 500 n. mi. or 1,160 n. mi. divided by 500 n. mi. = 3, as the inclusive integer). Since the area of passage can be covered by two of those areas and a fraction of a third, one or two selected airfields could be located slightly outside the area of passage and still guarantee that the shuttle would always fly within its assumed 250 n. mi. range of one of the airfields once per day. The area of passage location is constrained to include 102.5°W longitude by the desirability to provide a landing opportunity during the first revolution within the CONUS as is discussed in section 7.0. Considering the mission profiles, then, three optimally-located airfields must be selected to cover the area of passage as developed in the preceding discussion.

## 6.2 Alternate Continental United States Airfield Selections

As derived previously, alternate CONUS airfields are constrained to cover the area of passage within the CONUS, centered between about 30°N and 33°N latitude. These airfields are further constrained to be only military or NASA owned and operated airfields to avoid interruptions of the existing heavy civilian air traffic, for safety purposes, and for security. The selected airfields are to be the best available as described in section 4.0.

Table II lists all the United States military and NASA bases available that meet the constraints so far developed. From this table, several airfields can be deleted from consideration because of their lack of the highly desirable navigation aid (the ILS) and their lack of the necessary runway strength to withstand repeated landings of the heavy shuttle. The airfields--Luke AFB, Arizona; San Nicolas Island Orbital Launch Facility (OLF), California; and Holloman AFB, New Mexico--were all deleted from consideration because of their lack of both an ILS and of high runway strengths. The airfields--Yuma MCAS/Yuma Intl., Arizona; Cape Kennedy AFS Skid Strip, Florida; Cecil Field NAS, Florida; Key West NAS, Florida; Mirimar NAS, California; Albany NAS, Georgia; Dobbins AFB/Atlanta NAS, Georgia; and Beaufort MCAS, South Carolina--were deleted because of their lack of an ILS. The airfields--Williams AFB, Arizona; El Toro MCAS, California; Shaw AFB, South Carolina; and Reese AFB, Texas--were deleted because of their lack of runway strength.

Of the remaining airfields from which to select, one unique field is necessary as discussed in section 7.0. This airfield must be located within the 250 n. mi. shuttle hypersonic crossrange of 102.5°W longitude to meet the requirement for a CONUS landing opportunity during the first revolution. This airfield can also serve as an alternate CONUS airfield if constrained to be within the area of passage developed in section 6.1. Only one of the remaining airfields meet all of these requirements. It is Biggs AAF, outside El Paso, Texas. This airfield does not have the required ILS, which will have to be installed. (The appendix describes selected airfields in detail).

Now the problem is to select two more alternate CONUS airfields to fill in the 25° in longitude area of passage. To the west of Biggs AAF, only two airfields remain from which to select (table II)--March AFB, California; and Davis Monthan AFB, Arizona. March AFB is 49 n. mi. east of the heart of Los Angeles. Just 24 n. mi. east/northeast of March AFB is a mountain range having a peak of 11,502 feet in elevation. About 21 n. mi. west is a peak reaching 5,082 feet in elevation. About 18 n. mi. southwest is a 5,696-foot peak; some 12 n. mi. southwest is a 2,767-foot peak; 12 n. mi. west is a 2,861-foot peak; and 5 n. mi. north is a 5,696-foot peak. In general, March AFB is surrounded by mountains with high peaks, which makes it a poor choice for an alternate CONUS airfield.

Davis Monthan AFB is located 5 n. mi. southeast of the heart of Tucson, Arizona. To the east a mountain range rises to an elevation of 8,800 feet within 17 n. mi. To the north/northeast, a mountain range rises to an elevation of 9,196 feet within 17 n. mi. About 15 n. mi. west/northwest is a mountain range reaching 4,683 feet in elevation and 23 n. mi. north/northwest is a 4,800-foot elevation peak. In line with the runway approach path at 6 n. mi. north/northwest, is a 281-foot tower. In general, therefore, Davis Monthan AFB would be a poor choice for an alternate CONUS airfield, also.

To the east of Biggs AAF, and within 500 n. mi. (twice the 250 n. mi. shuttle crossrange), are located several good airfields. However, Sheppard AFB, Carswell AFB, and Dyess AFB (all in Texas), are too far north to provide landing opportunities within 250 n. mi. of a 28.5° inclination mission; and, therefore, these are deleted. Kelley AFB, located at 29.28°N, is a possible airfield to select, but it is located in the city limits of San Antonio, Texas. A better airfield is Bergstrom AFB, located outside of Austin, Texas, with no significant obstacle or weather problems. Bergstrom AFB is the best airfield available in this area; and, therefore, it is the second selected alternate CONUS airfield.

To the east of Bergstrom AFB, and at least within 500 n. mi. of Bergstrom, only three airfields remain from which to select--Barksdale AFB, Louisiana; Chennault Field, Louisiana; and Columbus AFB, Mississippi. Both Barksdale AFB and Chennault Field lie within about 250 n. mi. of Bergstrom AFB, and therefore will not provide total coverage of the $25^{o}$ longitude area of passage. Barksdale AFB is also within the densily populated Shreveport area. Chennault Field is presently a private field. This leaves only Columbus AFB, Mississippi, which is within about 500 n. mi. of Bergstrom. It is located in a thinly populated area about 7 n. mi. north/northwest of the city of Columbus, Mississippi, on flat terrain. This airfield, though, is located too far north to be within 250 n. mi. of a $28.5^{o}$ inclination orbit; however, both Bergstrom AFB and Biggs AAF, in combination with KSC, furnish the required once-per-day landing opportunities for the $28.5^{o}$ inclination missions. Columbus AFB will provide landing opportunities for missions with inclinations from about $30^{o}$ to $90^{o}$. Columbus AFB, then, is the third and final selected alternate CONUS airfield.

In summary, the selected airfields to support landings of the shuttle orbiter within the CONUS (fig. 3) are the end-of-mission airfield to be built at KSC and the alternate CONUS airfields at Columbus AFB, Mississippi; Bergstrom AFB, Texas; and Biggs AAF, Texas. The airfield at KSC is the primary landing field--the one that will normally be landed on by the shuttle and the one requiring the highest level of operational support. The other three CONUS airfields are the alternate CONUS airfields and are used to guarantee at least one landing opportunity per day within the CONUS. These airfields, except for Biggs AAF discussed in section 7.0, have a low possible frequency of use, since most of the landings will be designed to occur at KSC, and only remote-probability emergency aborts from orbit will result in landing at Bergstrom AFB or Columbus AFB. These two airfields, therefore, would require essentially no premission development of operational support capability. Such operational support capability would be provided when a landing has been designated to occur at one of these airfields on an "after-the-fact" basis.

The landing opportunity coverages provided by each of the CONUS selected airfields are illustrated in fig. 4 for each of the three mission profiels studied. The data for this figure were generated from the two computer programs--the LTP and AIRAC.

## 7.0 FIRST REVOLUTION SUPPORT AIRFIELD

An end-of-first-revolution landing opportunity for the shuttle orbiter is a requirement due to the presently planned insertion orbit's low perigee altitude and the relatively high possibility of an abort by the end of the first revolution.

The shuttle program currently has the orbiter insertion orbit designed for a 100 n. mi. altitude apogee and a 50 n. mi. altitude perigee requiring a subsequent circularization maneuver to raise the perigee to about 100 n. mi. in altitude. If this circularization maneuver fails (resulting from a two-engine failure), the orbiter will be forced to reenter near perigee (end of the first revolution), because of contact with the earth's atmosphere. An airfield within 250 n. mi. range of the end of the first revolution passage over the CONUS is, therefore, required to support such a possible occurrence.

In the case of a system malfunction during or immediately after the launch phase, a prime method of abort will be for the shuttle orbiter to reach a contingency orbit and then deorbit and land at the end of the first revolution. The probability of detection of some malfunction requiring an abort by the end of the first revolution following a good launch is highest during the early parts of the first revolution. This indicates a desirability to have an airfield selected to support such possible aborts.

Such an airfield to support the above two cases will be constrained in location by orbital considerations. If the shuttle aborts from its insertion orbit or a contingency orbit during the first revolution, it will be from a low-altitude earth orbit of approximately 100 n. mi. in altitude. Even if the shuttle reenters from a normal mission at the end of the first revolution, it will probably be deorbiting from a low-altitude earth orbit. For the total mission inclination range ($28.5^\circ$ to $90^\circ$), then, the longitude of the shuttle would be about $22.5^\circ$ to the west of the launch site at KSC (fig. 1). This longitude, after the first revolution, would be about $102.5^\circ$W. Considering the previously developed constraints, the only acceptable airfield that is within the assumed 250 n. mi. crossrange of the shuttle from $102.5^\circ$W longitude is Biggs AAF, El Paso, Texas. This airfield will be the support site for end-of-first-revolution landings. It is an alternate CONUS support airfield, and from all missions considered, it is also usually within the orbiter crossrange one revolution following a passage within landing range of KSC. This makes Biggs AAF a prime backup landing airfield to KSC. These three factors illustrate that Biggs AAF has a possible high frequency of use and as such should require a significant level of operational support on site above the after-the-fact low level of support required at the other two alternate CONUS airfields.

## 8.0 ORBITAL EMERGENCY SUPPORT AIRFIELDS

In the event of an emergency in orbit that requires an immediate deorbit and landing (an orbital abort), it may be impossible to reach one of the four CONUS airfields. In this case, airfields elsewhere in the world would be required in addition to support such emergency landings. If such an emergency does arise, it is highly improbable that the shuttle could deorbit within one revolution (except during the first revolution of the shuttle following a launch, since this orbit will be generally 100 n. mi. in altitude or less, and the shuttle will be actively configured for such a deorbit during this time). An attempt to select emergency support airfields, therefore, will not be made to provide a landing opportunity for every revolution within any considered mission profile. Also, since no airfields exist within large areas of the Pacific and Atlantic Oceans, a shuttle could quite often make more than one revolution without passing within range of an airfield. The number of revolutions, or maximum in-orbit waits, before a landing opportunity occurs for the shuttle will be derived from the selection of a set of the best airfields available in the free world. These airfields will meet all of the constraints set forth in section 4.0.

### 8.1 Airfield Constraints

The constraints set up for these additional emergency support airfields are relaxed from those for the CONUS airfields. These emergency airfields will not require runway strengths as high as those of the CONUS airfields since the emergency airfields can be assumed to be used only one time by the shuttle and not subjected to the wear and tear of possible repeated use. Also, lower level ground navigational aids are assumed to be acceptable at the emergency airfields, although, at least an ILS, GCA, PAR, or ASR is desirable. To be within 250 n. mi. of the 28.5$^{\circ}$ inclination mission, these airfields are limited to locations not above about 33$^{\circ}$N or below about 33$^{\circ}$S latitudes. Also, both military and civilian airfields were considered.

## 8.2 Airfields Selections

After considering all of the constraints previously developed, table III lists the airfields remaining to select from the free world outside the CONUS. All those not selected in table II also remain to select from. Some of the airfields in table III were found to be undesirable for use because of persistently bad weather, rugged surrounding terrain, or dangerous obstructions. Galeao, Brazil, was deleted from consideration because of the obstructions of a mountain range within 8 miles of the field, which surrounds the airfield and Rio de Janeiro. Conakry, Guinea, was deleted because of its persistently heavy rainy season from May to October, with a mean annual rainfall of 169 inches. Conakry's drainage is also very inadequate after these heavy rains. El Libertador, Venezuela, was deleted since a mountain range running east to west with peaks of 7,998 feet elevation is located about 15 miles north of the airfield. All of the airfields in South Vietnam were deleted from consideration because of the persistent rainy weather in this area, consisting of two heavy rainy seasons with a mean cloudiness of from 50 percent in April to 75 percent in December.

Several airfields are located so close to others suitable for consideration that they each provide the same landing opportunities. In these cases, only the airfield considered the best was not deleted. Andersen AFB, Guam, was chosen in preference to Agana NAS, Guam, since Andersen AFB has a stronger runway surface and is in better maintenance. Clark AB, Phillipine Islands, was chosen over Manila Intl., Phillipine Islands, because its runway surface is stronger, and it is a USAF-controlled airfield. Ramey AFB, Puerto Rico, was chosen over Puerto Rico Intl., since Ramey AFB is a USAF base instead of civilian, and it has a stronger runway surface and an ILS and GCA. Ramey AFB was chosen over Roosevelt Roads NS, Puerto Rico, since Ramey AFB has a stronger runway surface and has an ILS; whereas, Roosevelt Roads NS does not. Chia I, Taiwan, was selected over Hsin Chu, Tai Nan and T'ao Yuan (all in Taiwan), because of the latters' weaker runway surfaces and lack of navigational aids. Chia I was also selected over Ching Chuan Kang AB, Taiwan, since Chia I generally has better weather and flying conditions. Ching Chuan Kang AB has excessively heavy rainfall and monsoons in the summer; whereas, Chia I generally has clear skies and good flying conditions, even though it is also subjected to the monsoons.

From table III, only 21 airfields outside the CONUS remained from which to select those for the orbital abort support. Several airfields within the CONUS remained; but, since landing opportunities are already provided by the four CONUS airfields for overflights of the area from

Florida to Arizona, only the airfields meeting the constraints of section 8.1, and located from about Davis Monthan AFB, Arizona, to the West Coast, as listed in table II, were retained as possibilities.

By analyzing 7 days of the groundtracks of the three representative mission profiles considered in this study and by determining when the groundtracks come within 250 n. mi. or less of an airfield by use of the LTP and AIRAC programs previously mentioned, it is possible to find one unique set of airfields that are the best available and provide the largest number of landing opportunities and smallest duration of in-orbit waits for the full range of possible shuttle missions.

The first group of this set of airfields are the four CONUS airfields previously selected--Kennedy Space Center, Columbus AFB, Bergstrom AFB, and Biggs AAF--since they are already available for support of previous mission phases and can also provide for part of the orbital abort landing opportunities.

One more CONUS airfield, located about 500 n. mi. or so to the west of Biggs AAF, could provide landing opportunities for at least one additional pass over the continent. Only three military airfields in this area provide any significant coverage. (The available civil airfields only duplicate the coverage offered by the three military bases). These airfields are Yuma MCAS/Yuma Intl., Arizona; Davis Monthan AFB, Arizona; and San Nicolas Is. OLF, California. Only one of these airfields is required and was selected, based on the groundtrack analysis.

