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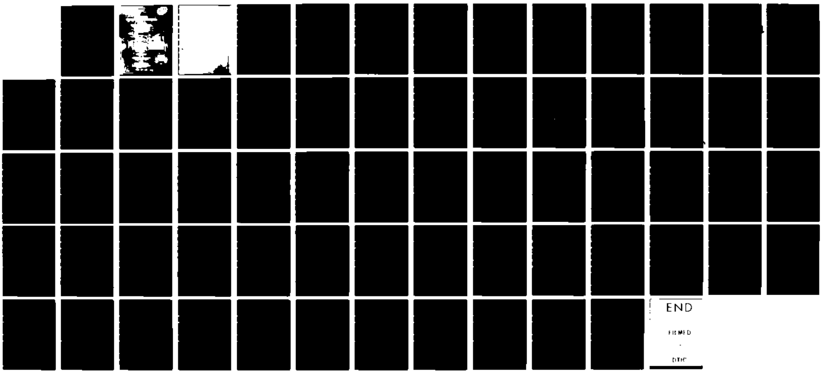

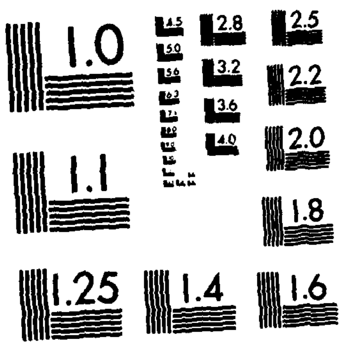
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16. Abstract


The Oceanic (and selected Non-Oceanic) Area System Improvement Study (OASIS), conducted by SRI International under contract with the Federal Aviation Administration (FAA), was part of a broad oceanic aeronautical system improvement study program coordinated by the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation" (also called the Aviation Review Committee or the ARC). The OASIS Project, with inputs from the international aviation community, examined current and potential future oceanic air traffic control (ATC) systems in the North Atlantic (NAT), Central East Pacific (CEP), and Caribbean (CAR) regions. This phase of the Aviation Review Committee program began in late-1978 and was completed in mid-1981.

The thrust of the Aviation Review Committee program, which OASIS broadly supported, was to analyze the present ATC systems; examine future system requirements; identify areas where the present systems might be improved; and develop and analyze potential system improvement options. The time frame of this study is the period 1979 to 2005.

(Central East Pacific)

This report describes the present air traffic services (ATS) system in the CEP region. This system provides ATC, flight information, and alerting services to aircraft in oceanic control areas (CTAs)/flight information regions (FIRs). The report addresses the operations, technical components, and costs of the following ATS units: Oakland Area Control Center (ACC) and Honolulu ACC.


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Oceanic Area System Improvement Study (OASIS)

Final Report

This report is one of a set of companion documents which includes the following volumes:

Volume I
Executive Summary and Improvement Alternatives Development and Analysis

Volume II
North Atlantic Region Air Traffic Services System Description

Volume III
Central East Pacific Region Air Traffic Services System Description

Volume IV
Caribbean Region Air Traffic Services System Description

Volume V
North Atlantic, Central East Pacific, and Caribbean Regions Communication Systems Description

Volume VI
North Atlantic, Central East Pacific, and Caribbean Regions Navigation Systems Description

Volume VII
North Atlantic Region Flight Cost Model Results

Volume VIII
Central East Pacific Region Flight Cost Model Results

Volume IX
Flight Cost Model Description

Volume X
North Atlantic, Central East Pacific, and Caribbean Regions Aviation Traffic Forecasts

## PREFACE

The Oceanic Area System Improvement Study (OASIS) was conducted in coordination with the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation (also called the Aviation Review Committee or the ARC)." This study examined the operational, technological, and economic aspects of the current and proposed future oceanic air traffic systems in the North Atlantic (NAT), Caribbean (CAR), and Central East Pacific (CEP) regions and assessed the relative merits of alternative improvement options. A key requirement of this study was to develop a detailed description of the present air traffic system. In support of this requirement, and in cooperation with working groups of the Committee, questionnaires were distributed to the providers and users of the oceanic air traffic systems. Responses to these questionnaires, special reports prepared by system provider organizations, other publications, and field observations made by the OASIS staff were the basis for the systems descriptions presented in this report. The descriptions also were based on information obtained during Working Group A and B meetings and workshops sponsored by Working Group A. The information given in this report documents the state of the oceanic air traffic system in mid 1979.

In the course of the work valuable contributions, advice, data, and opinions were received from a number of sources both in the United States and outside it. Valuable information and guidance were received and utilized from the International Civil Aviaiton Organization (ICAO), the North Atlantic Systems Planning Group (NAT/SPG), the North Atlantic Traffic Forecast Group (NAT/TFG), several administrations, the International Air Transport Association (IATA), the airlines, the International Federation of Airline Pilots Association (IFALPA), other aviation associated organizations, and especially from the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation."

It is understood of course, and should be noted, that participation in this work or contribution to it does not imply either endorsement or agreement to the findings by any contributors or policy agreement by any administration which graciously chose to contribute.

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## EXECUTIVE SUMMARY

Air traffic services (ATS) provided to aircraft flying in the Central East Pacific (CEP) oceanic region include: (1) air traffic control (ATC), (2) flight information and (3) alerting services. Control areas (CTAs) and flight information regions (FIRs) have been established for the performance of these services. In the CEP combined CTA/FIR's provide all three types of ATS, with ATS units called area control centers (ACC's) serving both oceanic and domestic airspace. The designated areas and ATS units are established by international agreement under the auspices of the International Civil Aviation Organization (ICAO).

This report is a description of the present ATS system in the CEP and emphasizes the services provided by the Oakland ACC and the Honolulu ACC (excluding that portion west of longitude 160 degrees West).

Radar surveillance of CEP airspace is not conducted due to the lack of suitable ground sites for antennae, and thus ATS personnel monitor oceanic flights by processing pilots' position reports; these voice reports are transmitted about once per hour. Direct air-ground communications between oceanic aircraft and ATS personnel are not available, again because of ground site restrictions on ATS communication systems. Instead, the ATS units are supported by communication (COM) stations which operate long-range, high-frequency (HF) radio facilities and relay messages between pilots and ATS unit personnel. The stations, located separately from the ATS units, include the San Francisco and Honolulu COM stations. The ATS units and COM stations as well as airline, military, meteorological, and other aviation facilities are connected by the aeronautical fixed telecommunications network (AFTN), which provides teletype service, and ATS direct speech circuits.

CEP flights are flown on random tracks, charted routes, or the organized route system (ORS), a set of roughly parallel tracks between Hawaii and California. CEP routes are navigated by aircraft typically equipped with inertial navigation system (INS) or Omega and doppler devices.

Based on an analysis of data describing high altitude subsonic turbojet traffic on a representative peak day in July 1979, approximately 110 flights used the ORS, and approximately 70 flights used random tracks. The charted routes were used by no more than a few flights each day.

By international agreement, each aircraft flying in the oceanic CTAs files a flight plan with each ATS unit along the route of flight and is provided with separation service by each unit. The flight plan is based on an analysis of meteorological conditions and aircraft performance characteristics and describes the desired flight track, altitude and speed of the aircraft. If there are no potential violations of separation minima with other aircraft, the oceanic ATS unit issues a clearance to the aircraft for its desired flight path. In the event of a potential conflict, the ATS unit identifies and issues an oceanic flight path clearance that conforms to the aircraft separation requirements. An oceanic clearance is issued by the ATS unit while the aircraft is in direct voice radio contact with the unit (or an adjacent domestic ATS unit) and before the aircraft enters the oceanic airspace. After oceanic entry, the COM station relays pilot position reports, requests for altitude change (if any) and other messages as well as responses from the ATS unit. The ATS unit follows the progress of each flight by manually recording each reported position on paper flight strips. Each flight on an ORS track is issued a conflict-free clearance at a fixed flight level for the full length of the track to landfall.

A pilot may request an altitude change while in oceanic airspace when the aircraft burns off sufficient fuel to attain a more economical higher flight level. A step climb approval is granted by the ATS unit subject to the satisfaction of the separation minima.

Coordination between ATS units is routinely conducted by means of the ATS direct speech and AFTN circuits. ATS units must coordinate with each other to pass flight data for aircraft crossing their boundaries.

ACKNOWLEDGEMENTS

We wish to thank Mr. V. E. Foose, FAA Program Manager, Mr. N. Craddock and Mr. J. Loos of the FAA, and the FAA personnel at Oakland and Honolulu Area Control Centers for their guidance and assistance in this research. We are also grateful to Continental Airlines, Pan American Airlines, United Airlines, and Western Airlines for providing valuable information and assistance to the project team. We are highly appreciative of the guidance provided by the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation."

This work was performed by SRI International under the leadership of Dr. George J. Couluris with the support of Mr. David B. Koretz. Dr. Bjorn Conrad, Mr. Robert Lieberman and Ms. Marika E. Garskis participated in this system description effort. Ms. Geri Childs prepared this report. The project was conducted under the administrative supervision of Dr. Robert S. Ratner and Mr. Joel R. Norman.