Figure 4 presents the landing opportunities provided by each of the remaining airfields. From analyzing figure 4, the following airfields (excluding the four CONUS airfields) provide at least one landing opportunity during a revolution that no other airfield provides--Darwin, Australia; N Djili, Congo; Honolulu Intl./Hickam AFB, Hawaii; Nandi Intl., Fiji Is.; Lusaka Intl., Zambia; Perth Intl., Australia; Chia I, Taiwan; Bangkok Intl., Thailand; Karachi Civil, W. Pakistan; La Tontonta, New Caledonia; Anderson AFB, Guam; Ramey AFB, Puerto Rico; Kadena AB, Ryukyu Is.; Faaa, Society Is.; Udorn, Thailand; and San Nicolas Is. OLF, California. No other combination of these best airfields can increase the coverage that the listed 16 airfields plus the four CONUS airfields provide. These 20 airfields provide a maximum in-orbit wait (MIW) before a landing opportunity of three revolutions or about 4.25 hours from a 90° inclination, 400 n. mi. altitude mission. This MIW occurs only one time in 7 days or 102 revolutions. An MIW of two revolutions or about 4.0 hours occurs 21 times for this example mission. From a 55° inclination. 270 n. mi. altitude mission. these

20 airfields provide an MIW of two revolutions or about 3.0 hours that occurs 13 times in 7 days or 100 revolutions. From a 28.5° inclination, 100 n. mi. altitude mission, these airfields provide an MIW of two revolutions occurring seven times in 7 days or 114 revolutions. If either Calcutta or Nagpur, India, were added to the support airfields for the 55° inclination sample mission, the MIW would still be two revolutions; but, it would occur only seven times in the 100 revolutions. However, since an MIW of two revolutions is the fallout of selecting the best set of airfields, a slight increase in the occurrence of this MIW seems reasonable to accept. Calcutta or Nagpur, therefore, were not added to the selected airfields list.

Several of these 20 airfields can be deleted from use if increased MIW's (occurring more often) and thus, fewer landing opportunities can be tollerated. For instance, Faaa, Bangkok, Chia I, Karachi Civil, and Udorn can all be deleted and still keep the two-revolution MIW's for all missions considered; but, the frequency of occurrence of these MIW's will increase. For the 28.5° inclination sample mission, this two-revolution MIW occurs 18 times in 114 revolutions when the above mentioned five airfields are deleted. For the 55° inclination sample mission, this MIW occurs 16 times in 100 revolutions; and for the 90° inclination mission, this MIW occurs 26 times in 102 revolutions; with these five deletions. The 90° inclination mission, though, still has a three-revolution MIW occurring one time in the 102 revolutions.

Some additional reasons for the deletion of the above listed five airfields exist. For instance, Faaa is located on a small island that rises to 7,000 feet elevation within 5 miles of its coast, and to the west about 10 miles is an 8,000-foot peak on an adjacent island, all of which could hamper a shuttle emergency landing. Bangkok is located in a densely populated city which could be endangered by an emergency type of landing. Chia I is subjected to two monsoon seasons that could hamper an emergency landing. Karachi Civil is subjected to dust storms in the summer and rains in the winter, which could hamper emergency landings. Udorn has a heavy rainy season from May to October, which could hamper emergency landings.

For each individual mission profile, not even all of the remaining 15 airfields are required to support a two-revolution MIW. For example, the 28.5° inclination mission can be provided a two-revolution MIW that occurs 20 times in 114 revolutions by using eight out of the 15 airfields--KSC, Biggs AAF, Honolulu Intl./Hickam AFB, Darwin, Nandi Intl., Anderson AFB, Ramey AFB, and Kadena AB. The 55° inclination mission can be provided a two-revolution MIW that occurs 28 times in 100 revolutions by using eight of the 15 airfields--KSC, Biggs AAF, Bergstrom AFB, Honolulu Intl./Hickam AFB, Nandi Intl., Perth Intl., Kadena AB, and San Nicolas Is. OLF. The $90^{\circ}$ inclination mission can be provided a two-revolution MIW that occurs 28 times and a three-revolution MIW that occurs one time in 102 revolutions by using all but one--Ramey AFB--of the 15 airfields. This information indicates that for any specific mission profile, only a few of the selected unique 15 airfields would be required for support of the four types of landings considered in this paper.

The deletion of any additional airfields will increase the MIW's to three or more revolutions. To guarantee a three-revolution MIW, 12 airfields are required for the entire mission range considered. These fields are KSC, Biggs AAF, Bergstrom AFB, Columbus AFB, Darwin, N Djili, Honolulu Intl./Hickam AFB, Lusaka Intl., Perth Intl., La Tontonta, Andersen AFB, and Kadena AB. The coverage provided for the $28.5^{\circ}$ inclination mission allows a three-revolution or about a 4.5-hour MIW to occur 11 times in 114 revolutions and a two-revolution MIW to occur 11 times in 114 revolutions. The coverage for the $55^{\circ}$ inclination mission allows a three-revolution or about a 4.5-hour MIW to occur eight times in 100 revolutions and a two-revolution MIW to occur 25 times in 100 revolutions. The coverage for the $90^{\circ}$ inclination mission allows a three-revolution or about a 4.25-hour MIW to occur five times in 102 revolutions and a two-revolution MIW to occur 27 times in 102 revolutions.

For each individual mission, these same 12 airfields or a set out of these 12 can guarantee a three-revolution MIW. The $28.5^{\circ}$ inclination mission can be guaranteed a three-revolution MIW that occurs 15 times in 114 revolutions with a two-revolution MIW that occurs nine times when supported by only five of the above 12 airfields--KSC, Biggs AAF, Darwin, Andersen AFB, and Kadena AB. The $55^{\circ}$ inclination mission can be guaranteed a three-revolution MIW that occurs 28 times in 100 revolutions with a two-revolution MIW that occurs seven times when supported by five of the airfields--KSC, Biggs AAF, Bergstrom AFB, Honolulu Intl./Hickam AFB, and Kadena AB. The $90^{\circ}$ inclination mission requires all 12 of the above airfields to guarantee the three-revolution MIW.

Various other combinations and fewer numbers of these 12 airfields will guarantee MIW's from four revolutions to 13 revolutions. For the $28.5^{\circ}$ inclination mission, a four revolution or about a 6.25-hour MIW is guaranteed, using four airfields--KSC, Biggs AAF, Darwin, and Kadena AB. For the $55^{\circ}$ inclination mission, a five-revolution or about an 8.25-hour MIW is guaranteed, using four airfields--KSC, Biggs AAF, Bergstrom AFB, and N Djili. For the $90^{\circ}$ inclination mission, a four-revolution or about a 6.5-hour MIW is guaranteed, using 11 airfields--KSC, Biggs AAF, Columbus AFB, Bergstrom AFB, Darwin, N Djili, Honolulu

Intl./Hickam AFB, Lusaka Intl., La Tontonta, Andersen AFB, and Kadena AB. For the 28.5° inclination mission, a seven-revolution or about a 10-hour MIW is achieved, using only three airfields--KSC, Biggs AAF, and Kadena AB. A 13-revolution or about a 19-hour MIW is achieved using only two airfields--KSC and Biggs AAF. For the 55° inclination mission, a nine-revolution or about a 13.75-hour MIW is achieved using three airfields--KSC, Biggs AAF, and Bergstrom AFB. For the 90° inclination mission, a seven-revolution or about a 12-hour MIW is achieved using six airfields--KSC, Biggs AAF, Bergstrom AFB, Columbus AFB, Darwin, and Andersen AFB. An eight-revolution or about a 12.75-hour MIW is achieved using only the four CONUS airfields. In general, various numbers and combinations of the above 12 selected airfields can provide MIW's ranging from three revolutions to 13 revolutions, depending upon the mission profile.

In conclusion, since these orbital emergency support airfields are selected to provide for the very low possibility of an untimely reentry that will not allow a return to KSC or an alternate CONUS airfield, they will require no premission operational support. Support will be provided at the airfield only when one of the selected airfields outside the CONUS has been selected (in real time) for an emergency landing. Such support, as required, will be transported to the emergency support airfield as soon as possible to perform the required postlanding, pre-ferry, and take-off operations. These outside the CONUS emergency support airfields are considered to require an operational support level similar to the alternate CONUS airfields--Bergstrom AFB and Columbus AFB. Since the emergency support airfields will require no special premission operational support, opportunities to land as often as possible will require very little support effort. It seems desirable, therefore, to provide opportunities to land as often as possible. The 15 selected airfields (fig. 5) provide such opportunities with the occurrence, every-so-often, of a two-revolution in-orbit wait for the entire mission range considered in this study. Out of these 15 unique airfields, a subset can be selected to guarantee a two-revolution MIW for specific missions. This MIW, however, will occur more often than when all 15 airfields are used; but, if a two-revolution MIW can be accepted 10 times in a 7-day mission, its occurring 20 times seems insignificant throughout 7 days. This study, therefore, shows that a subset out of 15 unique airfields will provide any level of support for emergency, untimely landings from earth orbit of the shuttle orbiter.

## 9.0 SHUTTLE ORBITER DESIGN IMPLICATIONS

Because of the available airfield characteristics, several shuttle orbiter design considerations can be implied. Since airfields with runway lengths of 10,000 feet or more can provide acceptable in-orbit waits and since available runways of over about 12,000 feet in length are significantly fewer in number, the orbiter should be designed to land and take off on, at most, a 10,000-foot runway. Since the minimum runway strengths out of the 15 airfields selected can support an equivalent single-wheel loading of about 50,000 lb and a tire pressure of about 155 psi, the orbiter's landing gear should be designed to not exceed these runway minimum strengths. Since the airfields selected possess either an ILS or GCA, or both, the orbiter should be designed to use the ILS and GCA. Since the selection of the airfields assumed an orbiter crossrange of 250 n. mi. and showed that such a crossrange could allow desirable landing opportunities, the shuttle orbiter should be designed to have at least a 250 n. mi. hypersonic crossrange capability. All of these design implications are based on the characteristics of the best available airfields.

## 10.0 GENERAL OPERATIONAL PHILOSOPHY

A general landing and recovery operational philosophy can be derived from the fact that this study provided for four categories of landing opportunities--end-of-mission, end-of-first-revolution, once-per-day CONUS, and orbital emergency. For the planned end-of-mission, the operational philosophy should provide for the highest level of operations, as required, with the greatest level of support. For the end-of-first-revolution landing support, the operational philosophy should normally require a medium level of operations and support, since fewer actual landings should occur at this airfield than at the launch site. The operational philosophy should normally require no premission operational support for the highly remote probability emergency landings from earth orbit at any one of the two alternate CONUS airfields--Bergstrom AFB and Columbus AFB--or any one of the selected airfields outside the CONUS. Any required operational support at these airfields will be provided on an after-the-fact basis. These three general levels of landing and recovery operations are based on the possible rates of use of the selected landing airfields.

## 11.0 RECOMMENDATIONS

As a result of this study, the following support concept for landings of the Space Shuttle Orbiter from earth orbit is recommended. The primary end-of-mission airfield will normally be the planned landing site and will be located near the launch site at KSC. Three alternate CONUS airfields will be required to guarantee a once-per-day landing opportunity within the CONUS. These three airfields will be Columbus AFB, Mississippi; Bergstrom AFB, Texas; and Biggs AAF, Texas. One of these airfields will be required to provide a landing opportunity for possible landings by the end of the first revolution. This airfield will be Biggs AAF, since it is the best available to provide this first revolution landing support. At most, 15 airfields will be required to support possible emergency aborts from earth orbit. These airfields will be the one at KSC, Florida (to be built); Columbus AFB, Mississippi; Bergstrom AFB, Texas; Biggs AAF, Texas (an ILS to be added); Darwin, Australia; N Djili, Congo; Honolulu Intl./Hickam AFB, Hawaii; Nandi Intl., Fiji Islands; Lusaka Intl., Zambia; Perth Intl., Australia; La Tontonta, New Caledonia; Andersen AFB, Guam; Ramey AFB, Puerto Rico; Kadena AB, Ryukyu Islands; and San Nicolas Island OLF, California. From these 15, for specific missions, a subset of less than 15 will be selected. Such a concept will provide a reasonable landing and recovery operations and support approach to the space shuttle program.

## 12.0 REFERENCE

Ferguson, Jonny E.: Optimized Land-Landing Sites, Landing and Recovery Division, NASA, Manned Spacecraft Center, Houston, Texas, NASA Apollo Program Working Paper MSC-00159, dated September 30, 1969.

TABLE I - DISTRIBUTION OF FREE WORLD AIRFIELDS

| Runway lengths, ft | Location | Number of airfields | | | |
|---|---|---|---|---|---|
| | | Concrete | Asphalt | Other | Total |
| ≥8,000 | Inside U.S.A. | 133 | 184 | 6 | 323 |
| | Free world outside U.S.A. | 288 | 475 | 68 | 831 |
| | Total free world | 421 | 659 | 74 | 1154 |
| ≥10,000 | Inside U.S.A. | 81 | 59 | 1 | 141 |
| | Free world outside U.S.A. | 99 | 127 | 34 | 260 |
| | Total free world | 180 | 186 | 35 | 401 |
| ≥12,000 | Inside U.S.A. | 34 | 19 | 0 | 53 |
| | Free world outside U.S.A. | 18 | 27 | 14 | 59 |
| | Total free world | 52 | 46 | 14 | 112 |
| ≥14,000 | Inside U.S.A. | 2 | 2 | 0 | 4 |
| | Free world outside U.S.A. | 1 | 3 | 7 | 11 |
| | Total free world | 3 | 5 | 7 | 15 |

Source--Department of the Air Force, Headquarters; Aeronautical Chart and Information Center, Second and Arsenal: Printout of Selected Airfields; St. Louis, Missouri; November 5, 1969.

TABLE II - MILITARY AIRFIELDS SELECTED WITHIN THE CONTINENTAL UNITED STATES
HAVING RUNWAY LENGTHS OF 10,000 FEET OR GREATER

| State | Name | Lat., Long., deg-min | Elevation, ft | Runway | | | Navigation Aids |
|---|---|---|---|---|---|---|---|
| | | | | Length, ft | Construction | Strength (a) | |
| Arizona | Davis Monthan AFB | 32-10N, 110-53W | 2705 | 13,645 | Concrete | T-210K lb | TACAN, LOM, ILS, ASR, PAR |
| Arizona | Luke AFB | 33-33N, 112-23W | 1101 | 10,000 | Asphalt | T-160K lb | TACAN, RBN, ASR, PAR |
| Arizona | Williams AFB | 33-18N, 111-39W | 1385 | 10,400 | Concrete | T-100K lb | VORTAC, ILS, ASR, PAR |
| Arizona | Yuma MCAS/Yuma Intl. | 32-39N, 114-36W | 213 | 13,300 | Concrete | T-225K lb<br>SWL-62K lb | TACAN, VORTAC, RBN, D/F, GCA |
| California | El Toro MCAS | 33-40N, 117-44W | 383 | 10,000 | Asphalt | T-135K lb<br>SWL-40K lb | VOR, TACAN, RBN, UHF/DF, PAR, ASR, GCA, ILS |
| California | March AFB | 33-54N, 117-15W | 1533 | 13,300 | Concrete | T-260K lb | VOR, TACAN, ILS, PAR |
| California | Mirimar NAS | 32-52N, 117-09W | 477 | 12,000 | Concrete | T-181K lb<br>SWL-55K lb | TACAN, RBN, VHF/UHF/DF, ASR, PAR |
| California | San Nicolas Is. OLF | 33-14N, 119-27W | 504 | 10,000 | Asphalt | T-99K lb<br>SWL-36K lb | TACAN, RBN, ASR, PAR, GCA |
| Florida | Cape Kennedy AFS Skid Strip | 28-28N, 80-34W | 9 | 10,000 | Asphalt | --- | VFR daylight operations only |
| Florida | Cecil Field NAS | 30-13N, 81-52W | 80 | 12,500 | Asphalt | T-165K lb<br>SWL-50K lb | VORW, TACAN, RBN, VHF/DF, ASR |
| Florida | Eglin AFB | 30-29N, 86-32W | 85 | 12,000 | Asphalt | T-205K lb | VOR, TACAN, RBN, LMM, ILS, ASR, PAR |

(a) - Runway surface strength may be designated by: (1) T - weight exerted on runway by twin or tandem wheel landing gear in pounds, (2) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, or (3) maximum pressure runway will support in pounds per square inch.

TABLE II - CONTINUED

| State | Name | Lat., Long., deg-min | Elevation, ft | Runway | | | Navigation Aids |
|---|---|---|---|---|---|---|---|
| | | | | Length, ft | Construction | Strength (a) | |
| Florida | Homestead AFB | 25-29N, 80-23W | 7 | 11,200 | Asphalt | T-280K lb | VOR, TACAN, RBN, ILS ASR, PAR |
| Florida | Key West NAS | 24-35N, 81-41W | 6 | 10,000 | Asphalt | T-150K lb SWL-50K lb | TACAN, RBN, ASR, PAR |
| Florida | MacDill AFB | 22-51N, 82-31W | 13 | 11,420 | Asphalt | T-210K lb | ILS, TACAN, RBN, ASR, PAR |
| Florida | McCoy AFB | 28-26N, 81-19W | 96 | 12,002 | Concrete | T-330K lb | TACAN, RBN, ASR, PAR, ILS, VOR, VORTAC, GCA |
| Florida | Tyndall AFB | 30-04N, 85-35W | 18 | 10,000 | Concrete | T-180K lb | TACAN, ILS, ASR, PAR |
| Georgia | Albany NAS | 31-36N, 84-05W | 212 | 12,050 | Asphalt | T-200K lb | TACAN, RBN, ASR, PAR |
| Georgia | Dobbins AFB/ Atlanta NAS | 33-55N, 84-31W | 1068 | 10,000 | Concrete | T-300K lb | RBN, BVORTAC, ASR, PAR |
| Georgia | Hunter AAF | 32-01N, 81-09W | 42 | 11,375 | Asphalt | 650 psi SWL-65K lb | LOM, ILS, ASR, PAR |
| Georgia | Robins AFB | 32-28N, 83-36W | 294 | 12,000 | Asphalt | T-300K lb | RBN, LOM, UHF/DF, BVORTAC, ILS, ASR, PAR |
| Louisiana | Barksdale AFB | 32-30N, 93-40W | 167 | 11,754 | Concrete | T-260K lb | TACAN, ILS, ASR, PAR |
| Louisiana | Chennault Field | 30-13N, 93-09W | 16 | 11,465 | Concrete | --- | VORTAC, ILS |
| Mississippi | Columbus AFB | 33-39N, 88-27W | 214 | 12,000 | Concrete | 230 psi SWL-79K lb | ILS, ASR, PAR |
| New Mexico | Holloman AFB | 32-51N, 106-06W | 4094 | 12,228 | Asphalt | T-155K lb | VOR, TACAN, RBN, ASR, PAR |

(a) - Runway surface strength may be designated by: (1) T - weight exerted on runway by twin or tandem wheel landing gear in pounds, (2) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, or (3) maximum pressure runway will support in pounds per square inch.

TABLE II--CONCLUDED

| State | Name | Lat., Long., deg-min | Elevation, ft | Runway Length, ft | Runway Construction | Runway Strength (a) | Navigation Aids |
|---|---|---|---|---|---|---|---|
| South Carolina | Beaufort MCAS | 32-29N, 80-43W | 38 | 12,200 | Concrete | SWL-50K lb | TACAN, RBN, UHF/DF, ASR, PAR |
| South Carolina | Shaw AFB | 33-58N, 80-29W | 252 | 10,000 | Concrete | T-165K lb | TACAN, RBN, ILS, ASR, PAR |
| Texas | Bergstrom AFB | 30-12N, 97-40W | 541 | 12,250 | Concrete | 100 psi SWL-77K lb | TACAN, RBN, BVORTAC, VOR, ILS, ASR, PAR |
| Texas | Biggs AAF | 31-51N, 106-23W | 3947 | 13,572 | Concrete | T-330K lb | BVOR, ASR |
| Texas | Carswell AFB | 32-46N, 97-26W | 650 | 12,000 | Concrete | 750 psi SWL-65K lb | TACAN, VOR, ILS, ASR, PAR |
| Texas | Dyess AFB | 32-25N, 99-51W | 1789 | 13,500 | Concrete | T-250K lb | TACAN, RBN, BVORTAC, ILS, ASR, PAR |
| Texas | Kelley AFB | 29-23N, 98-35W | 690 | 11,500 | Concrete | T-200K lb | VOR, TACAN, UHF/DF, ILS, ASR, PAR |
| Texas | Reese AFB | 33-36N, 102-03W | 3338 | 10,500 | Concrete | T-100K lb SWL-25K lb | TACAN, UHF/DF, BVORTAC, ASR, PAR |
| Texas | Sheppard AFB | 33-59N, 98-30W | 1015 | 13,100 | Concrete | T-220K lb | TACAN, VHF/UHF/DF, ILS, ASR, PAR |

(a) - Runway surface strength may be designated by: (1) T - weight exerted on runway by twin or tandem wheel landing gear in pounds, (2) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, or (3) maximum pressure runway will support in pounds per square inch.

Source--Department of the Air Force, Headquarters; Aeronautical Chart and Information Center, Second and Arsenal: Printout of Selected Airfield; St. Louis, Missouri; November 5, 1969.

TABLE III - AIRFIELDS SELECTED OUTSIDE THE CONTINENTAL UNITED STATES HAVING RUNWAY LENGTHS OF 10,000 FEET OR GREATER

| Country | Name | Lat., Long., deg-min | Elevation, ft | Runway | | | Navigation Aids |
|---|---|---|---|---|---|---|---|
| | | | | Length, ft | Construction | Strength (a) | |
| Australia | Darwin | 12-25S, 130-52E | 104 | 11,000 | Asphalt | 707, DC-8 | VHF, VOR, ILS, RBN, DME, Approach Control |
| Australia | Perth Intl. | 31-56S, 115-58E | 69 | 10,300 | Asphalt | C-135, 155 psi, SWL-57K lb | RBN, VOR, ILS, VHF/DF, Approach Control |
| Brazil | Galeao | 22-49S, 43-15W | 20 | 10,827 | Concrete | C-135 | VOR, ILS, RBN, ASR, Approach Control |
| Congo | N Djili | 4-23S, 15-27E | 1014 | 15,420 | Concrete | 140 psi SWL-99K lb | UHF/VHF/DF, ILS |
| Fiji Is. | Nandi Intl. | 17-46S, 177-27E | 63 | 10,500 | Concrete | 190 psi SWL-65K lb | RBN, VOR, ILS, VHF/DF, Approach Control |
| Guam | Agana NAS | 13-29N, 144-47E | 298 | 10,000 | Asphalt | 155 psi SWL-46K lb | GCA, ASR, PAR, RBN, VOR, TACAN, UHF/VHF/DF, Approach Control |
| Guam | Andersen AFB | 13-35N, 144-55E | 624 | 11,200 | Concrete | 285 psi SWL-110K lb | ILS, ASR, PAR, VOR, RBN, GCA, Approach Control |
| Hawaii | Honolulu Intl./ | 21-20N, 157-55W | 13 | 12,371 | Asphalt | 285 psi SWL-110K lb | VORTAC, RBN, UHF/VHF/DF, ILS, ASR |
| India | Bombay/Santa Cruz | 19-05N, 72-52E | 35 | 11,005 | Concrete | 160 psi SWL-52K lb | ILS, RBN, VOR, VHF/DF, Approach Control |
| India | Calcutta | 22-39N, 88-27E | 15 | 10,500 | Concrete | 155 psi SWL-57K lb | ILS, VOR, RBN, Approach Control |

(a) - Runway surface strength may be designated by: (1) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, (2) maximum pressure runway will support in pounds per square inch, or (3) heaviest aircraft known to land without causing surface damage.

TABLE III--CONTINUED

| Country | Name | Lat., Long., deg-min | Elevation, ft | Runway Length, ft | Runway Construction | Runway Strength (a) | Navigation Aids |
|---|---|---|---|---|---|---|---|
| India | Nagpur | 21-05N, 79-03E | 1020 | 10,500 | Concrete | 105 psi SWL-36K lb | ILS, VOR, RBN, DF, Approach Control |
| Guinea | Conakry | 9-35N, 13-37W | 72 | 10,827 | Concrete | 330K lb gross | PAR, RBN, VHF/DF, VOR, Approach Control |
| Malaysia Federation | Kuala Lampur Intl. | 3-08N, 101-33E | 89 | 11,400 | Asphalt | 155 psi SWL-56K lb | ILS, RBN, Approach Control |
| New Caledonia | La Tontonta | 22-01S, 166-13E | 52 | 10,663 | Asphalt | 155 psi SWL-46K lb | ILS, VOR, RBN |
| Peru | Jorge Chavez Intl. | 12-02S, 77-07W | 105 | 11,500 | Concrete | KC-135 | ILS, Approach Control, VOR, RBN |
| Phillipines | Clark AFB | 15-11N, 120-33E | 478 | 10,500 | Concrete | 100 psi SWL-106K lb | ILS, ASR, PAR, GCA, VOR, TACAN, UHF/DF, Approach Control |
| Phillipines | Manila Intl. | 14-31N, 121-01E | 74 | 11,000 | Asphalt | SWL-50K lb | ILS, VOR, RBN, Approach Control |
| W. Pakistan | Karachi Civil | 24-54N, 67-09E | 95 | 10,500 | Concrete | 155 psi SWL-57K lb | ILS, VOR, RBN, Approach Control |
| Puerto Rico | Puerto Rico Intl. | 18-27N, 66-00W | 9 | 10,000 | Concrete | 160 psi SWL-52K lb | ASR, UHF/DF, VORTAC, RBN, Approach Control |
| Puerto Rico | Ramey AFB | 18-30N, 67-08W | 30 | 11,700 | Concrete | 285 psi SWL-108K lb | ILS, GCA, UHF/DF, VOR, RBN, TACAN, Approach Control |
| Puerto Rico | Roosevelt Roads NS | 18-15N, 65-38W | 39 | 11,000 | Concrete | 150 psi SWL-122K lb | GCA, TACAN, RBN, UHF/VHF/DF, Approach Control |

(a) - Runway surface strength may be designated by: (1) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, (2) maximum pressure runway will support in pounds per square inch, or (3) heaviest aircraft known to land without causing surface damage.

TABLE III--CONTINUEI

| Country | Name | Lat., Long., deg-min | Elevation, ft | Runway Length, ft | Runway Construction | Runway Strength (a) | Navigation Aids |
|---|---|---|---|---|---|---|---|
| Ryukyu Is. | Kadena AB | 26-21N, 127-46E | 142 | 12,100 | Concrete | 285 psi SWL-155K lb | ILS, ASR, PAR, VOR, RBN, TACAN, Approach Control |
| Zambia | Lusaka Intl. | 15-20S, 28-27E | 3779 | 13,000 | Asphalt | 270 psi SWL-106K lb | ILS, ASR, VHF/DF, VOR, DME, Approach Control |
| Society Is. | Faaa | 17-33S, 149-36W | 6 | 11,204 | Asphalt | 155 psi SWL-46K lb | ILS, VOR, RBN, VHF/DF, Approach Control |
| Thailand | Bangkok Intl. | 13-55N, 100-37E | 12 | 10,500 | Concrete | 190 psi SWL-65K lb | ILS, GCA, TACAN, VOR, RBN, VORTAC, Approach Control |
| Thailand | Udorn USAF | 17-23N, 102-48E | 585 | 10,000 | Concrete | 190 psi SWL-65K lb | GCA, TACAN, RBN |
| Taiwan | Chia I | 23-28N, 120-23E | 82 | 10,006 | Concrete | 190 psi SWL-65K lb | GCA, RBN, TACAN, DF, Approach Control |
| Taiwan | Ching Chuan Kang | 24-16N, 120-37E | 663 | 12,000 | Concrete | 190 psi SWL-65K lb | ILS, GCA, VOR, RBN, TACAN, UHF/DF, Approach Control |
| Taiwan | Hsin Cha | 24-49N, 120-56E | 25 | 10,012 | Concrete | 76 psi SWL-60K lb | ASR, PAR, TACAN, RBN |
| Taiwan | Tai Nan | 22-37N, 120-12E | -- | 10,004 | Concrete | 76 psi SWL-60K lb | GCA, TACAN, RBN, VOR, UHF/DF, Approach Control |
| Taiwan | T'Ao Yuan | 25-03N, 121-14E | -- | 10,005 | Concrete | 76 psi SWL-60K lb | ASR, PAR, TACAN, RBN, UHF/DF |

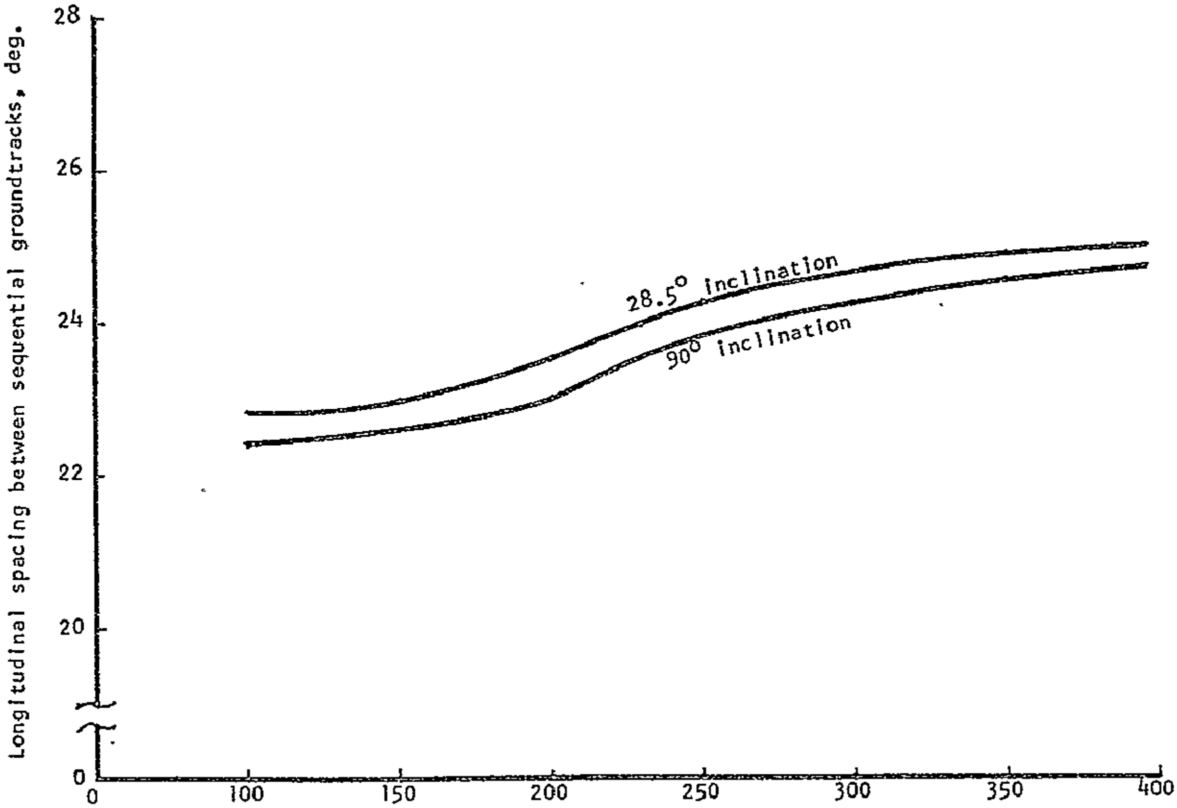
(a) - Runway surface strength may be designated by: (1) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, (2) maximum pressure runway will support in pounds per square inch, or (3) heaviest aircraft known to land without causing surface damage.