## GLOSSARY OF ACRONYMS

| | |
|---|---|
| ACC | Area control center |
| ADF | Automatic direction finding |
| ADIS | Automated Data Interchange System |
| AFTN | Aeronautical fixed telecommunications network |
| A/G | Air/ground |
| AIREP | Air report |
| ANP | Air navigation plan |
| ATC | Air traffic control |
| ATS | Air traffic services |
| CEP | Central East Pacific |
| CERAP | Combined en route and radar approach |
| COM | Communications |
| CTA | Control Area |
| DME | Distance measuring equipment |
| EDT | Estimated departure time |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulations |
| FDP | Flight data processing |
| FIC | Flight information center |
| FIR | Flight information region |
| FL | Flight level |
| ft | Feet |
| GMT | Greenwich Mean Time |
| GTS | Global Telecommunications System |
| HF | High frequency |
| hr | Hour |
| ICAO | International Civil Aviation Organization |
| IFR | Instrument flight rule |
| INS | Inertial navigation system |
| LORAN | LOng RAnge Navigation system |

| | |
|---|---|
| mbar | Millibar |
| MHz | Megahertz |
| min | Minute |
| MNPS | Minimum navigation performance specifications |
| MTT | Minimum time track |
| NDB | Nondirectional beacon |
| NMC | National Meteorological Center |
| nmi | Nautical mile |
| nmi/hr | Nautical mile per hour |
| NWS | National Weather Service |
| OACC | Oceanic area control center |
| ORS | Organized route system |
| PTT | Post, telephone and telegraph |
| RNAV | Area navigation |
| SELCAL | Selective calling |
| SIGMET | Significant meteorological data |
| SSB | Single sideband |
| SSR | Secondary surveillance radar |
| TMA | Terminal Control Area |
| UHF | Ultra high frequency |
| US | United States |
| VHF | Very high frequency |
| VOR | Very high frequency omnidirectional range |

# 1.0 INTRODUCTION

## 1.1 General

Various nations serve as contracting states to the International Civil Aviation Organization (ICAO) and provide air traffic services (ATS) within designated areas of international oceanic airspace. Flights in these areas receive aircraft separation, traffic flow facilitation, information processing, and emergency assistance services. The areas are determined by regional air navigation agreements that are approved by the Council of ICAO, normally on the advice of Regional Air Navigation Meetings. Each contracting state designates the authority responsible, typically a government agency, for establishing and providing ATS in accordance with the ICAO standards and recommended practices. These services are provided and supported by a complex structure of interrelated operational and technical components. Generally, the operational components--operating rules, procedures, requirements and associated facilities--are considered to be part of the ATS system. The technical components--communication, navigation, surveillance, and meteorological factors, etc.--are often considered as separate systems. However, because operating rules and procedures are dependent on the technological performance of the equipment in use, any description of an ATS system also should address its technical components.

## 1.2 Scope and Objective

This report presents a description of the operational and technical components of the present international ATS system in the upper airspace of the Central East Pacific (CEP) region. The purpose of this description is twofold: (1) to provide further understanding of the requirements and capabilities of the present ATS system, and (2) to provide an information base for subsequent evaluations of the system. The ATS descriptions contained herein also provide background material useful for general-purpose reference.

## 1.3 Contents of This Report

The information and data presented are based on observations made during on-site visits to ATS facilities, consultations with air carrier and ATS operations and support personnel, ICAO reports (ref. 1 through 5) and data obtained from the Federal Aviation Administration (FAA) in the United States (US) and associated US government documents (ref. 6 and 7).

This report consists of six sections, as well as a number of appendices that provide supplemental descriptive data. Section 2.0 gives an overview of the ATS in the CEP operating environment, including air traffic flow patterns, airspace organization and facilities, technical systems, oceanic route structures, and ATS operating procedures. Sections 3.0, 4.0 and 5.0 provide detailed descriptions of the interrelationships among the ATS component parts sufficient for an understanding of the system. These sections respectively address: technical aspects of the communication, navigation, and surveillance systems; separation minima; and the procedures by which ATS are provided. Section 6.0 contains preliminary estimates of the costs required to provide ATS in the CEP.

## 2.0 ATS OVERVIEW--CEP OPERATIONAL ENVIRONMENT

### 2.1 General Requirements for ATS Provision

ATS in the CEP is provided in accordance with ICAO provisions (ref. 1, 2) by designated ATS units that are responsible for operations in each airspace area. The ATS provided consists of the following (ref. 1):

(1) Air traffic control (ATC) service, whose objectives are to provide separation between aircraft and to expedite and maintain an orderly flow of air traffic. ATC service in this report is restricted to area control service in en route airspace (i.e., excludes approach control service and aerodrome control service).

(2) Flight information service, whose objective is to provide advice and information useful for the safe and efficient conduct of flight.

(3) Alerting service, whose objective is to identify an emergency event and then notify appropriate organizations regarding aircraft in potential need of search and rescue aid and assist such organizations as needed.

#### 2.1.1 Designation of ATS Areas

ATS areas are designated in relation to the particular services provided as follows (ref. 1):

(1) Flight information region (FIR), where flight information and alerting service are provided.

(2) Control area (CTA), where ATC service is provided.

An FIR is delineated to cover the entire air route structure to be served by the region, and includes all airspace from the surface upward within its lateral limits.

A CTA is delineated so as to contain the flight paths of those instrument flight rule (IFR) flights that are to receive ATC service, taking into account the capabilities of the navigation aids normally used in the vicinity. Although ICAO (ref. 1) specifies that the lower limit of a CTA should be established at a height above the surface of not less than 700 ft., the lower limit of oceanic CTA's in the CEP is at flight level (FL) 55 (i.e., at an atmospheric pressure altitude of 5500 ft.).

2.1.2 Designation of ATS Units

Two general types of ATS units provide service in the CEP en route airspace:

(1) ATC unit; specifically: area control center (ACC)

(2) Flight information center (FIC).

ATC units are established to provide full ATS--ATC service, flight information service, and alerting service--in designated airspace areas. Where an ATS unit provides both flight information and ATC services, the provision of ATC service has precedence over the provision of flight information service. Units providing services in strictly oceanic CTAs are oceanic area control centers (OACCs), while units serving combined oceanic and domestic CTAs are area control centers (ACCs). Although control centers generally have responsibility for total ATS service, in practice they may delegate elements of the flight information service to other units, including non-ATS units. For example, the duty of transmitting significant meteorological (SIGMET) data to aircraft in an oceanic area may be assigned to an aeronautical communications (COM) station supporting an ATC unit.

An FIC provides flight information and alerting service within FIRs, unless the responsibility of providing such services is assigned to an ATC unit. An FIC, as in the case of the ACC example above, may delegate certain elements of the flight information service to other units.

2.1.3 Aircraft Separation

ATC units provide separation services between aircraft in CTAs except where aircraft are required to provide their own separation as in the case of operations in airspace reservation areas. Separation service provided in the CEP oceanic areas offers the following forms of separation (ref. 1):

(1) Vertical separation, maintained by assigning different levels of flight.

(2) Horizontal separation, obtained by providing longitudinal or lateral intervals (time or distance) between aircraft satisfying minimum horizontal spacing specifications.

(3) Composite separation, consisting of a combination of vertical and lateral separation forms using minima for each which may be lower than, but not less than half of, those used for each of the combined elements when applied individually.

The vertical, horizontal and composite separation minima and methods of application in the CEP are prescribed by ICAO (ref. 3,4).

## 2.2 Airspace Organization and ATS Facilities

The en route upper airspace jurisdictional structure in the CEP is shown in Figure 1, which identifies the CTA/FIR established by international agreement and described by the ICAO Air Navigation Plan (ref. 5). The area addressed by this study includes the Oakland CTA/FIR and the portion of the Honolulu CTA/FIR that lies east of 160 degrees West longitude. Note that the CEP CTA/FIRs are bounded to the north, west and south by other oceanic control areas including the Anchorage, Honolulu Central West Pacific (CWP), Nandi, Auckland and Tahiti CTA/FIRs. The CEP is bounded to the east by the Vancouver, Seattle, Oakland and Los Angeles domestic control areas in Canada and the US as well as by an uncontrolled open area off the Mexican coast in which ATS is not provided.

The Oakland ACC and Honolulu ACC provide ATS in the CEP. Table 1 summarizes the designated CEP oceanic areas, ATS operating units (unit responsibilities are noted), unit locations, and provider authority and contracting state. Other ACCs provide ATS in the adjacent CTA/FIRs.

## 2.3 Air Traffic Flow Patterns

The CEP air traffic is composed of scheduled and charter air carrier, general aviation and military flights. Figure 2 shows the general origin and destination flow patterns of the scheduled commercial turbojet flights through the CEP upper airspace for a selected day in July 1979 (i.e., a representative busy day). The numbers indicated in Figure 2 are the daily total scheduled flights for each geographic flow pattern, and are based on the published airline schedules, as well as flight strip data for charter, general aviation and military flights. The traffic is fairly uniform throughout the day, except that very few flights depart in early morning hours (i.e., 2 to 6 a.m. local time).

Of the total 177 daily flights shown, 77 percent (i.e., 136 flights) are between Hawaii and mainland North America, excluding Alaska. The remaining traffic is between the Far East and North America (17 percent; 30 flights), between the South Pacific (i.e., Oceania) and North America (3 percent; 6 flights) and between Alaska and Hawaii or the West Coast (3 percent; 5 flights). The large concentration of flights between Hawaii and California accounts for the greatest loading on ATS facilities in the CEP. There are 20 CEP military flights included, or 11 percent of the total.

The actual route and altitude desired by each flight are defined by the aircraft operator, usually an airline, based on minimum flight time and/or fuel burn considerations, meteorological conditions, aircraft performance characteristics and published route requirements. As a

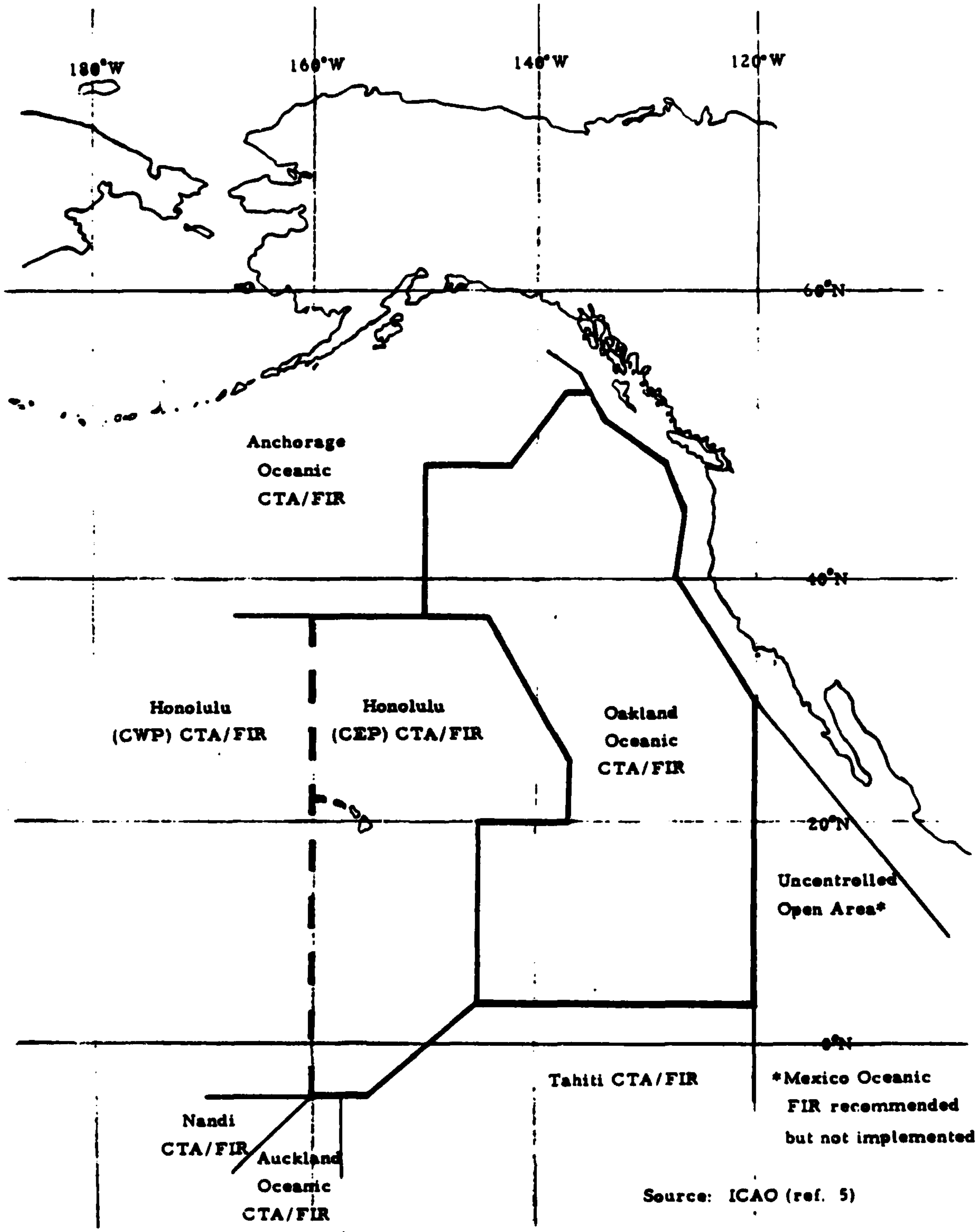



FIGURE 1. JURISDICTIONAL STRUCTURE OF CEP AND SURROUNDING AIRSPACE

Table 1

CEP ATS ORGANIZATIONS AND FUNCTIONS

| | Honolulu CTA/FIR | Oakland CTA/FIR |
|---|---|---|
| ATS Operating Unit: | Honolulu ACC | Oakland ACC |
| ATS Responsibilities*: | ATC, FI, ALERT | ATC, FI, ALERT |
| Location: | Honolulu, Hawaii, U.S. | Fremont, Calif, U.S. |
| Provider Authority, Contracting State: | Federal Aviation Administration (FAA), Department of Transportation (DOT), United States | |

*The ATS responsibilities include ATC, Flight Information (FI) and alerting (ALERT) services.

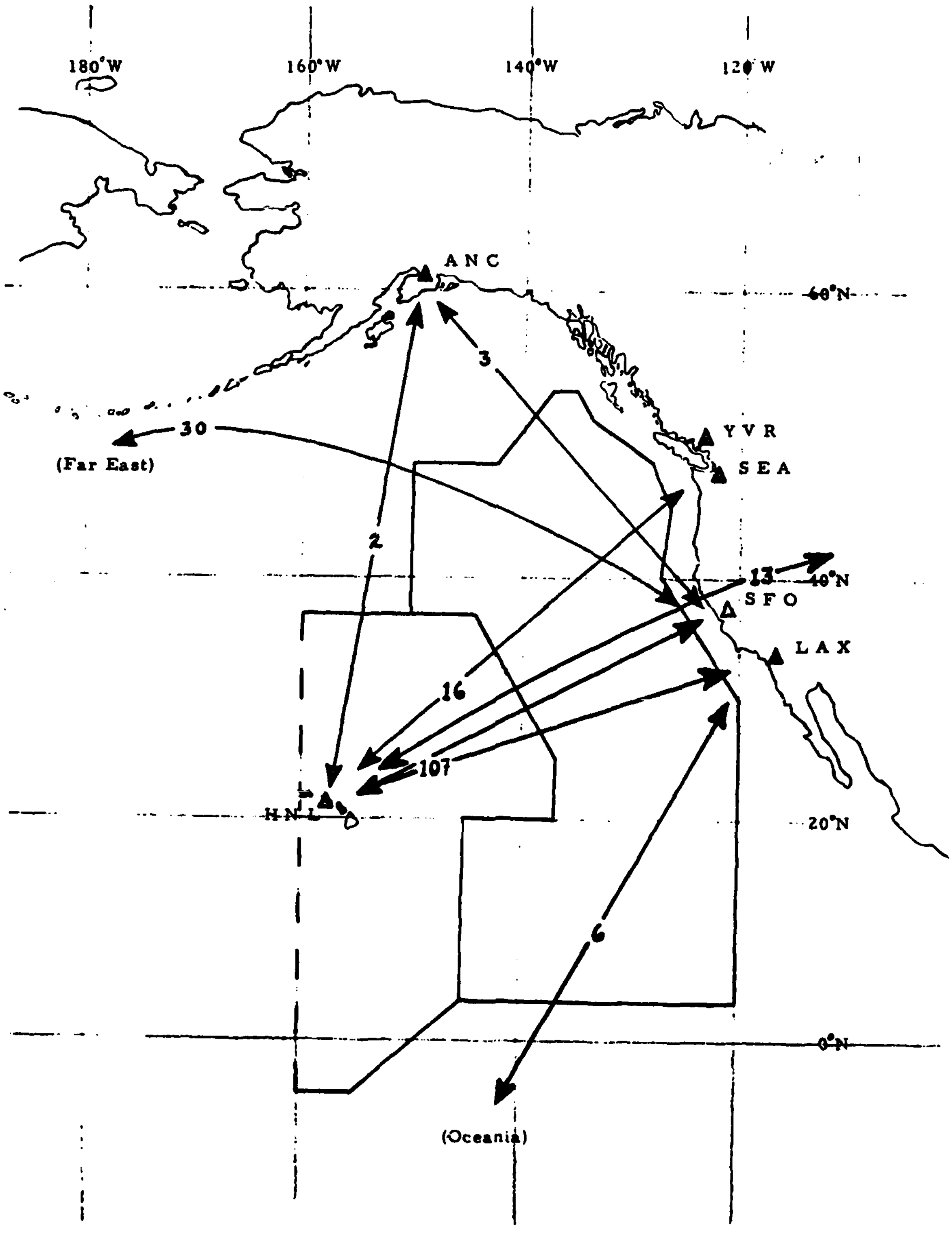



FIGURE 2. CEP DAILY AIR TRAFFIC FLOW PATTERNS, SAMPLE DAY, JULY 1979

result, congestion occurs where preferred routes coincide and flights are frequent. For example, the major traffic flows between San Francisco and Hawaii, and between Los Angeles and Hawaii, each experience moderate congestion in their respective corridors because of high demand and similar routings. Depending on meteorological conditions, traffic to and from Hawaii originating in or destined to inland North America (e.g., Chicago, Denver) often fly on routes coincidental with the California-Hawaii traffic and contribute to congestion in the major flow corridors. Flights between Hawaii and the Pacific Northwest (e.g., Seattle, Portland, Vancouver) generally fly north of the major traffic flow but may experience some congestion where they funnel together in the vicinity of the Hawaiian Islands. Flights between the South Pacific and North America generally are routed south of the major flow and do not contribute significantly to congestion.

Although not a major congestion problem, the intersection of the Pacific Northwest-Hawaii and North America-Far East routes causes interference between these two traffic flows in the Oakland CTA/FIR. The North America-Far East traffic consists mostly of flights between Japan and the West Coast and Midwest. Flights between the North American northeast coast and the Far East normally fly north of the Oakland CTA/FIR and do not enter the CEP.

## 2.4 Technical Systems Overview

Although advanced ATS technical systems are in use in domestic airspace, their general application has not been extended to oceanic operations. Instead, alternative technologies have been employed to support oceanic ATS. The main distinctions between the oceanic and domestic technical environments are in the communication, navigation, and surveillance systems. For the most part, limitations on the service range of the domestic systems and the lack of suitable land sites in the oceanic areas have precluded the extensive use of the domestic systems in the CEP.

For example, most domestic air-ground voice communications between pilots and ATS units are conducted by means of very-high frequency (VHF) short-range systems; short-range ultra-high frequency (UHF) is used by some military operations. These systems, although quite adequate for domestic ATS purposes, cannot satisfy the long-range transmission requirements of the CEP operation. Instead, a high frequency (HF) radiotelephony system is used in which COM stations, rather than ATS units (which are not HF equipped), conduct longrange communications with over-ocean aircraft. Radio operators in the COM stations carry out these communications.

Point-to-point communications between ATS units generally are conducted by voice through ATS direct speech circuits and by teletype through aeronautical fixed telecommunications network (AFTN) circuits. The ATS direct speech and AFTN systems in the CEP are integrated with those in use in other areas and are part of multi-regional interfacility communication networks. ATS direct speech interphone and AFTN teletype lines are established between the Oakland and Honolulu ACCs as well as between adjacent ATS units. Advanced computerized data processing systems in the Oakland ACC are connected by data link with similar systems elsewhere in the US.

Aircraft navigation in domestic airspace normally uses ground-based systems of short-range VHF omnidirectional range (VOR) and distance measuring equipment (DME) radionavigation aids or nondirectional beacon (NDB) aids and automatic direction finding (ADF) equipment. Neither the VOR/DME nor the NDB/ADF systems can meet the long-range navigation requirements of the trans-oceanic flights in the CEP. Long-range navigation commonly is accomplished by means of Inertial Navigation System (INS) avionics or a low-frequency radio navigation system provided with worldwide coverage and referred to as "Omega".