TABLE III--CONCLUDED

| Country | Name | Lat., Long., deg-min | Elevation, ft | Runway | | | Navigation Aids |
|---|---|---|---|---|---|---|---|
| | | | | Length, ft | Construction | Strength (a) | |
| Venezuela | El Libertador | 10-11N, 67-33W | 1450 | 10,224 | Concrete | 270 psi SWL-106K lb | ASR, VHF/DF |
| South Vietnam | Cam Ranh Bay | 11-59N, 109-13E | 31 | 10,000 | Concrete | 190 psi SWL-65K lb | GCA, TACAN, RBN, Approach Control |
| South Vietnam | Chu Lai AB | 15-25N, 108-42E | 25 | 10,000 | Concrete | C-141 | GCA, TACAN, Approach Control |
| South Vietnam | Phan Rang | 11-37N, 108-57E | 102 | 10,000 | Concrete | C-141 | GCA, TACAN, RBN |
| South Vietnam | Da Nang | 16-03N, 108-12E | 30 | 10,000 | Asphalt | 190 psi SWL-65K lb | ASR, PAR, VOR, RBN, TACAN, Approach Control |
| South Vietnam | Bien Hoa | 10-58N, 106-49E | 36 | 10,000 | Concrete | C-141 | PAR, ASR, RBN, TACAN |
| South Vietnam | Phu Cat | 13-57N, 109-02E | 101 | 10,000 | Concrete | 190 psi SWL-65K lb | ASR, PAR, RBN, TACAN |
| South Vietnam | Tan Son Nhut | 10-49N, 106-39E | 33 | 10,000 | Concrete | C-141 | ILS, ASR, PAR, RBN, TACAN |

(a) - Runway surface strength may be designated by: (1) SWL - equivalent single-wheel loading or single isolated wheel loading of landing gear in pounds, (2) maximum pressure runway will support in pounds per square inch, or (3) heaviest aircraft known to land without causing surface damage.

Source--Department of the Air Force, Headquarters; Aeronautical Chart and Information Center, Second and Arsenal: Printout of Selected Airfields; St. Louis, Missouri; November 5, 1969.




Note: Information for this graph was obtained from ref. 1

Figure 1.- Spacing between sequential groundtracks

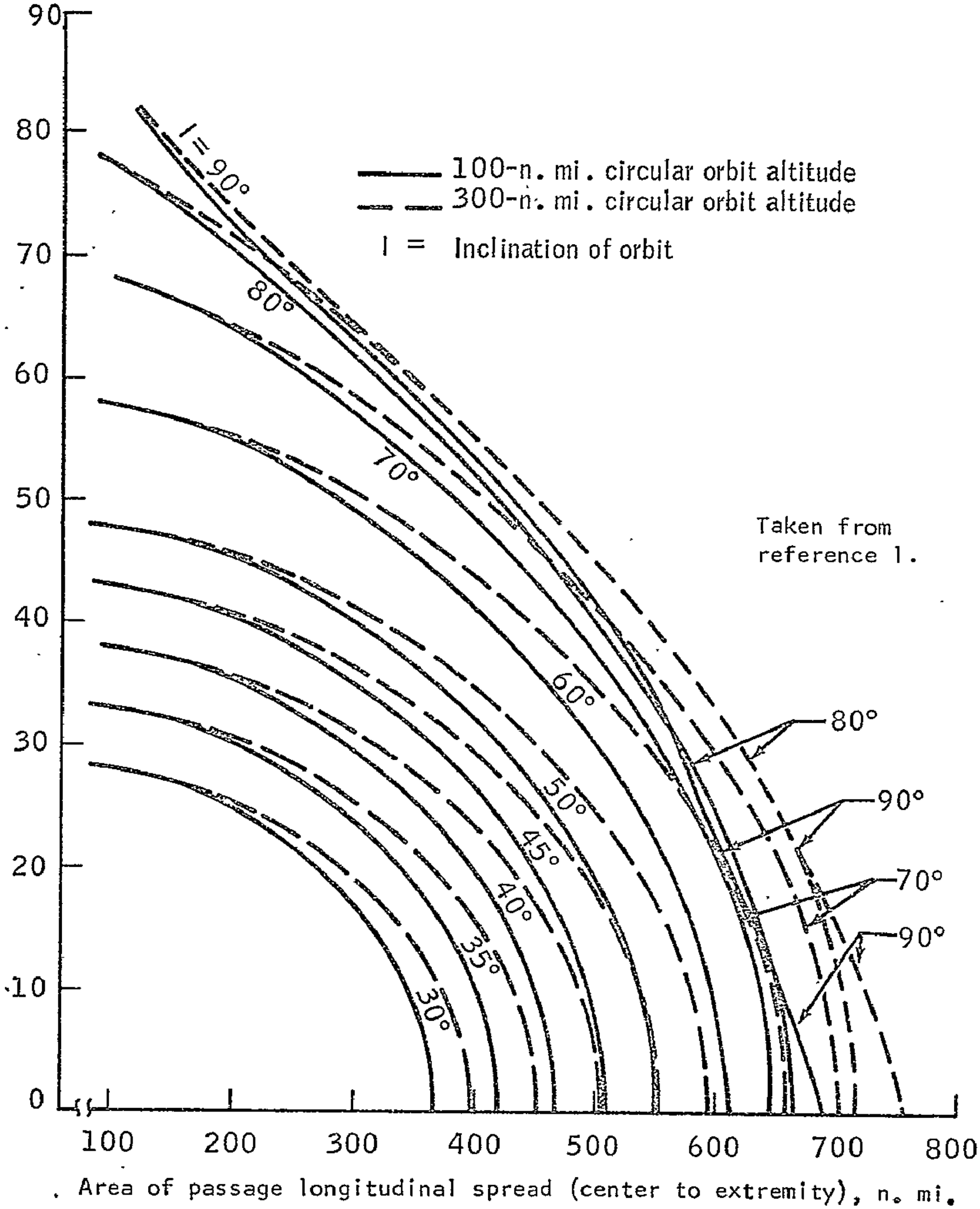



Figure 2.- Area of passage sizing

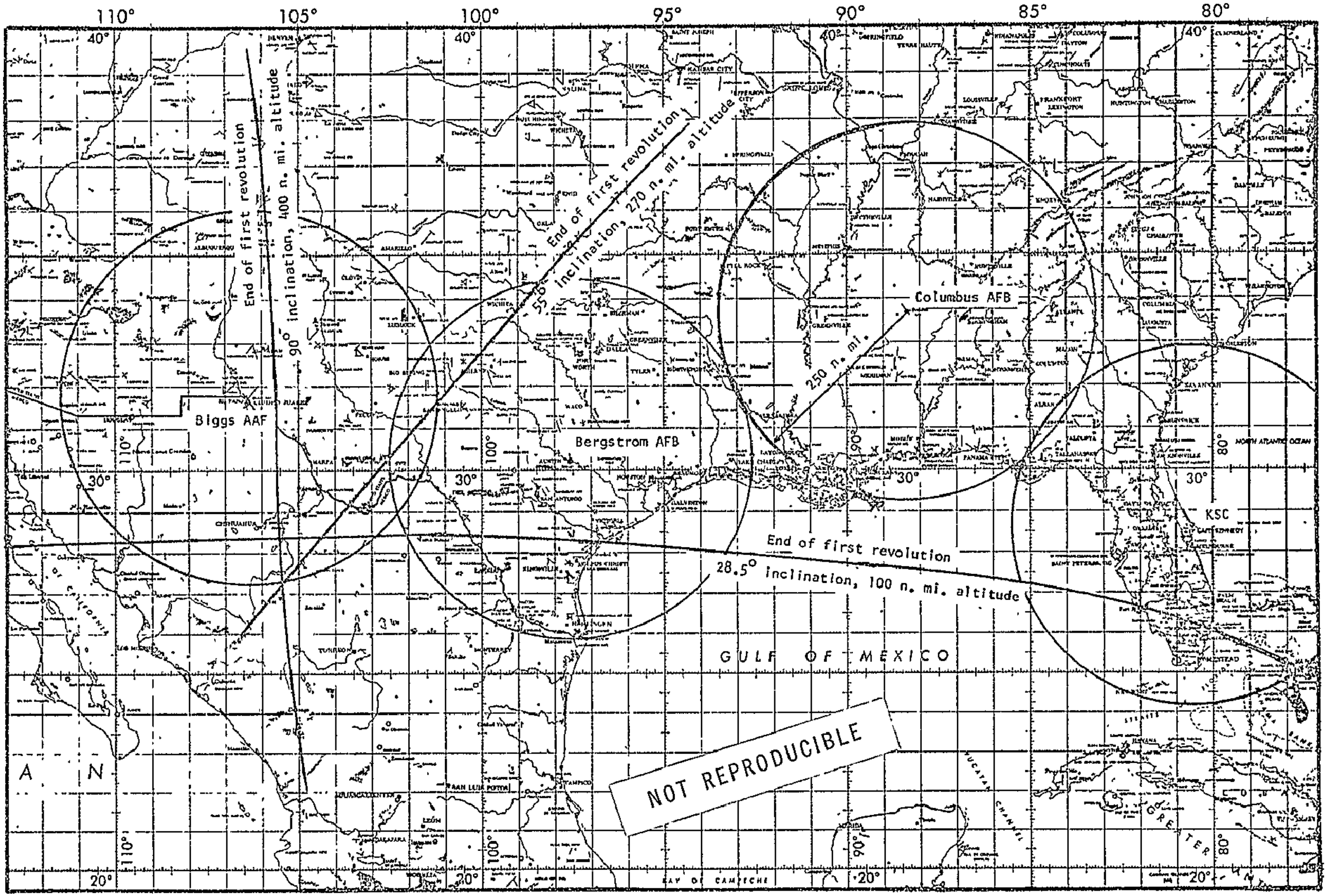



Figure 3.- End-of-mission, end-of-first-revolution, and alternate CONUS support airfields.

Figure 4. Landing Opportunities at Selected Airfields

EXPLANATION

The data depicted in this figure was obtained from a computer analysis by the Airfield Accessibility Program (AIRAC) No. E021 at the Manned Spacecraft Center, Houston, Texas. Three specific missions were analyzed: (1) a $90^{o}$ inclination, 400 n. mi. circular altitude mission, (2) a $55^{o}$ inclination, 270 n. mi. circular altitude mission, and (3) a $28.5^{o}$ inclination, 100 n. mi. circular altitude mission.

The upper part of each page of the figure illustrates, where an "X" appears, the revolution in which the orbiter has an opportunity to land at the named airfield from the designated mission.

The lower part of each page of the figure illustrates, where an "X" appears, the revolutions in which the orbiter has an opportunity to land at one of the cumulation of airfields designated by the number at the left. This part shows that at least one of the several designated airfields provides a landing opportunity during the revolution where an "X" appears. The spaces, or revolutions, where no "X" appears illustrate the revolutions where an in-orbit wait in excess of one revolution occurs. The maximum number of revolutions in which in-orbit waits occur are designated in the lower right-hand column under the heading "MIW" (maximum in-orbit wait) for each combination of airfields designated in the lower left-hand columns.

| Airfield number | Airfield name | 1–5 | 6–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31– |
|---|---|---|---|---|---|---|---|---|
| 1 | Kennedy Space Center | XX | X | | | | X | |
| 2 | Biggs AAF | X | X | | | | | X |
| 3 | Bergstrom AFB | | | | X | X | | |
| 4 | Columbus AFB | | X | | | | X | |
| 5 | Darwin | | X | | | | X | |
| 6 | N Djili | X | | | | X | | |
| 7 | Honolulu Intl. | X | | X | | | | X |
| 8 | Nandi Intl. | | | X | | | | X |
| 9 | Lusaka Intl. | | | | X | | | |
| 10 | Perth Intl. | | | | | X | | |
| 11 | Chia I | | | | | X | | |
| 12 | Bangkok Intl. | | | X | | | | |
| 13 | Calcutta | X | | | | X | X | |
| 14 | Karachi Civil | X | | | | X | | X |
| 15 | La Tontonta | | | | X | | | |
| 16 | Andersen AFB | | | | X | | | |
| 17 | Bombay/Santa Cruz | | | | X | | | |
| 18 | Nagpur | | X | | X | | | |
| 19 | Jorge Chavez Intl. | | | | | X | X | |
| 20 | Kuala Lumpur Intl. | | | X | | | | |
| 21 | Clark AB | | | | | X | | |
| 22 | Ramey AFB | | | X | | | | |
| 23 | Kadena AB | | X | X | | | | |
| 24 | Faaa | X | | | | X | | |
| 25 | Udorn | | X | X | | | | |
| 26 | Yuma MCAS/Yuma Intl. | | | | | | | |
| 27 | Davis Monthan AFB | | X | | | | | X |
| 28 | San Nicolas Is. OLF | | | | X | X | | |