The radar systems used for domestic aircraft surveillance are not capable of long-range surveillance. No alternative technology is currently employed in the CEP for surveillance purposes, although, as will be noted, indirect flight monitoring is based on pilot radio reports of aircraft positions.

## 2.5 Oceanic Route Structures

Various oceanic route structures are in use to accommodate the various traffic densities and routings. These route structures are categorized as follows for the purposes of this study:

(1) Organized route system (ORS).

(2) Charted routes.

(3) Random tracks.

### 2.5.1 ORS

The ORS, shown in Figure 3, is a set of six published fixed tracks which serve the major traffic flow between Hawaii and the California West Coast and which are configured to enable effective organization and management of the numerous flights in this airspace. The ORS consists of two sets of three tracks each. The northern set of nearly parallel tracks (designated R63, R64 and R65) runs between Hawaii and the San Francisco/Oakland area while the southern set of nearly parallel tracks (designated R76, R77 and R78) runs between Hawaii and the Los Angeles/San Diego area. The three tracks in each set are basically 50 nmi apart and include two one-way tracks--one eastbound and one westbound--and an outermost bi-directional track. The direction of flight by flight level is assigned as shown in Figure 3 such that even altitudes (i.e., FL300, 320, 340 to 400) or odd altitudes (i.e., FL290, 310, 330 to 410) are

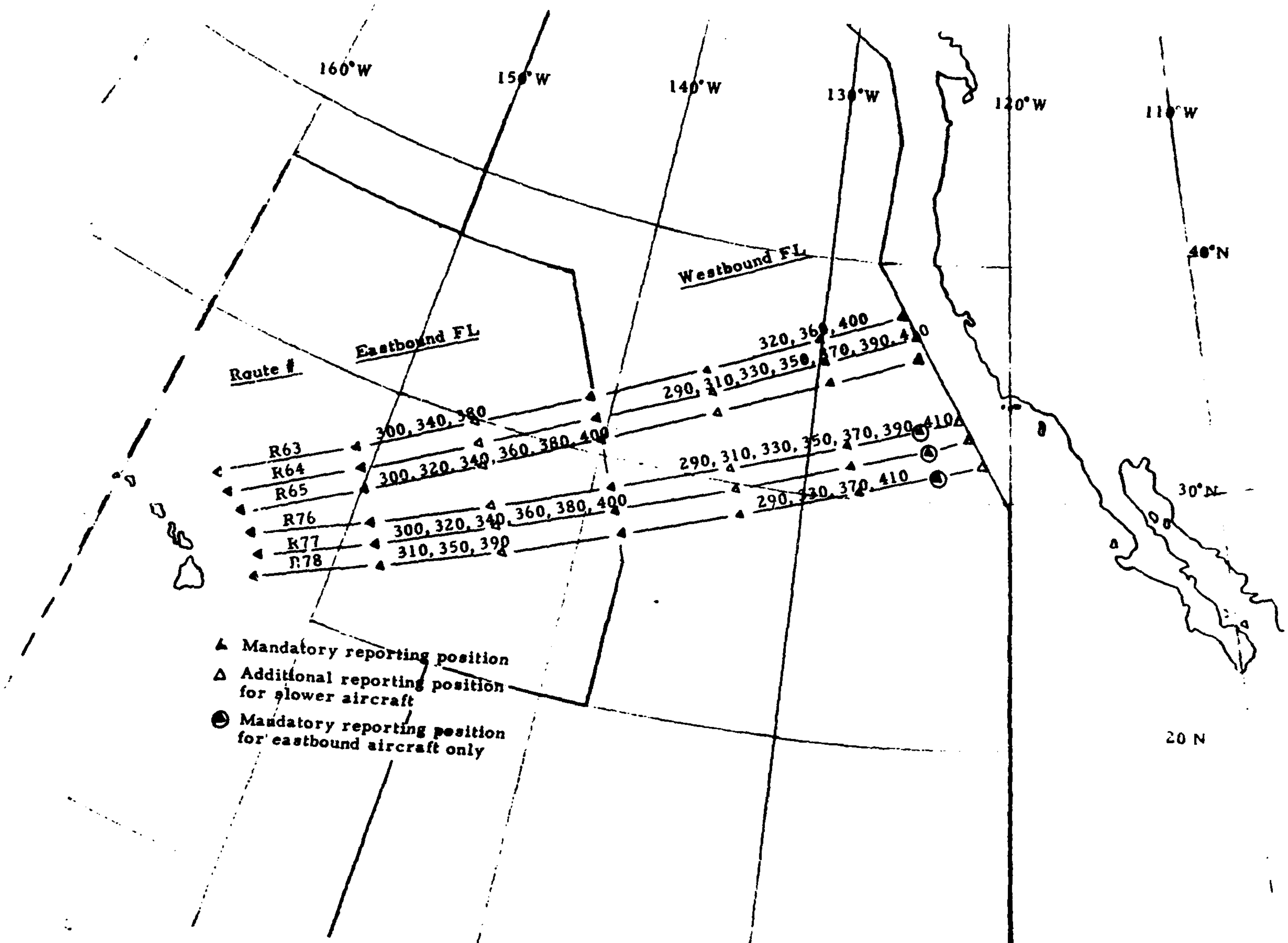



FIGURE 3. CEP ORGANIZED ROUTE SYSTEM

assigned alternately on successive tracks. The ORS is configured to provide composite separation to aircraft flying legal flight levels on the tracks. The ORS tracks are very nearly great circle routes between their endpoints.

### 2.5.2 Charted Routes

Charted routes are geographically stationary and are identified as fixed routes in aeronautical charts. A charted route is a single route between two fixes and is not part of a set of offset parallel tracks. The five tracks currently established in the CEP join Los Angeles, Vancouver and Honolulu with South Pacific locations as shown in Figure 4.

### 2.5.3 Random Tracks

Aircraft are not required to fly fixed routes (ORS or charted routes) but often do so when constrained by procedural restrictions or to take advantage of the reduced aircraft separation requirements. Aircraft fly on random tracks when flying between points where no formal tracks are defined (such as between Hawaii and the Pacific Northwest and between the Far East and North America). A random track is selected by an aircraft operator based on available navigation services and prevailing weather conditions, and is designated for an individual flight. A random track is not retained for subsequent flights. Random tracks in the CEP normally are flown by INS or Omega equipped aircraft, although less sophisticated navigation techniques may be used where permitted.

## 2.6 ATS Operations Overview

The provision of full ATS in CTAs requires that separation service be provided by ATS units and that aircraft operators comply with procedures established by international agreement; these procedures include the filing of flight plans and adherence to communications practices (ref. 2). The flight plans describe the aircraft identities, equipment and planned speeds, routes, altitudes, and times of flight and related data, and are submitted to ATS units by aircraft operators. The communication practices include the transmittal of flight information--position reports or air reports (AIREPs)--by pilots and the issuance of clearances to proceed along the route of flight and traffic advisories (i.e., alerts describing nearby aircraft) by ATS units.

An aircraft is initially given an abbreviated clearance (i.e., specification of route and altitude) to the destination airport by an ATS unit, and flies through domestic airspace from takeoff to the point of CEP oceanic entry. The domestic and oceanic airspace areas are divided into sectors on the basis of facilities, routes and workload. The domestic sector controllers, who generally are supported by radar, VHF communications and VOR/DME navigation facilities, provide separation services based on considerably closer spacings than are permitted by CEP oceanic procedures. The proper oceanic separations must be established

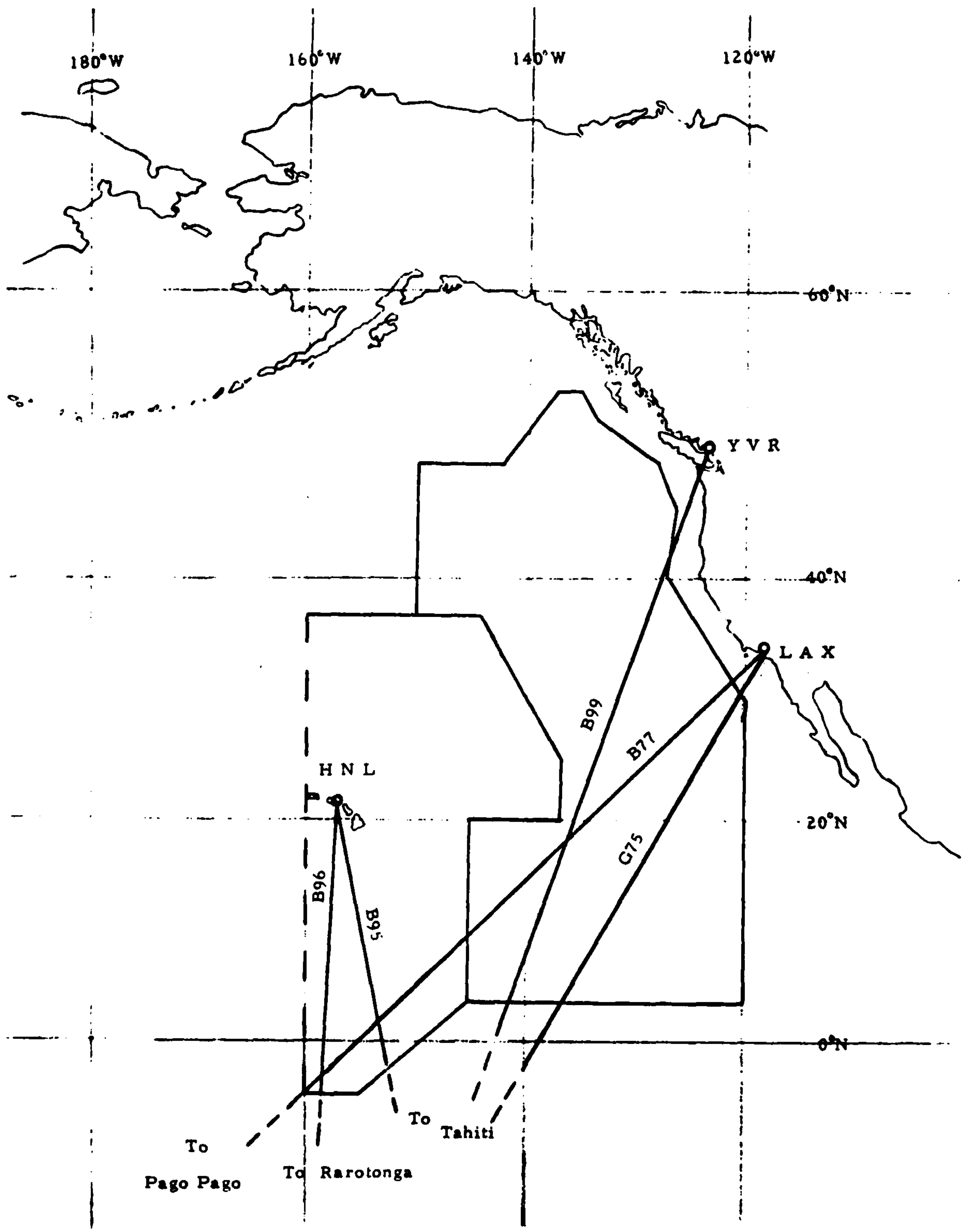



FIGURE 4. CEP CHARTED ROUTES

before aircraft enter the oceanic CTA/FIR. In the case of CEP flights departing Hawaiian and California coastal airports, the clearance issued before takeoff includes the approved oceanic track and flight level needed to satisfy the oceanic separation minima. In the case of other flights, such as those from inland North America, the Pacific Northwest, Alaska, the Far East and the South Pacific, the current clearance is checked and revised if necessary to assure proper oceanic separation while the aircraft is in flight and approaching the CEP airspace. These oceanic clearances are determined by Oakland ACC and Honolulu ACC controllers responsible for CEP operations, but normally are relayed to pilots by the domestic controllers or COM station radio operators who are in direct radio contact with the aircraft.

Once aircraft enter any of the CEP oceanic CTA/FIRs, they are monitored by an oceanic en route sector controller in order to assure that the required minimum separations are maintained. Pilot positions reports are the only means of following flights through the non-radar CEP sectors. The position reports are transmitted directly from pilots by HF radio (or in some cases VHF radio) to a COM station radio operator for relay to controllers. The same HF-based communications relay procedure is used to send controller messages to pilots.

The sector controllers use paper flight progress strips to follow flights. The flight strips are maintained on a flight progress board and each strip describes the aircraft's flight plan. A sector controller hand copies a pilot's reported time of fix crossing and time estimates for the next fix crossings onto a flight strip. The reporting fixes are strategically located along the routes and at route intersections and the flight status data shown at each fix are used to assess the situation for potential violations of separation minima (i.e., potential conflicts). The controller reviews the crossing times shown for aircraft at each fix posting on the flight progress board and mentally calculates the time separations projected between intersecting or following aircraft.

Flight data is forwarded and coordination is carried out between CEP units by means of the ATS direct speech circuits and AFTN.

# 3.0 ATS TECHNICAL STRUCTURE

## 3.1 Introduction

The primary ATS technological components influencing oceanic operations include: communications systems, navigation systems, and surveillance systems. These components are described in this section.

## 3.2 Communications Systems

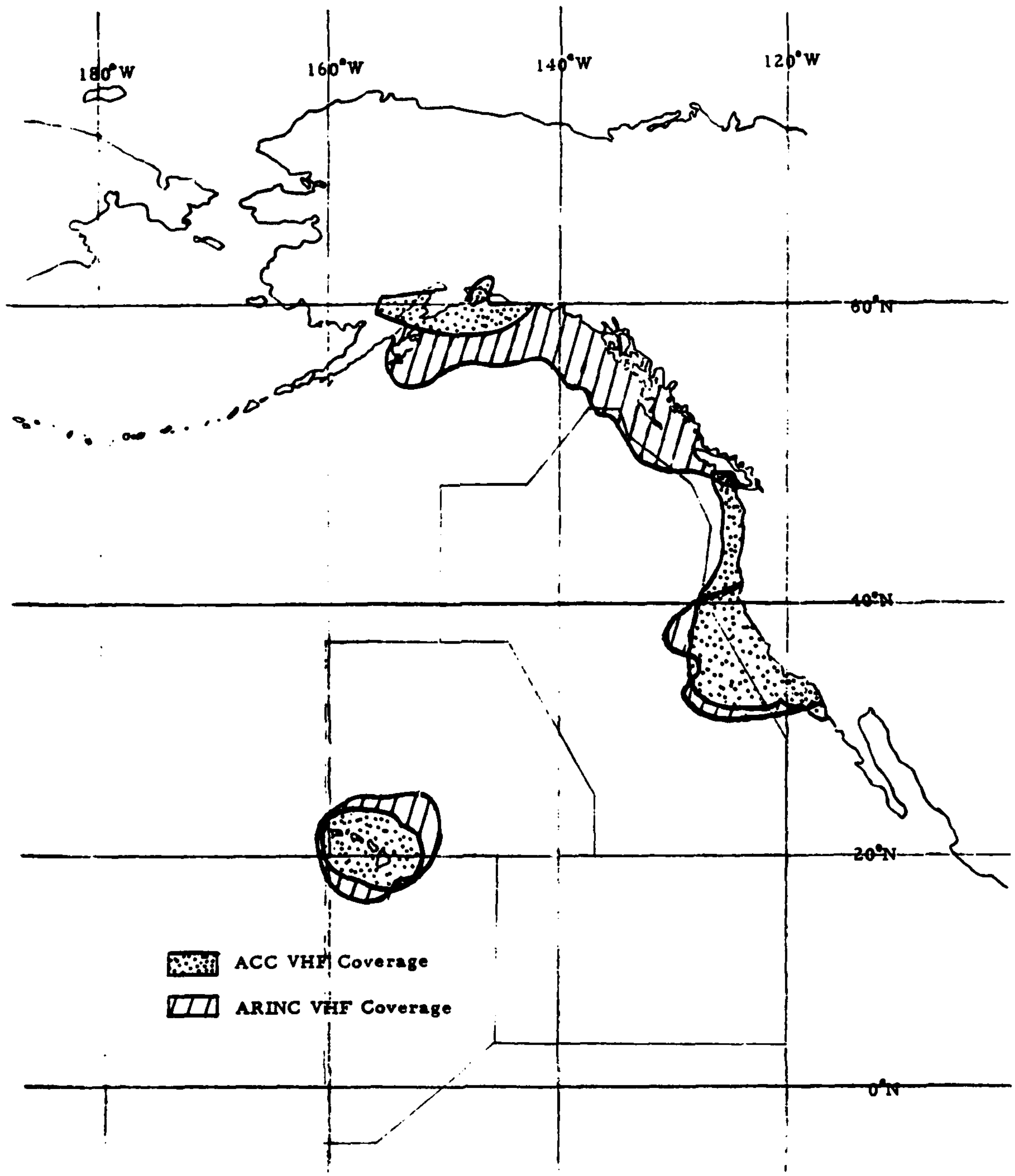
ATS information is distributed by aeronautical mobile and aeronautical fixed communications systems. The mobile systems provide air-ground voice communications between aircraft and ground stations whereas the fixed systems provide voice and teletype and other data link communications between various ground facilities. The ground facilities include the ATS units, aeronautical COM stations, flight operations offices, meteorological centers, search and rescue centers, and associated facilities that participate in or support the ATS operation.

### 3.2.1 Aeronautical Mobile Communications

The range of VHF systems is limited in part by the line-ofsight nature of the transmissions and is a function of the power applied. Most VHF ground transmitters are omnidirectional with a range of about 200 nmi at FL300. Extended range VHF (ERVHF), which uses directional antennas and high power, can achieve a coverage distance of 400 nmi at FL300. All civil aircraft carry VHF equipment because VHF is used extensively in most areas of the world.

VHF transmitter and receiver ground sites located along the CEP region and operated by ATS units provide shortrange radiotelephony service to aircraft transitioning between domestic airspace and oceanic CTA/FIRs. Over-ocean aircraft within range of the VHF ground sites communicate directly with the Oakland and Honolulu ACCs and other ATS domestic sector controllers. Extended range VHF service is provided under contract by Aeronautical Radio, Inc (ARINC) which operates the San Francisco and Honolulu COM stations. Figure 5 shows the approximate VHF coverage provided in the CEP region.

The San Francisco and Honolulu ARINC COM stations, as described in Table 2, also provide HF service in the CEP as do military COM facilities such as McClellan and Hickam Airways. HF transmission characteristics enable over-the-horizon voice transmissions between aircraft and HF transmitter and receiver ground sites located on the West Coast of North America and in Hawaii. The ARINC COM stations are located separately from the Oakland and Honolulu ACCs that they support.




Sources: Air-Ground Radiotelephone Stations International Service, ARINC (March 1979) and FAA Advisory Circular 91-52 (June 21, 1968)

FIGURE 5. APPROXIMATE VHF COVERAGE OF THE CEP AT 24,000 FEET, INCLUDING NON-CEP AIRSPACE IN ANCHORAGE CTA/FIR

Table 2

**MAJOR COMMUNICATIONS STATIONS IN SUPPORT OF CEP ACCs**

| | San Francisco ARINC | Honolulu ARINC |
|---|---|---|
| Location | Foster City, California, US | Honolulu, Hawaii, US |
| Primary Coordinating ATS Unit | Oakland ACC | Honolulu ACC |
| Radio Coverage | CEP-5 (ref. 5) | CEP-5 (ref. 5) |
| ERVHF Frequency | 131.95 | 131.95 |
| HF Frequencies | 3001,* 3467, 5554,* 5603<br>8875, 8931, 13312,* 13339,<br>17909,* 17925<br>(SSB available)<br>SELCAL | 3001,* 3467, 5554,* 5603<br>8875, 8931, 13312,* 13336,<br>17909,* 17925<br>(SSB available)<br>SELCAL |

*For use on a secondary basis, i.e., its use shall be restricted to such areas and conditions that harmful interference cannot be caused to other authorized operations of stations in the aeronautical mobile service (ref. 5).