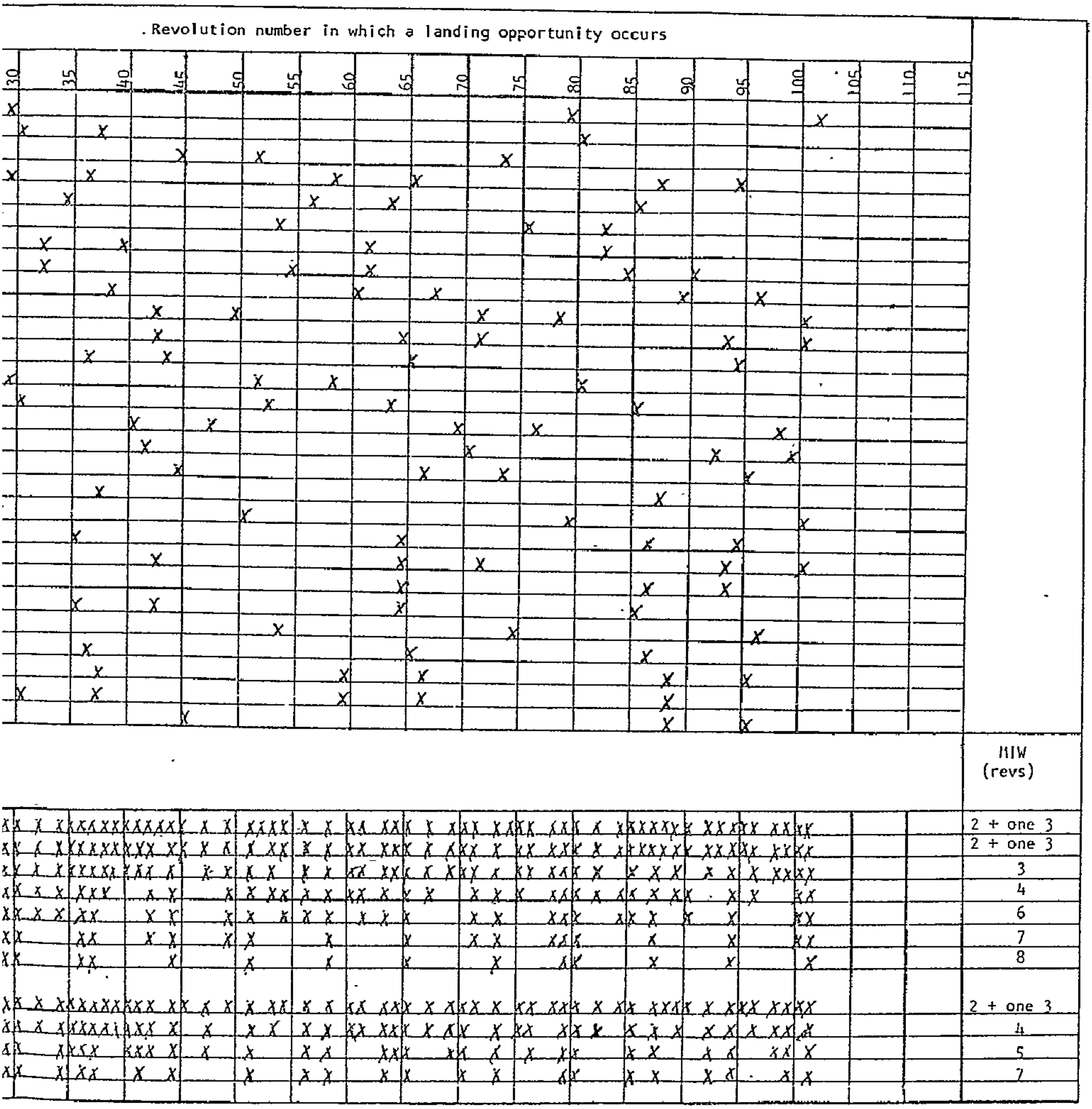
Cumulative landing opportunities

| Total | Airfield number | 1–5 | 6–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31– |
|---|---|---|---|---|---|---|---|---|
| 20 | 1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,22,23,24,25,28 | XXXX | XXXX | XXXX | XXXXX | XXXXX | XX | XXX |
| 15 | 1,2,3,4,5,6,7,8,9,10,15,16,22,23,28 | XXXX | XXXX | XXX | XXXXX | XXXX | XX | XXX |
| 12 | 1,2,3,4,5,6,7,9,10,15,16,23 | XXXX | XXXX | XX | XXXX | XXX | XX | XXX |
| 9 | 1,2,3,4,5,6,8,9,10 | XXX | XXX | X | XX | XXX | XX | XXX |
| 7 | 1,2,3,4,5,8,10 | XX | XXX | X | X | XX | XX | XXX |
| 5 | 1,2,3,4,10 | XX | XX | | X | XX | X | X |
| 4 | 1,2,3,4 | XX | XX | | X | X | X | X |
| 14 | 1,2,3,4,5,6,7,8,9,10,15,16,23,28 | XXXX | XXXX | XXX | XXXXX | XXX | XX | XXX |
| 11 | 1,2,3,4,5,6,7,9,15,16,23 | XXXX | XXXX | XX | XXXX | XX | XX | XXX |
| 8 | 1,2,3,4,5,15,16,23 | XX | XXXX | X | XXX | X | XX | XX |
| 6 | 1,2,3,4,5,16 | XX | XXX | | XX | X | XX | XX |

(a) 90° inclination, 400 n

FOLDOUT FRAME 1

Figure 4. Landing Oppor




), 400 n. mi. circular altitude mission

FOLDOUT FRAME 2

ng Opportunities at Selected Airfields

| Airfield number | Airfield name | Revolution | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | |
| 1 | Kennedy Space Center | | | X | | | X | | | X |
| 2 | Biggs AAF | X | | X | | | | | | |
| 3 | Bergstrom AFB | X | X | X | X | | X | X | | X |
| 4 | Columbus AFB | | | | | | | | | |
| 5 | Darwin | X | | | X | | | X | | |
| 6 | N Djili | | X | | | X | | | X | |
| 7 | Honolulu Intl. | X | X | | X | X | | X | X | |
| 8 | Nandi Intl. | X | | X | X | X | | X | X | |
| 9 | Lusaka Intl. | X | | | X | | | X | | |
| 10 | Perth Intl. | X | | X | X | | X | X | | X |
| 11 | Chia I | | | X | | | X | | X | |
| 12 | Bangkok Intl. | | X | | | X | | X | | |
| 13 | Calcutta | | X | | | X | | | X | |
| 14 | Karachi Civil | | X | | | X | | | X | |
| 15 | La Tontonta | | | | | | | | | |
| 16 | Andersen AFB | X | | | X | | | X | | |
| 17 | Bombay/Santa Cruz | | | | | | | | | |
| 18 | Nagpur | | X | X | | X | X | | X | X |
| 19 | Jorge Chavez Intl. | | | | | | | | | |
| 20 | Kuala Lumpur Intl. | | | | | | | | | |
| 21 | Clark AB | | | | | | | | | |
| 22 | Ramey AFB | | X | X | X | | X | X | | X |
| 23 | Kadena AB | | | X | | | X | | X | |
| 24 | Faaa | | | | | | | | | |
| 25 | Udorn | | X | X | | X | X | X | | X |
| 26 | Yuma MCAS/Yuma Intl. | | | | | | | | | |
| 27 | Davis Monthan AFB | | | | | | | | | |
| 28 | San Nicolas Is. OLF | X | X | | X | X | X | X | | X |

Cumulative landing opportunities

| Total | Airfield number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,22,23,24,25,28 | XXX X | XX XX | XXXXX | XX XX | X XXX | XXXXX | X XXX | XXXX | XXXX |
| 15 | 1,2,3,4,5,6,7,8,9,10,15,16,22,23,28 | XXX X | XX XX | XXXXX | XX XX | X XXX | X XXX | X XXX | XXXX | XXX |
| 12 | 1,2,3,4,5,6,7,9,10,15,16,23 | X X X | X XX | XX X | XX XX | XX | X XX | X XX | XX X | XX |
| 9 | 1,2,3,4,5,6,7,8,9,10 | X X X | X X | X X X | XX XX | XX | XX | X XX | XX | XX |
| 7 | 1,2,3,4,5,8,10 | X X X | X | X X X | X XX | X | XX | X XX | X | XX |
| 5 | 1,2,3,4,10 | X X | X | X X | XX | | XX | XX | | XX |
| 4 | 1,2,3,4 | X | X | X | X | | X | X | | X |
| | | | | | | | | | | |
| 8 | 1,2,3,7,8,10,23,28 | XXX X | XX X | XXX X | XX XX | X X X | X XXX | X XXX | X XX | XX |
| 5 | 1,2,3,7,23 | X X | X X | X X | X X | X | X X | X X | X X | X |
| 4 | 1,2,3,6 | X | X X | X | X | X | X | X | X | X |
| 3 | 1,2,3 | X | X | X | X | | X | X | | X |
| | | | | | | | | | | |

(b) 55° inclination, 270 n. mi. circu

FOLDOUT FRAME 1

Figure 4. (continued)

Revolution number in which a landing opportunity occurs

| 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | | | X | | | X | | | X | | X | | | X | | | |
| X | X | | X | X | | X | X | | X | X | X | X | | X | | | |
| | X | | | X | | | X | | X | | X | X | | X | | | |
| | | X | | | X | | | X | | X | | | X | | | | |
| | X | X | X | | X | X | X | | X | X | | X | X | | | | |
| | X | X | X | | X | X | | X | X | | X | X | X | | | | |
| | X | | X | | | X | | | X | | | X | | | | | |
| | X | | X | X | | X | X | X | X | | X | X | | X | | | |
| | | X | | | X | | | | | | | | | | | | |
| | X | | | X | | | X | | | X | | | X | | | | |
| | | X | | X | | | X | | | X | | | X | | | | |
| | | X | | | X | | X | | | X | | | X | | | | |
| | | | | | | | | | | | | | | | | | |
| | X | | | X | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | X | X | X | | X | X | X | | X | X | | X | X | | | |
| | | | | | | X | | X | | | X | | | X | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | X | | X | X | | X | X | X | | X | X | X | | X | | | |
| | | X | | | X | | | X | | | X | | | X | | | |
| | | | | | | | | | | | | | | | | | |
| | X | | X | X | X | | X | X | | X | X | | X | X | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| X | X | | X | X | | X | X | | X | X | | X | X | X | | | |

| 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 | MIW (revs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| XX | X XXX | XXXX | XXXXX | XXX | XXXXX | XXXX | XXX X | X XXXX | XXX X | XX XX | XXXXXX | XX XX | XXXXX | XXXXX | | | | 2 |
| X X | X XXX | XXXX | XXXX | XXX | XXXX | XXXX | XXX X | XXXXX | XXX X | XX XX | XXXXX | XX XX | XXXXX | XXXXX | | | | 2 |
| X | X XX | XX X | XX X | XX | XX X | XX X | XX X | X XX | X X X | X XX | XXXX | X XX | XX | XXXX | | | | 3 |
| X | X XX | XX | XX X | XX | XX | XX X | XX | XX X | X X X | X X | X XXX | X XX | XX | XXX | | | | 4 |
| X | X XX | X | XX X | XX | X | XX X | XX | X X | X X X | X | X XXX | X XX | X | XXX | | | | 5 |
| X | XX | | XX | XX | | XX | XX | X | X X | X | XX | XX | | XX | | | | 8 |
| X | X | | X | X | | X | X | | X | X | X | X | | X | | | | 9 |
| | | | | | | | | | | | | | | | | | | |
| XX | X XXX | X XX | XXXX | XXX | X XX | XXXX | XXX X | XXX | XXX X | XX X | XX XX | XX XX | X X X | X XXX | | | | 2 |
| X | X X | X X | X X | X | X X | X X | X X | X | X X | X X | X X | X X | X | X X | | | | 3 |
| X | X | X | X | X | X | X | X | X | X | X X | X | X | X | X | | | | 5 |
| X | X | | X | X | | X | X | | X | X | X | X | | X | | | | 9 |
| | | | | | | | | | | | | | | | | | | |

70 n. mi. circular altitude mission

e 4. (continued)

FOLDOUT FRAME 2

| Airfield number | Airfield name | 1–5 | 6–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31–35 | 36–40 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Kennedy Space Center | XX | | X | X X | | | XXX | |
| 2 | Biggs AAF | X | | | X | | | XX | |
| 3 | Bergstrom AFB | X | | | XX | | | XX | |
| 4 | Columbus AFB | | | | | | | | |
| 5 | Darwin | X | | X | X | | X | X | |
| 6 | N Djili | X | X | | X | X | | X | X |
| 7 | Honolulu Intl. | X | X | | X | X | | X | X |
| 8 | Nandi Intl. | | | X X | | | X | X | |
| 9 | Lusaka Intl. | X | X | | X | X | | X | X |
| 10 | Perth Intl. | | | | X | | | X | |
| 11 | Chia I | X | X XX | | | XX X | X | | XX X |
| 12 | Bangkok Intl. | X | | | | X | X | | X |
| 13 | Calcutta | | X | X | | X | X | | X |
| 14 | Karachi Civil | | XX | XX | | XX | X X | | X |
| 15 | La Tontonta | | | X X | | | X | X | |
| 16 | Andersen AFB | X | X | | X | | X | X | |
| 17 | Bombay/Santa Cruz | | X | X | | X | X | | X |
| 18 | Nagpur | | X | X | | X | X | | X |
| 19 | Jorge Chavez Intl. | | | X | | | X | | X |
| 20 | Kuala Lumpur Intl. | | | | | | | | |
| 21 | Clark AB | X | | X | | X | X | | X |
| 22 | Ramey AFB | X | | X | X | | X | X | |
| 23 | Kadena AB | X | X XX | | | XXX X | | | XXXX |
| 24 | Faaa | | X | X | | X | X | | |
| 25 | Udorn | | X | X | | X | X | | X |
| 26 | Yuma MCAS/Yuma Intl. | | | | | | | | |
| 27 | Davis Monthan AFB | X | | | X | | | X | |
| 28 | San Nicolas Is. OLF | | | | | | | | |