The HF transmissions are subject to interference by atmospheric disturbances that degrade voice quality. However, the availability of multiple frequencies and the recent introduction of single side band (SSB) HF modulation have been useful in partially overcoming the HF signal propagation problems. SSB also affords the capability to increase the number of HF channels available for future use.

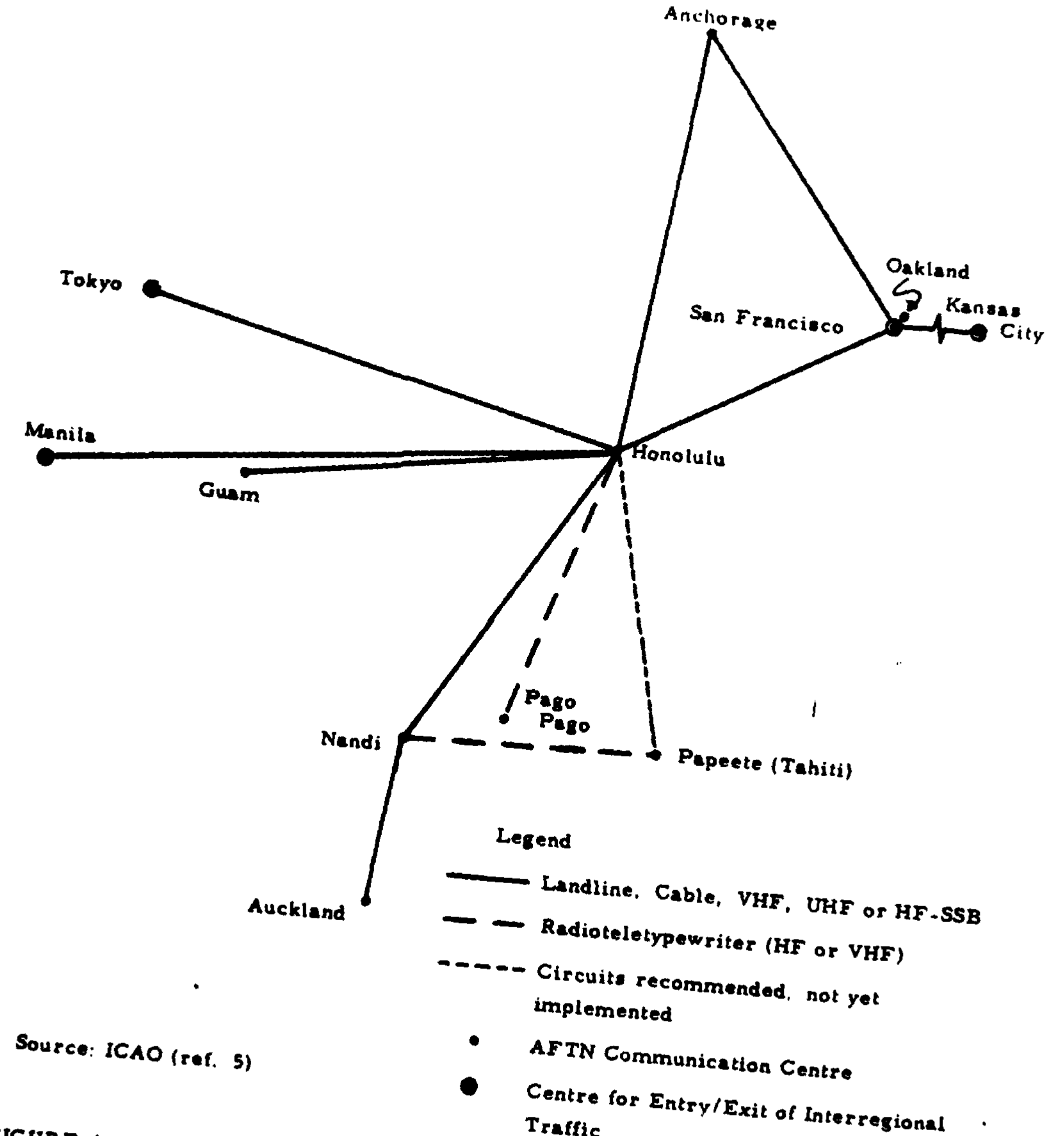
### 3.2.2 Aeronautical Fixed Communications

ATS units, COM stations, aircraft operations offices and supporting units communicate with each other by means of specially provided aeronautical fixed communications networks. The networks include landlines and marine cables, satellite relay, HF point-to-point channels, and switching mechanisms for routing messages through facilities. The links may be dedicated to voice or data transmission or shared by each and, for the most part, are leased from commercial services such as post, telegraph and telephone (PTT) services. The fixed communications system includes the AFTN, ATS direct speech circuits and miscellaneous circuits used as cicumstances warrant for interfacility computer data exchange, meteorological data distribution and the like.

The AFTN distributes teletype messages to interconnected oceanic and domestic facilities. Figure 6 shows the basic AFTN system in the CEP and adjacent non-CEP areas as described by ICAO (ref 5). The various operating facilities are linked by a system of leased PTT landlines, radioteletype links and marine cables. AFTN messages are sent from and received at teletype terminals located in each CEP facility, including ATS units, COM stations, and user units, and meteorological and other support units.

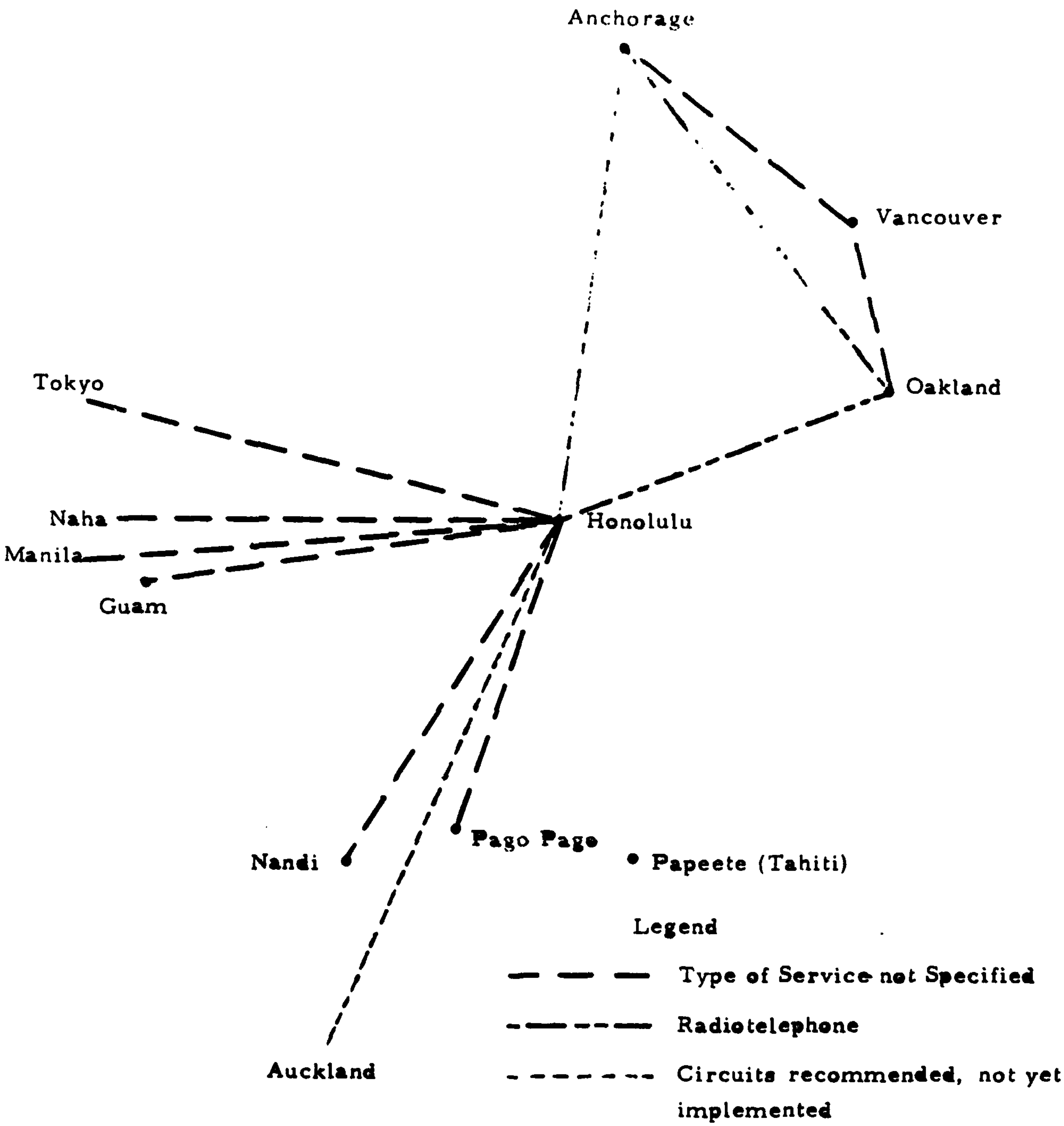
Teletype messages between sites are generally routed indirectly through the AFTN communication centers shown in Figure 6 rather than directly from one site to another. The Kansas City switching center, for example, is a primary interchange point and connects the CEP with other areas such as the North America, North Atlantic, Europe, Africa, Caribbean and South America regions. In some cases, circuitous routings through multiple switching points may occasionally experience message delays. Such a situation occurs in regard to AFTN messages between the Oakland ACC and Tahiti which are routed by radio through Nandi and then through Honolulu (see Figure 6).

The ATS direct speech interphone circuits provide for voice communication between the ATS, COM and associated operating units in the CEP and adjacent non-CEP areas. The basic ATS direct speech circuits in the CAR, as described by ICAO (ref. 5) and updated based on operating unit personnel comments, are shown in Figure 7. The circuits are systems of leased landlines, radiotelephone links and marine cables, with leased satellite links connecting the Honolulu ACC with both the Oakland and Anchorage ACCs. In cases where ATS direct speech circuits




Source: ICAO (ref. 5)

FIGURE 6. BASIC AFTN CIRCUITS IN CEP AND CONNECTED PACIFIC OCEAN FACILITIES




Source: ICAO (ref. 5)

FIGURE 7. BASIC ATS DIRECT SPEECH CIRCUITS FOR CEP AND CONNECTED PACIFIC OCEAN FACILITIES

are not provided (such as between the CEP ACCs and Auckland and Tahiti), AFTN is used extensively; otherwise, public telephone is available for direct voice communication or the ARINC HF relay may be used as an alternative.

A special non-AFTN teletype link between the San Francisco ARINC COM station and the Oakland ACC forwards pilot position reports from the COM station to a receive-only teleprinter unit at the Oakland ACC. The Honolulu operation does not have a special teletype link.

In addition to the AFTN, ATS direct speech and special teletype circuits, an FAA computerized flight data processing system distributes flight information between US domestic ATS units in the conterminous US. However, such data link service is not currently available between the Oakland and Honolulu ACCs.

### 3.3 Navigation Systems

The great lengths of the over-ocean routes typically flown in the CEP require a long-range navigation capability which complements the short-range navigation systems used in domestic airspace. The following paragraphs provide a brief perspective on navigation in the CEP.

#### 3.3.1 Long-Range Navigation

The CEP has no minimum navigation performance specification (MNPS) but most aircraft use INS and Omega as long-range navigational aids since they are operated by many of the same carriers that fly MNPS areas. Some aircraft still use Loran A and C, doppler, and celestial navigation techniques, among others.

#### 3.3.2 Short-Range Navigation

Short-range navigation service is provided by the VOR/DME radio-navigation aids which typically have an effective range of approximately 200 nmi at FL300 based on VHF line-of-sight and transmission power limitations. Because the aids are the basis for the domestic systems of jetways and airways, virtually all aircraft flying oceanic routes are equipped with VOR/DME avionics units.

VOR/DME navigation aids located along the West Coast of North America and in Hawaii provide position information to aircraft transitioning between oceanic and domestic airspace. This network of VOR/DME aids is used to establish precise navigational reference points for the start and end of oceanic flight routes. The coverage and current location of each of the VOR/DMEs in the CEP is such that extended and continuous oceanic navigation along a series of aids is not possible. The lack of land sites precludes the general expansion of the VOR/DME network in the CEP into a fully connected oceanic navigation system.

Ground-reference navigation service of longer range but less precision than the VOR/DME system is provided by the NDB aids which are used by aircraft equipped with ADF avionics units. The effective navigational range of an NDB aid is determined by the power sizing designed for the individual site. Although navigation range varies among NDBs, individual units with a transmission radius of the order of 400 nmi are representative of the present coverage. NDB radionavigation aids stationed in Hawaii and in the Farallon Islands (off the California coast near San Francisco) provide bearing information to oceanic aircraft within their range.

### 3.4 Surveillance Systems

Radar is available only in domestic airspace where suitable land sites exist for antenna location. The systems typically used for ATC surveillance include primary radar--which tracks aircraft skin reflections ("skin paint") of the radar signals-- and secondary surveillance radar (SSR)--which tracks aircraft beacon responses to radar interrogation. The ground antenna transmits and receives signals which are limited by line-of-sight and transmission power constraints. Therefore, the effective coverage area at FL300 normally extends only 200 nmi from the land-based sites, as indicated in Figure 8 for the CEP region.

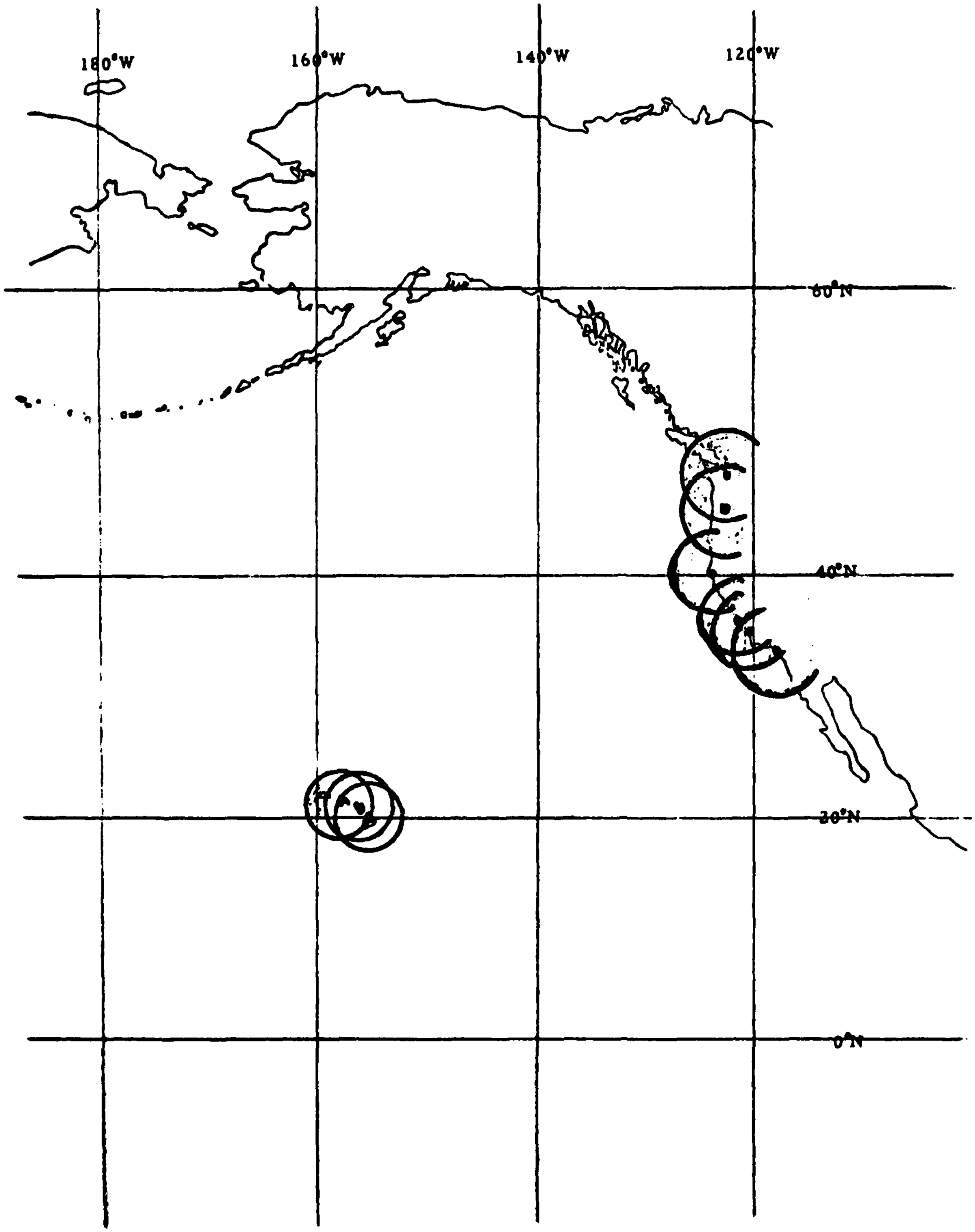



FIGURE 8. APPROXIMATE CEP RADAR COVERAGE AT 30,000 FEET

# 4.0 SEPARATION MINIMA

## 4.1 CEP Separation Standards

The separation minima applied in the CEP are established by agreements of the ICAO contracting states in the region and are described in ICAO Document 7030 (ref. 4) and Document 4444 (ref. 3). The basic characteristics of the vertical, lateral and longitudinal separation minima and their application in the CEP are summarized in the following paragraphs.

## 4.2 Vertical Separation

Subsonic jet aircraft routinely cruise above FL290 where the vertical separation minimum is 2,000 ft. Below FL290, the vertical separation minimum is 1,000 ft. Above FL450, 4,000 ft is required between SST aircraft and any other aircraft. Subsonic IFR aircraft in cruise are assigned altitudes of odd or even flight levels (e.g., FL180, 190, 200...280) below FL290 and odd flight levels (e.g., FL290, FL310, 350, 370) above FL290; otherwise, aircraft may step climb between such flight levels when cleared to do so.

## 4.3 Lateral Separation

As stated in ICAO Document 7030 (ref. 4), the basic minimum lateral separation between aircraft flying at the same flight level is 100 nmi in the CEP.

## 4.4 Longitudinal Separation

A 15 min longitudinal separation is required between subsonic turbojet aircraft operating at the same flight level provided that:

(1) The "Mach number technique" is applied, and

(2) The aircraft concerned have reported over the same entry point into the oceanic airspace and are on the same track or continuously diverging tracks (ref. 4).

The Mach number technique requires aircraft to adhere to an ATC cleared Mach number (ref. 3). The 15 min minimum also applies to aircraft not reporting over the same entry point but that are established with proper time intervals on oceanic courses under radar coverage (ref. 4).

The 15 min separation applied under the Mach number technique and track requirements stated above may be reduced to the following separations as stipulated in the ICAO Regional Supplementary Proceaures (ref. 4):

> 10 minutes at the entry point into oceanic controlled airspace if the preceding aircraft is maintaining a speed of at least Mach 0.03 greater than that of the following aircraft.
>
> 5 minutes at the entry point into oceanic controlled airspace if the preceding aircraft is maintaining a speed of at least Mach 0.06 greater than that of the following aircraft.

A 20 min longitudinal separation is required between all aircraft not covered by the 15, 10, and 5 min separation rules addressed above (ref. 4). For example, the 20 min separation is applied in the CEP to aircraft not adhering to the Mach number technique requirements, to aircraft changing altitude, and to aircraft crossing, joining or leaving the track of other aircraft.