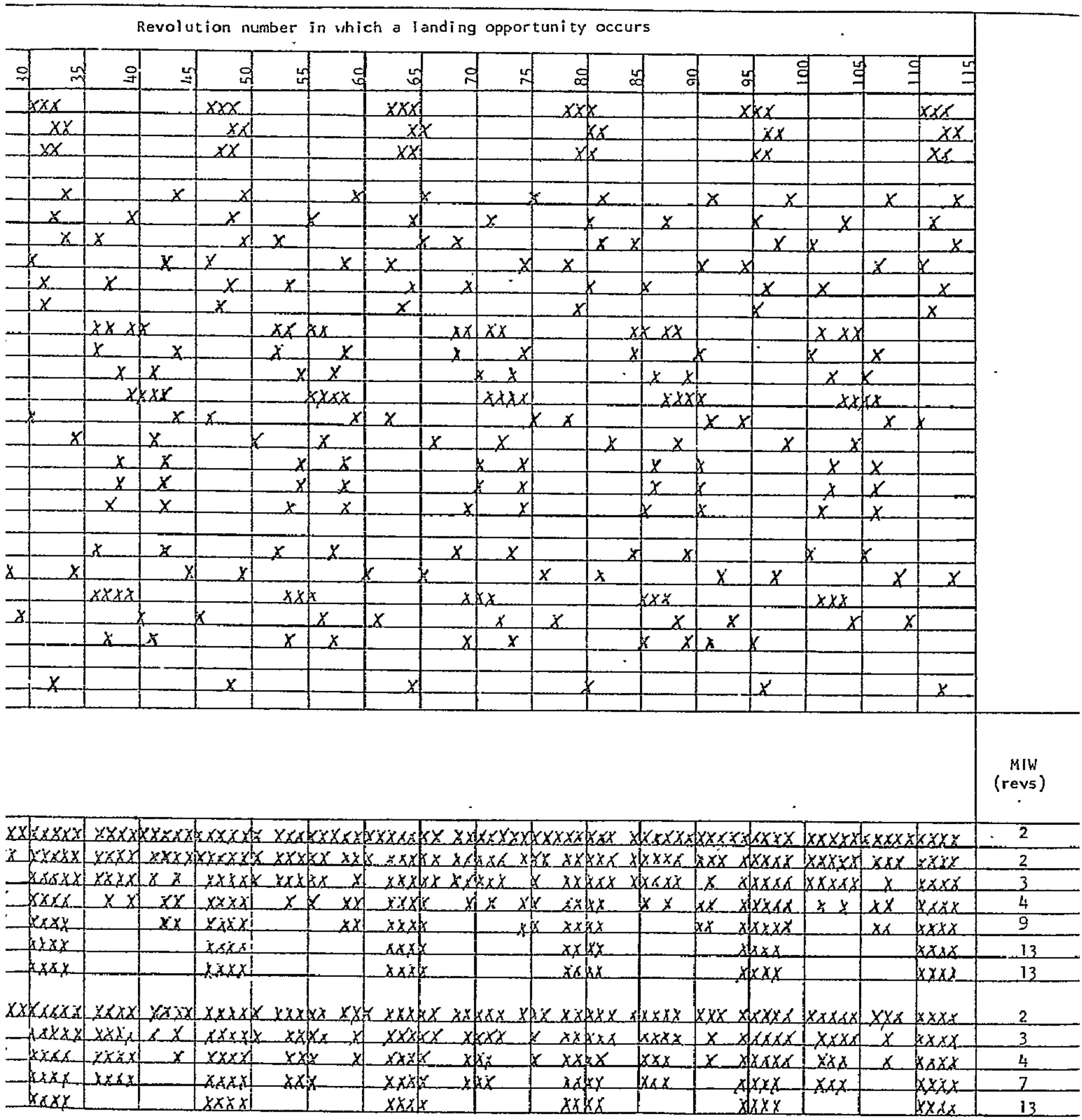
Cumulative landing opportunities

| Total | Airfield number | 1–5 | 6–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31–35 | 36–40 |
|---|---|---|---|---|---|---|---|---|---|
| 20 | 1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,22,23,24,25,28 | XXX X | XXXXX | XXXXX | XXXX | XXXXX | XXXXX | XXXXX | XXXX |
| 15 | 1,2,3,4,5,6,7,8,9,10,15,16,22,23,28 | XXX X | XXXXX | XXX X | XXXX | XXXXX | XXXX | XXXXX | XXXX |
| 12 | 1,2,3,4,5,6,7,9,10,15,16,23 | XXX X | XXXXX | X X | XXXX | XXXXX | X X | XXXXX | XXXX |
| 9 | 1,2,3,4,5,6,8,9,10 | XX | XX | XX X | XXX | XX | X XX | XXXX | X X |
| 7 | 1,2,3,4,5,8,10 | XX | | XX X | XXX | | XX | XXXX | |
| 5 | 1,2,3,4,10 | XX | | X | XXX | | | XXXX | |
| 4 | 1,2,3,4 | XX | | X | XXX | | | XXXX | |
| 8 | 1,2,7,5,8,16,22,23 | XXX X | X XXX | XXX X | XXX | XXX X | XXXX | XXXX | XXXX |
| 5 | 1,2,5,16,23 | XXX X | X XXX | X X | XXXX | XXX X | X X | XXXXX | XXXX |
| 4 | 1,2,5,23 | XX X | X XX | X X | XXX | XXX X | X | XXXX | XXXX |
| 3 | 1,2,23 | XX X | X XX | X | XXX | XXX X | | XXXX | XXXX |
| 2 | 1,2 | XX | | X | XXX | | | XXXX | |

(c) 28.5° inclination, 100 n. mi.

FOLDOUT FRAME 1

Figure 4. (conclu




on, 100 n. mi. circular altitude mission

FOLDOUT FRAME 2

jure 4. (concluded)

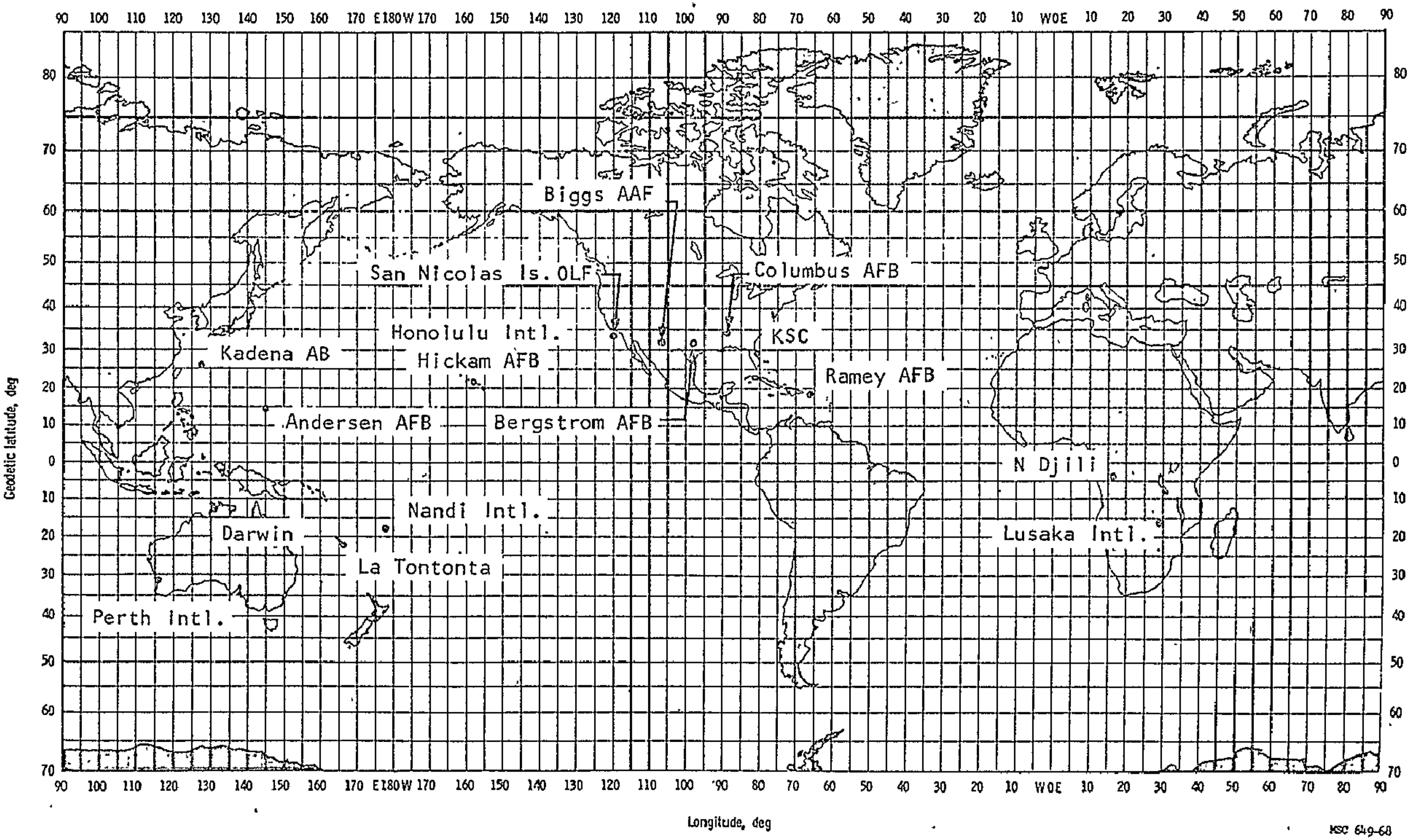



Figure 5. - Orbital Emergency Support Airfields

# APPENDIX--AIRFIELD DESCRIPTIONS

## Explanation of Terms

Several terms used in this appendix need explaining. Under the sub-headings "Runway" and "Taxiway," the surface strength is designated by three methods. One is by listing the heaviest known aircraft to land at the field without causing runway or taxiway surface damage. A second method is by listing the single-wheel loading (SWL) in pounds which the surface will withstand. The listed SWL includes information submitted in terms of equivalent single-wheel loading and single isolated wheel loading. The third method is by listing the maximum pressure the runway will support in psi.

Under the sub-heading "Navigational Aids," several abbreviations are used. These abbreviations are defined as follows:

ILS--Instrument landing system

GCA--Ground controlled approach

PAR--Precision approach radar

ASR--Approach surveillance radar

UHF--Ultra high frequency

VHF--Very high frequency

VOR--VHF omni directional range

TACAN--Tactical air navigation UHF pulse-type omni range and distance measuring equipment

DME--Distance measuring equipment

VORTAC--Combination VOR and TACAN

RBN--Radio beacon

DF or D/F--Direction finding equipment

Under the sub-heading "Landing Weather," the abbreviation IFR is for instrument flight rules and means that the landing takes place using the instrumented landing techniques available at the airfield. Each airfield has different low ceilings and low visibilities below which an IFR landing cannot be made (this also excludes the possibility of a visual landing). In this appendix, the ceiling and visibility minimums for each airfield were obtained from appendix reference 1. The percent frequencies of occurrence of these weather minimums for each month for each airfield were obtained from appendix reference 2. The information listed under the sub-heading "Terrain" was obtained from map studies by the authors, unless otherwise referenced. The information by all the other sub-headings was obtained from appendix reference 3, unless otherwise designated.

Assumed Kennedy Space Center Airfield, Florida (To Be Built)

Coordinates: Approximately 28-28N, 80-34W.

Elevation: Approximately 9 ft.

Runway: Length--approximately 10,000 ft; surface--concrete; strength--approximately 250 psi.

Taxiways: Width--unknown; surface--concrete; strength--approximately 250 psi.

Navigational Aids: ILS.

Controlling Agency: National Aeronautics and Space Administration.

Weather Forecasting: Station at KSC with 24-hour service.

Climate: This area is subtropical with short, mild winters and hot, humid summers. It is often threatened by hurricanes from June through December, but no direct hits are on record. The average yearly cloud cover is 0/10 to 3/10 about 40.6 percent of the time, 4/10 to 7/10 about 23.2 percent of the time, and 8/10 to 10/10 about 36.2 percent of the time (reference 4).

Local Features: Located on the Atlantic Ocean side of the Florida peninsula on flat and marshy land. Elevations range from sea level to 12 feet or so. The area is covered with coarse grasses, shrub, palmetto, several citrus groves, and pine trees (reference 4).

Columbus AFB, Mississippi

Coordinates: 33-38-35N, 88-26-33W.

Elevation: 214 ft.

Runway: Length x width--12,000 ft x 300 ft; extendable; surface--concrete; strength--B-52 support capability.

Taxiways: Width--175 ft; surface--concrete; strength--B-52 support capability.

Navigational Aids: ILS, GCA, Approach Control, VORTAC, and D/F.

Lighting: Approach, threshold, runway, taxiway, flood, obstruction, and rotating beacon.

Communications: Telephone, telegraph, and teletype.

Controlling Agency: United States Air Force - Strategic Air Command.

Maintenance Facilities: Full base maintenance and repair services.

Special Purpose Equipment: Crash, fire, and cargo handling equipment.

Logistics: Roads and railroads are available.

Medical Facilities: Available.

Weather Forecasting: Station available.

Landing Weather: The airfield IFR landing weather minimum is for a 200-foot cloud ceiling and a 1/2-mile visibility. At worst, this weather occurs 3 percent of the time in January and 4 percent of the time in December. All other months have less than a 3-percent frequency of occurrence of the minimum.

Local Features: The airfield is located 7 n. mi. north/northwest of Columbus, Mississippi, in relatively flat terrain. The Meridian Intensive Student Jet Training Area is located 20 n. mi. away and covers an area from west/southwest to southeast of the airfield. Vertical obstructions include a 500-foot high structure located 6 n. mi. south/southeast, a 381-foot high structure located 9 n. mi. south/southeast, and a 360-foot high structure located 11 n. mi. west/southwest.

Bergstrom AFB, Texas

Coordinates: 30-11-42N, 97-39-30W.

Elevation: 541 ft.

Runway: Length x width--12,250 ft x 300 ft; estimated extendable; surface--concrete; strength--B-52 support capability.

Taxiways: Width--175 ft; surface--concrete; strength--B-52 support capability.

Navigational Aids: ILS, GCA, RBN, Approach Control, VORTAC, TACAN, and D/F.

Lighting: Approach, threshold, runway, taxiway, obstruction, and rotating beacon.

Communications: Telephone, teletype, and C/W.

Controlling Agency: United States Air Force - Tactical Air Command.

Maintenance Facilities: Full base maintenance and repair services.

Special Purpose Equipment: Crash, fire, and cargo handling equipment.available.

Logistics: Roads and railroads available.

Medical Facilities: Available at field.

Weather Forecasting: Station on base.

Landing Weather: The airfield IFR landing weather minimum is for a 200-foot ceiling and a 1/2-mile visibility. At worst, during each of the months of January, February, and December, the minimum occurs at most 5 percent of the time.

Local Features: Located 3 n. mi. south/southwest of Austin, Texas, near the edge of the Edwards Plateau in an area of rolling hills. The Edwards Plateau, 5 to 10 miles to the west, is generally 500 to 600 feet higher than the airfield. Vertical obstructions include the Edwards Plateau at 5 to 10 miles west, a 400-foot high structure at 3 n. mi. northeast, a 1,197-foot high structure at 8 n. mi. northwest, a 425-foot high structure at 6 n. mi. west, and a 310-foot high structure at 5 n. mi. north, near the flight approach path.

. <u>Biggs AAF, Texas (Fort Bliss AAF)</u>

Coordinates: 31-50-52N, 106-22-45W.

Elevation: 3,947 ft.

Runway: Length x width--13,572 ft x 300 ft; extendable by 9,999 ft; surface--concrete; strength--B-52 support capability.

Taxiways: Widths--160 ft and 200 ft; surface--concrete and asphalt; strength--B-52 support capability.

Navigational Aids: VOR and approach control. ILS will have to be installed.

Lighting: Approach, threshold, runway, taxiway, flood, obstruction, and rotating beacon.

Communication: Telephone and teletype.

Controlling Agency: U. S. Army.

Maintenance Facilities: Available.

Special Purpose Equipment: Crash, fire, and cargo handling equipment available.

Logistics: Roads and railroads available and in good condition.

Medical Facilities: Available in El Paso.

Weather Forecasting: Weather station at El Paso International, with 24-hour forecasting.

Landing Weather: The airfield IFR landing weather minimum is for a 400-foot ceiling and a 1.0 n. mi. visibility. At worst, during each of the winter and spring months, the minimum occurs 1 to 3 percent of the time.

Local Features: Located in relatively flat terrain, approximately 2 n. mi. northeast of El Paso. Vertical obstructions include a mountain range of about 7,000 ft elevation, located about 4 n. mi. west; a 5,990-foot elevation peak located 10 n. mi. southwest; a 5,026-foot peak located 15 n. mi. northeast; a 6,000-foot mountain range located 20 n. mi. east; and an 825-foot high structure on the approach path located 5 n. mi. southwest.

Honolulu International/Hickam AFB, Hawaii

Coordinates: 21-19-33N, 157-55-18W.

Elevation: 13 ft.

Runway: Length x width--12,371 ft x 200 ft; not extendable; surface--asphalt; strength--SWL = 110,000 lb, 285 psi.

Taxiways: Widths--100 ft and 150 ft; surface--asphalt; strength--SWL = 110,000 lb, 285 psi.

Navigational Aids: ILS, VORTAC, RBN, ASR, UHF/VHF/DF, and approach control.

Lighting: Rotating beacon, obstruction, threshold, taxiway, high-intensity on runway 08/26, medium-intensity on runways 04L/22R and 04R/22L, flush-type on runway 04R/22L, and VASI* on runway 04L.

Communications: Hawaiian telephone and telegraph, teletype, and radio available.

Controlling Agency: Federal Aviation Administration and United States Air Force.

Maintenance Facilities: All types of maintenance and repair services available.

Special Purpose Equipment: Two FFN crash trucks, fifteen 5,000 foam fire trucks, wreckage removal equipment, and cargo handling equipment.

Search and Rescue: Honolulu Rescue Coordination Center has extra long-range aircraft, medium-range rotary wind aircraft, and rescue vessels.

Medical Facilities: A 6,486 bed USAF dispensary, 1,500 bed Tripler Army Hospital at Moanalua, 42 bed Naval Medical Facilities at Pearl Harbor, and 14 civilian hospitals on island.

Logistics: Excellent roads, standard gauge railroads available, Honolulu Harbor and Pearl Harbor available.

Weather Forecasting: U. S. Weather Bureau station at airfield provides 24-hour forecasting.

Landing Weather: The airfield IFR landing weather minimum is for a 200-foot ceiling and a 1/2-mile visibility. This minimum occurs near zero percent of the time for all months.

Climate: Subtropically maritime.

Local Features: Located on the west side of Honolulu on relatively flat terrain. The area is rectangular in shape. Most of the area is coral filled. Area has good drainage both naturally and artificially. Vertical obstructions include a mountain range with altitudes up to

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*Visual approach slope indicator system

3,000 ft, located 8 n. mi. northeast, a mountain range with altitudes up to 4,000 ft, located 9 n. mi. northwest, and a 260-foot high structure 6 n. mi. east/southeast.

San Nicolas Island OLF, California

Coordinates: 33-14-23N, 119-27-37W.

Elevation: 504 ft.

Runway: Length x width--10,000 ft x 200 ft; extendable; surface--asphalt; strength--C-118 support capability; SWL = 36,000 lb.

Taxiways: Width--75 ft; surface--asphalt; strength--C-118 support capability.

Navigational Aids: GCA, TACAN, and RBN.

Lighting: Threshold, runway, obstruction, and rotating beacon.

Communications: Telephone and teletype.

Controlling Agency: United States Navy Drone and Missile Operations.

Maintenance Facilities: Limited facilities available.

Special Purpose Equipment: Crash, fire, and cargo handling equipment available.

Medical Facilities: Available.

Logistics: No roads or railroads; a navigable waterway is available.

Weather Forecasting: Station on base.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1.0 n. mi. visibility. At worst, during each of the months of July and August, the minimum occurs at most 13 percent of the time.

Local Features: Located about 6 n. mi. west of Los Angeles on San Nicolas Island, where the highest point is 907 feet, located 2 n. mi. west/northwest of the field.

Darwin, Australia

Coordinates: 12-25-00S, 130-52-20E.

Elevation: 104 ft.

Runway: Length--11,000 ft; surface--asphalt; strength--B-52 and B-707 support capability.

Taxiways: Capacity restricted.

Navigational Aids: ILS, RBN, VAR, DME, VDF, VOR, and approach control.

Lighting: Rotating beacon, high-intensity approach lighting, variable electric flare path, toledo flares available, sideline blue taxiway lighting, obstruction lights on towers, and visual approach slope indicator system (VASI) available.

Communications: Telephone, telegraph, teletype, cable, C/W, and radiophone.

Controlling Agency: Royal Australian Air Force and Australian Department of Civil Aviation.

Maintenance Facilities: Base presently has field maintenance capability. Additional facilities are under construction.

Special Purpose Equipment: One early rescue vehicle, one general purpose tender, one ambulance, three 6 by 6 fire trucks, two fire tenders, three water tankers, one 10-ton crane, one 50-ton crane, one 3 to 5 ton Fowler crane, one 3-ton general purpose crane, and cargo handling equipment.

Search and Rescue: Darwin Search and Rescue Center has medium and long-range aircraft and ships available.

Medical Facilities: Twelve-bed sick quarters on base operated by the RAAF. Complete hospital facilities in Darwin.

Logistics: Roads good; narrow-gauge railroad available; port facilities at Darwin Harbor; military vehicles available.

Weather Forecasting: Available on a 24-hour basis.

Landing Weather: The airfield IFR landing weather minimum is for a 400-foot ceiling and a 3/4-mile visibility. At worst, during each of the months of January, February, and April, this minimum occurs 3 percent of the time.

Climate: Tropical.

Local Features: Located on the northeast edge of Darwin. The surroundings are undulating and timbered with trees and swamp to the northeast. The airfield open drains are adequate. There are few vertical obstructions of importance.

Perth International, Australia

Coordinates: 31-55-54S, 115-58-06E.

Elevation: 69 ft.

Runway: Length x width--10,300 ft x 150 ft; surface--asphalt; strength--SWL = 56,600 lb, 155 psi.

Taxiways: Width--75 ft and 50 ft; surface--asphalt; strength--SWL = 56,600 lb, 155 psi.

Navigation Aids: ILS, VOR, DME, RBN, and a locator beacon.

Lighting: Runway, threshold, taxiway, field, obstruction, rotating beacon, and approach.

Communications: Telephone, telegraph, cable, civil radio, and teletype. Duplex circuits connect Perth, Sydney, Darwin, and Cocos Island.

Controlling Agency: Australian Department of Civil Aviation.

Maintenance Facilities: Organizational-type facilities for routine maintenance.

Special Purpose Equipment: Five crash vehicles, fire equipment, cargo handling equipment, and wreckage removal equipment available.

Search and Rescue: Rescue coordination center on field with short and medium range aircraft and boats available.

Medical Facilities: First aid and ambulance on field; several hospitals in Perth.

Logistics: Roads are excellent; double-track narrow gauge railroad at Guilford 3 miles northeast; deep-water port at Fremantle.

Weather Forecasting: Station on base provides 24-hour forecasting.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 3/4-mile visibility. At worst, during the month of May, this minimum occurs 1 percent of the time.

Local Features: Located 2 n. mi. east of Perth and surrounded by a developing surburban area. The airfield property comprises about 3,558 acres of land area with a very good drainage system. The airfield is west of a hilly area and is on a flat swampy plane between the sea and the hills. Vertical obstructions include hills with elevations up to 1,300 feet about 5 n. mi. east of the airfield, a 591-foot high structure located 3 n. mi. west, a 257-foot high structure located 8 n. mi. southwest, and a 475-foot high (1,585 feet in elevation) structure located 8 n. mi. southeast.

Significance: Perth International was used by heavy bombers of the RAAF in World War II. Improved and expanded in recent years, it is now utilized by heavy jet transport aircraft and is one of the two major air facilities in western Australia. Excellent surface transportation facilities exist in the area.

<u>Nandi International, Fiji Islands</u>

Coordinates: 17-46-00S, 177-27-00E.

Elevation: 63 ft.

Runway: Length x width--10,500 ft x 150 ft; not extendable; surface--concrete; strength--SWL = 65,100 lb, 190 psi.

Taxiways: Width--75 ft; surface--concrete and asphalt; strength--SWL = 65,100 lb, 190 psi.

Navigational Aids: ILS, RBN, VOR, VHF/DF, approach control.

Lighting: Beacon, approach, runway, taxiway, threshold, obstruction, flood, and tetrahedron.

Communications: Fiji commercial telephone, duplex RATT to Honolulu, cable, and telegraph.

Controlling Agency: New Zealand Civil Aviation Administration.

Maintenance Facilities: Accommodations for full base maintenance and repair services.

Special Purpose Equipment: One rescue unit, two ambulances, four general purpose vehicles, four 500-gallon fire trucks, four 1,400-gallon fire trucks, two $CO_2$ units, 16 baggage trolleys and towing units, one 1.5-ton A-crane, and one 3-ton crane.

Search and Rescue: Long-range aircraft, a rescue vessel, and a rescue boat.

Medical Facilities: 100-bed hospital on base.

Airfield Security: Fiji police have a small unit at the airfield.

Logistics: Roads fair; private sugar cane trains; full port facilities at Lautoka and Suva.

Weather Forecasting: 24-hour forecasting from the New Zealand Meteorological Service.

Landing Weather: The airfield IFR landing weather minimum is for a 400-foot ceiling and a 3/4-mile visibility. At worst, during each of the months of January, February, and March, the minimum occurs 2 percent of the time.

Climate: Maritime tropical.

Local Features: Located 6 n. mi. south/southwest of Nandi on a small area of fairly flat country located on the west by Nandi Bay and on the north, east, and south by mountains and hills. The closest is the Sambeto Mountain Range lying 3 miles to the north and rising to a height of 2,030 ft. Other vertical obstructions include a 3,921-foot altitude peak located 9 n. mi. northeast and a 3,528-foot altitude peak located 10 n. mi. southeast. Drainage is artificial and good.

Significance: The leading and best-equipped airfield in the south central Pacific. Excellent for recovery and turnaround of most types of aircraft.

La Tontonta, New Caledonia

Coordinates: 22-01-01S, 166-12-39E.

Elevation: 52 ft.

Runway: Length x width--10,663 ft x 148 ft; not extendable; surface--asphalt; strength--SWL = 46,000 lb, 155 psi.

Navigational Aids: ILS, RBN, and VOR.

Lighting: Approach, threshold, runway, taxiway, obstruction, visual, approach slope indicator system (VASI), and temporary.

Communications: Local telephone, telegraph to Noumea, point-to-point radio to Noumea, and international radio circuits to Noumea.

Controlling Agency: Civil Aviation Administration, Directorate of Civil Aviation (AVA/DAC).

Special Purpose Equipment: Three ambulances, one 792-gallon Berliet fire truck, one 132-gallon Simca fire truck, one 1,453-gallon Berliet fire truck with 370 gallons of foam, one 926-lb bromofluoride and carbon dioxide Hotchkiss truck, one 926-lb bromofluoride Latil truck, one 661-lb bromofluoride jeep trailer, wreckage removal equipment, and airline-type cargo handling equipment.

Search and Rescue: Limited SAR facilities at Noumea, a small military unit with two helicopters on call. New Caledonia is within the responsibility of SAR facilities at Lauthala Bay, Fiji Islands.

Medical Facilities: An infirmary on the base and a hospital and clinics in Noumea.

Logistics: Roads are winding and mountainous, with an all-weather road in fair condition to Noumea 35 miles away. A short line narrow gauge railroad runs from Paita to Noumea.

Weather Forecasting: Forecasts by the French Weather Service located at the airfield and Noumea.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1.0-mile visibility. At worst, during each of the months of February and April, the minimum occurs 2 percent of the time.

Climate: Tropical.

Local Features: Located near the western slope of New Caledonia about 21 n. mi. northwest of Noumea on a relatively flat area between a mountain range and the ocean. The drainage is adequate. Vertical obstructions include a mountain range running northwest to southeast with many peaks above 4,500 feet. The range is 10 n. mi. northeast of La Tontonta.

Lusaka International, Zambia

Coordinates: 15-19-45S, 28-27-10E.

Elevation: 3,779 ft.

Runway: Length--13,000 ft; extendable; surface--asphalt; strength--SWL = 106,000 lb, 270 psi.

Taxiways: Width--75 ft; surface--asphalt; strength--SWL = 65,000 lb, 190 psi.

Navigational Aids: ILS, ASR, DF, VHF, four non-directional beacons, VOR/DME, and approach control.

Lighting: Approach, slope indicators, threshold, touchdown baretts, runway centerline and edge, red stop bar, green taxiway centerline and blue edge, flood, obstruction, rotating beacon, and emergency flares.

Communications: Telephone, telegraph, teletype, and cable service at airfield.

Controlling Agency: Government Civil Aviation Authority.

Special Purpose Equipment: Wreckage removal equipment available and cargo handling equipment available at the Zambia Airways.

Search and Rescue: Short and medium-range aircraft. Related ATS units at Livinstone and Ndola.

Logistics: Roads good; railroads good; major port available.

Weather Forecasting: Station on base meets ICAO standards.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1.0-mile visibility. At worst, the minimum occurs 1 percent of the time for any month.

Climate: Tropical savanna, cooler uplands climate.

Local Features: Located 7 n. mi. northeast of Lusaka on a high (4,000-foot elevation) undulating plateau with sandy loam soil and scattered scrub. Approaches are over flat terrain, except for a 200-foot hill 4 miles west. Vertical obstructions include a 4,867-foot elevation peak located 10 n. mi. southeast and a 4,593-foot elevation peak 15 n. mi. northeast.

Significance: This is a new airfield and is the best in this part of Africa and will increase in importance.

Kadena AB, Ryukyu Islands

Coordinates: 26-21-08N, 127-46-15E.

Elevation: 142 ft.

Runway: Length x width--12,100 ft x 300 ft; extendable by 2,400 ft; surface--concrete; strength--SWL = 155,000 lb, 285 psi.

Taxiways: Widths--300 ft by 100 ft, and 75 ft; surface--concrete strength--SWL = 105,590 lb, 285 psi.

Navigational Aids: ILS, ASR, PAR, VOR, RBN, TACAN, and approach control.

Lighting: Runway, approach, taxiway, obstructions, security, threshold, and rotating beacon.

Communications: Worldwide telephone, duplex teletype, major stratcom relay, telegraph, cable, C/W, and radiophone, U. S. communication facilities.

Maintenance Facilities: All maintenance and repair services are available.

Special Purpose Equipment: Three 0-11, two R-2, and two P-2 crash and rescue units; six field and four civil ambulances; two 750-gallon pumpers; four 530-gallon pumpers; four pumper units; four 1,000-gallon tankers; one 1,500-gallon tanker; one 1-1/2 stake unit; and two P-6 ramp control units; one 50-ton crane, two 20-ton cranes; and seven truck wreckers; thirteen MB-2 aircraft towing tractors; and twenty-two MB-4 aircraft towing tractors; twelve 25-foot and twenty-five 40-foot trailers are all available.

Search and Rescue: Helicopters are available.

Medical Facilities: One hospital is available.

Airfield Security: The 824th Support Squadron provides 24-hour security and has 84 dog handlers.

Logistics: Excellent roads; no railroads; several ports on Okinawa.

Weather Forecasting: 24-hour forecasting by Det. 8, 20th Squadron.

Landing Weather: The airfield IFR landing weather minimum is for a 200-foot ceiling and a 1/2-mile visibility. At worst, during each of the months of May, June, August, and September, the minimum occurs 1 percent of the time.

Climate: Warm temperature climate.

Local Features: Located on the western shore of Okinawa-Jima on a mostly level clay and coral terrain. A 360-foot high structure is located 1.0 n. mi. south. The drainage is good, and the airfield is not subject to flooding.

N Djili, Congo

Coordinates: 4-23-05S, 15-26-42E.

Elevation: 1,014 ft.

Runway: Length x width--15,420 ft x 197 ft; extendable by 1,400 ft; surface--concrete; strength--SWL = 99,200 lb, 140 psi.

Taxiways: Width--100 ft; surface--concrete; strength--SWL = 99,200 lb, 140 psi.

Navigational Aids: ILS, VOR, RBN, D/F, and locator.

Lighting: Rotating light, approach, threshold, runway, taxiway, apron floods, wind indicator, obstruction, and flares.

Communications: U. S. communications facilities.

Controlling Agency: Congolese Directorate of Civil Aeronautics.

Maintenance Facilities: All types of aircraft maintenance shops and personnel are available; capabilities limited by limited personnel.

Special Purpose Equipment: Two ambulances, five fire trucks containing water, $CO_2$ foam, and powder.

Medical Facilities: 10-bed dispensary on base with doctors and nurses on call from hospitals in Kinshasa.

Airfield Security: Responsibility of city police.

Logistics: Four-lane asphalt road to Kinshasa; a single-track railroad spur to airfield from Kinshasa.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1.0-mile visibility. At worst, during each of the months of February, May, June, and November, the minimum occurs 1 percent of the time.

Climate: Tropical savanna.

Local Features: Located 8 n. mi. east/southeast of Leopoldville in the flat, swampy terrain surrounding the Congo River. The approach terrain is flat, with trees and bushes on all sides of the field. Vertical obstructions include a 2,379-foot elevation hill at 14 n. mi. southeast, a 2,700-foot elevation hill at 35 n. mi. northwest, and a 236-foot high structure at 8 n. mi. northwest.

Chia I, Taiwan

Coordinates: 23-27-55N, 120-22-55E.

Elevation: 82 ft.

Runway: Length x width--10,005 ft x 148 ft; surface--concrete; strength--SWL = 65,100 lb, 190 psi.

Taxiways: Width--74 ft; surface--concrete; strength--SWL = 65,100 lb, 190 psi.

Navigational Aids: GCA, radar, TACAN, RBN, approach control, and DF.

Lighting: Approach, runway, rotating beacon, flashing lights at runway end, taxiway, and apron.

Communications: Telephone HF, VHF, and UHF available, teletype passed by telephone to 13th ATF Comm CTR.

Controlling Agency: Chinese Air Force.

Maintenance Facilities: Electronic maintenance and ground power units are available.

Special Purpose Equipment: Wreckage removal equipment available.

Search and Rescue: CAT SA-15 Squadron provides air/sea rescue for all bases in Taiwan.

Logistics: One railroad spur from Chia I city.

Weather Forecasting: Chinese Air Force weather station on base.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1.0-mile visibility. At worst, during the month of February, the minimum occurs 5 percent of the time.

Climate: Sub-tropical with hot, humid summers and mild winters.

Local Features: Chia I is located about 3 n. mi. west of the city of Chia I in the middle of a vast plain on Taiwan's western coast. Vertical obstructions include an extensive mountain range running north to south with many peaks above 10,000 ft elevation, located 15 to 20 n. mi. east of the airfield; a 600-foot high structure some 10 n. mi. north; and a 430-foot high structure some 5 n. mi. north.

Bangkok International, Thailand

Coordinates: 13-54-40N, 100-36-30E.

Elevation: 12 ft.

Runway: Length x width--10,500 ft x 197 ft; extendable; surface--concrete; strength--SWL = 65,100 lb, 190 psi.

Taxiways: Widths--75 ft, 85 ft, and 98 ft; surface--concrete; strength--65,100 lb, 190 psi.

Navigational Aids: ILS, GCA, RBN, VORTAC, TACAN, VOR/DME, and approach control.

Lighting: Rotating beacon, runway, threshold, taxiway, approach, and obstruction.

Communications: Telephone, radio teletype circuits, and domestic and international radio circuits.

Controlling Agencies: Ministry of Communications and Royal Thai Air Force.

Special Purpose Equipment: Six USAF-operated crash trucks, ten RTAF-operated crash trucks, two fire stations with fourteen trucks, two 20-ton cranes, six bulldozers, three 10-ton cranes, and a complete air freight capability.

Search and Rescue: RTAF Air Rescue Squadron based at airfield.

Logistics: Excellent four-lane highways from Bangkok to airfield and double-track railroad adjacent to airfield.

Weather Forecasting: Thailand's major meteorological office is on the base.

Landing Weather: The airfield IFR landing weather minimum is for a 200-foot ceiling and a 1/2-mile visibility. At worst, during each of the months of January and February, the minimum occurs 1 percent of the time.

Climate: Tropical, but protected from northeast winds by mountain ranges.

Local Features: Located in north Bangkok on flat and swampy terrain. Vertical obstructions include a mountain range with elevations up to 6,800 ft, located 95 n. mi. west; a mountain range with elevations up to 4,500 ft, located 55 n. mi. northeast; a 2,618-foot elevation peak located 45 n. mi. south/southeast; a 306-foot high structure located 10 n. mi. southwest; a 290-foot high structure located 8 n. mi. southwest; and a 310-foot high structure located 11 n. mi. south/southwest.

Karachi Civil, West Pakistan

Coordinates: 24-54-20N, 67-09-25E.

Elevation: 95 ft.

Runway: Length x width--10,500 ft x 150 ft; extendable by 2,000 ft; surface--concrete; strength--SWL = 56,607 lb, 155 psi.

Taxiways: Widths--50 ft, 75 ft, and 100 ft; surfaces--concrete and asphalt; strength--56,607 lb, 155 psi.

Navigational Aids: ILS, VOR, RBN, D/F, and approach control.

Lighting: Rotating beacon, approach, runway, threshold, taxiway, flood, wind indicator, and obstruction.

Communications: Telephone, telegraph, teletype, cable, voice radio, and RCA worldwide communications circuits in Karachi.

Controlling Agency: Director General of Civil Aviation.

Maintenance Facilities: Numerous shops provide full maintenance capabilities.

Special Purpose Equipment: Wreckage removal equipment available, fire equipment available, and cargo handling equipment are available.

Search and Rescue: PAF Search and Rescue Squadron located at Masroor with short- and long-range aircraft and helicopters.

Medical Facilities: Several small dispensaries on airfield and four hospitals in Karachi.

Logistics: Two excellent highways from airfield to Karachi, a main railroad spur runs into the airfield, and the main Pakistan port is at Karachi.

Weather Forecasting: By the Airport Forecast Office and the Regional Office of Pakistan Meteorology Service located at the airfield.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 3/4-mile visibility. At worst, during each of the months of March, June, and October, the minimum occurs 1 percent of the time.

Climate: Sub-tropical steppe climate influenced by maritime air masses.

Local Features: Located between the cities of Karachi and Malir 5 n. mi. northeast of Karachi and 2 n. mi. southwest of Malir. The surrounding terrain is relatively flat. Vertical obstructions include a 476-foot elevation hill located 9 n. mi. west/northwest, a 769-foot elevation hill located 23 n. mi. west/southwest, a 1.759-foot elevation hill located 20 n. mi. northwest, a 246-foot high structure at 5 n. mi. southwest, a 226-foot-high structure at 7 n. mi. southwest, a 255-foot high structure at 1 n. mi. east, and a 230-foot high structure located at 7 n. mi. southeast.

Andersen AFB, Guam

Coordinates: 13-34-52N, 144-55-28E.

Elevation: 624 ft.

Runway: Length x width--11,200 ft x 200 ft; extendable by 3,000 ft; surface--concrete; strength--SWL = 110,000 lb, 285 psi.

Taxiways: Width--200 ft; surface--concrete; strength--110,000 lb, 285 psi.

Navigational Aids: GCA, VOR, TACAN, RBN, omni, UHF-VHF/DF, and approach control.

Lighting: Runway, threshold, taxiway, obstruction, approach, rotating beacon, and boundary.

Communications: Island telephone integrated with three automatic USN exchanges, teletype, radio teletype, radio telephone, radio telegraph, and cable facilities.

Controlling Agency: United States Air Force.

Maintenance Facilities: Full maintenance capability available on assigned aircraft.

Special Purpose Equipment: Seven crash trucks, six ambulances, ten fire trucks, two 15,000-lb fork lifts, and thirty-one 4,000- to 6,000-lb fork lifts.

Search and Rescue: SAR Guam Rescue Coordination Center with aircraft, helicopters, and one sea-going rescue vessel.

Medical Facilities: 25-bed dispensary on base and a 350-bed U. S. Naval Hospital 11 miles southeast of the base.

Logistics: Good roads, no railroads, and a good harbor nearby.

Weather Forecasting: USAF Weather Station on the base.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 3/4-mile visibility. At worst, during each of the months of January, February, August, September, and October, the minimum occurs 1 percent of the time.

Climate: Maritime tropical modified by dry northeast trade winds.

Local Features: Located on the northeast shore of Guam, with no major vertical obstructions.

<u>Ramey AFB, Puerto Rico</u>

Coordinates: 18-29-39N, 67-07-47W.

Elevation: 237 ft.

Runway: Length x width--11,700 ft x 300 ft; surface--concrete; strength--SWL = 105,590 lb, 285 psi.

Taxiways: Widths--75 ft, 100 ft, and 150 ft; surfaces--concrete and asphalt; strength--105,590 lb, 285 psi.

Navigational Aids: ILS, TACAN, VOR, RBN, UHF/DF, GCA, and approach control.

Search and Rescue: San Juan Island Rescue Control Center with extra long range, very long range, and long range aircraft is available

Logistics: Military highway from San Juan to Ramey AFB; no railroad.

Weather Forecasting: Air Weather Service (USAF) at Ramey and U. S. Weather Bureau Forecast Office at San Juan.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1/2-mile visibility. The minimum occurs zero percent of the time for all months.

Climate: Tropical rain forest.

Local Features: Located on the northwest shore of Puerto Rico on a relatively flat plain between mountains and the sea. Vertical obstructions include a 400-foot high structure located 4 n. mi. southeast, a 1,207-foot high peak located 9 n. mi. southeast, a 3,953-foot high peak located 29 n. mi. southeast, and a 4,390-foot high peak located 39 n. mi. southeast.

Faaa, Society Islands

Coordinates: 17-32-45S, 149-36-25W.

Elevation: 7 ft.

Runway: Length x width--11,204 ft x 148 ft; not extendable; surface--asphalt; strength--SWL = 46,000 lb, 155 psi.

Taxiways: Width--50 ft; surface--asphalt; strength--SWL = 46,000 lb, 155 psi.

Naviational Aids: ILS, VHF/DF, VOR, approach control.

Lighting: Threshold, runway, taxiway, obstruction, and approach.

Communications: Telephone to Papeete, telegraph, radio communication circuits in Papeete.

Controlling Agency: Civil Aviation Administration of French Polynesia (AVA).

Maintenance Facilities: Minor maintenance available at the airfield.

Special Purpose Equipment: One ambulance, four fire trucks, and cargo handling equipment are available.

Search and Rescue: Two Alouette II are available.

Medical Facilities: Hospital in Papeete with full facilities.

Logistics: Good road from Papeete to airfield and a port at Papeete 2.5 miles northeast.

Weather Forecasting: Meteorological Office and forecasting service at airfield.

Landing Weather: The airfield IFR landing weather minimum is for a 300-foot ceiling and a 1/2-mile visibility. At worst, during each of the months of January and November, the minimum occurs 2 percent of the time.

Climate: Tropical maritime.

Local Features: Located on the northwest shore of Tahiti. East of the airfield a steep slope begins and reaches a peak of 7,339 feet elevation 8 n. mi. from the airfield. About 10 n. mi. west is Moorea Island, with a peak of 3,975 feet elevation.

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Udorn, Thailand

Coordinates: 17-23-06N, 102-47-34E.

Elevation: 585 ft.

Runway: Length x width--10,000 ft x 125 ft; unlimited extendability; surface--concrete; strength--65,100 lb, 190 psi.

Taxiways: Width--75 ft; surface--concrete; strength--C-141 capacity.

Navigational Aids: GCA, DF, RBN, and TACAN.

Lighting: Rotating light, threshold, runway, taxiway, approach lights.

Controlling Agency: The Royal Thai Air Force.

Maintenance Facilities: Limited maintenance available for assigned aircraft.

Special Purpose Equipment: A 50-ton crane, a bulldozer, and four trucks.

Search and Rescue: USAF provides search and rescue helicopters for USAF units operating from this airfield.

Medical Facilities: Ten-bed dispensary in RTAF area; Air America has a small dispensary; USAF paramedics are available; and a Class B dispensary.

Logistics: Two primary roads, a railroad siding 1 mile east of field, and modern port facilities nearby.

Weather Forecasting: Observation station available on base.

Landing Weather: The airfield IFR landing weather minimum is for a 400-foot ceiling and a 3/4-mile visibility. At worst, during each of the months of March, August, and September, the minimum occurs 4 percent of the time.

Climate: Tropical.

Local Features: Located in relatively flat terrain 2 n. mi. south of Udorn Thani. The airfield is subjected to flooding during rainy season. No major vertical obstructions are in the area.

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