In regard to the ORS, the separation minima results in a situation in which subsonic turbojet aircraft entering an ORS track at a given altitude and using the Mach number technique are subject to a 15 min longitudinal minimum applied at any point along the track at the given altitude including the exit point with allowances for reductions to 5 or 10 min at the entry point only. Otherwise the longitudinal minimum for turbojet aircraft is 20 min, including the cases in which aircraft change ORS flight level or track.

## 4.5 Composite Separation

The composite separation in the CEP consists of a vertical minimum of 1000 ft combined with a lateral minimum of 50nmi which may be applied to aircraft operating at or above FL290 on the ORS (ref. 4). The ORS track placements and flight level assignments previously shown in Figure 3 conform to these composite separation minima. Note that the standard 2000 ft vertical separation minimum is applied between aircraft in the same track, and the standard 100 nmi lateral separation minimum is applied between aircraft at the same level on different tracks. The composite separation applies to aircraft flying in the same or opposite directions.

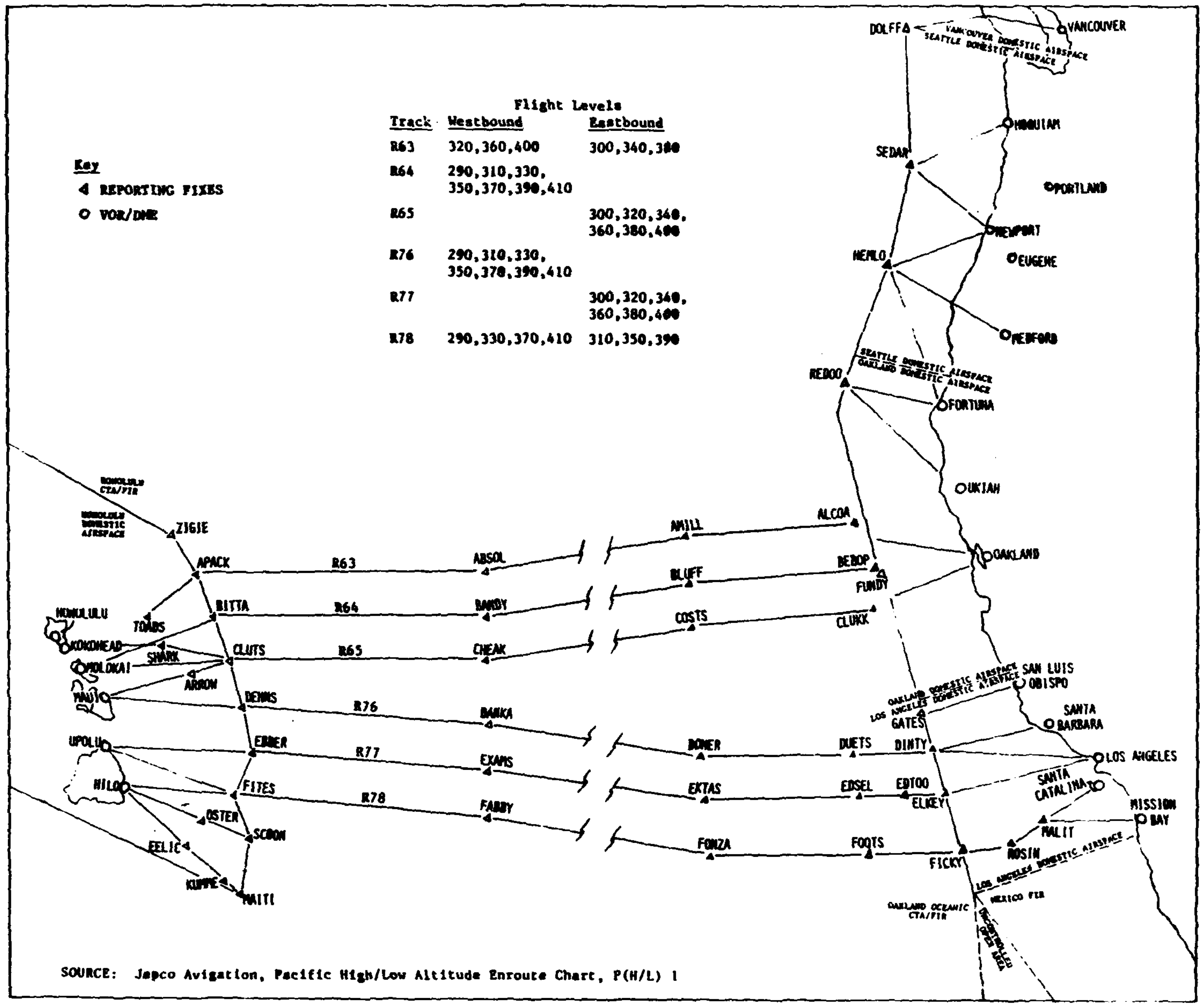
# 5.0 ATS OPERATIONS PROCEDURES

## 5.1 Flight Planning

Flight plans are developed by all aircraft operators--air carrier, general aviation and military--and submitted to ATS units in accordance with ICAO requirements. A flight plan is based on an analysis of en route meteorological forecasts, aircraft flight performance characteristics, route requirements, reserve fuel requirements between origin and destination airports, and estimated aircraft weight. Airlines normally use flight planning computer programs to evaluate the data compiled for an individual flight and determine the preferred routes and flight levels and associated fuel requirements between the origin and destination airports. The flight planning programs may be designed to achieve one of several objectives such as minimizing fuel burn, minimizing flight time or minimizing flight costs, (i.e., fuel, crew and maintenance costs). However, due to the overriding influence of fuel costs on direct operating costs, most airlines currently plan flights with the objective of minimizing fuel consumption. Flight plans filed by military and general aviation operators also are the result of structured flight planning procedures, although the primary consideration may be one of minimizing flight time rather than minimizing fuel burn.

### 5.1.1 Flight Routings

The ORS is fixed regardless of meteorological conditions, and flight planning for the ORS airspace is concerned with selecting an optimum ORS track and flight level. Wind conditions in this airspace normally are benign and the fixed tracks are quite suitable for efficient flight operations. However, during the winter storm season, some airlines develop random routings that lie north or south of the ORS tracks or use only part of an ORS track. For example, with reference to Figure 9, a westbound flight from San Francisco to Honolulu may plan a track that crosses the ALCOA gateway (i.e., an oceanic boundary fix) on ORS track R63, follows a course roughly parallel to and north of R63 (e.g., crosses 140 degrees West longitude and 35 degrees North latitude) and enters the Honolulu ACCs domestic airspace at APACK or ZIGIE. A westbound track south of the ORS may enter the CEP oceanic area at FICKY, proceed parallel to R78, and enter domestic airspace at SCOON. One airline, which maintains a meteorology staff (as opposed to relying heavily on published weather service data as do other airlines) frequently uses non-ORS tracks during winter months. Personnel of this airline claim that their flights experience consistently shorter flight times relative to those of other airlines.




Flight Levels

| Track | Westbound | Eastbound |
|---|---|---|
| R63 | 320,360,400 | 300,340,380 |
| R64 | 290,310,330, 350,370,390,410 | |
| R65 | | 300,320,340, 360,380,400 |
| R76 | 290,310,330, 350,370,390,410 | |
| R77 | | 300,320,340, 360,380,400 |
| R78 | 290,330,370,410 | 310,350,390 |

SOURCE: Jepco Avigation, Pacific High/Low Altitude Enroute Chart, P(H/L) 1

Figure 9: ORS Transition Areas

Flights between inland North America and Hawaii are often flight planned to use an ORS track, but, depending on meteorological conditions, may plan random tracks. A random track plan from Chicago to Honolulu may cross REDOO or HEMLO on the eastern CEP oceanic boundary and cross ZIGIE on the western boundary or join R63 at a mid-ocean fix. A random track plan from Dallas to Honolulu may pass through Mexican airspace, cross into oceanic airspace near 120 degrees West/30 degrees North and continue parallel to and south of R78 (i.e., cross 140 degrees West at 25 degrees North) to SCOON. Similar random tracks may be planned for ea .bound flights from Hawaii.

Random track flight plans determined for other non-ORS flights in the CEP also use the fixes shown in Figure 9. Flights between the Pacific Northwest and Hawaii are planned through CEDAR, HEMLO and occasionally DOLFF on the eastern CEP boundary and, as advised by ATS procedures (ref 7), through ZIGIE on the western boundary. Flight plan routes between the Far East and California usually cross ALCOA or REDOO, while oceanic flights between Alaska and California may cross HEMLO (note: approximately half of the Alaska-West Coast flights remain in domestic airspace without entering the CEP). Flights between the South Pacific and North America normally fly the B77 or G75 charted routes (previously shown in Figure 4) which are south of the ORS and cross FICKY at the CEP eastern boundary. Depending on weather conditions and in accordance with ATS practices, South Pacific-North America flights occasionally may be planned to fly through Hawaii and on an ORS track but are not planned so as to join or cross the ORS at mid-ocean.

## 5.2 Flight Plan Distribution

ICAO requirements specify submittal of a flight plan at least 30 min before airport departure or, if submitted during flight, at least 10 min before reaching a controlled area or airway or an advisory area or route. In the case of an international flight, the flight plan is required to be forwarded to all ATS units along the route of flight where area control service or advisory service is provided. (ref. 2)

An aircraft operator normally files a flight plan before departure with the local ATS unit by teletype using the AFTN. For some airline flights, the filing may be an update by telephone and mail of data for repetitive flights stored in an ATS unit computer file. The flight plan, in actual practice, is often filed several hours before estimated departure time (EDT) and is forwarded to the appropriate ATS units by AFTN or computer data link as addressed by the aircraft operator or the local ATS unit. For example, AFTN-filed or computer-stored flight plans are automatically distributed in the contiguous US by a computerized flight data processing system. These capabilities enable the Oakland ACC to automatically exchange CEP oceanic flight plans with the adjacent Los Angeles and Seattle ACCs as well as with inland US ACCs. Computerized flight data handling is not available elsewhere in the CEP, and

AFTN is the basic means for forwarding flight plan data to and from the Honolulu ACC. AFTN also is used to forward data to and from certain non-CEP ATS units (e.g., Anchorage, Tokyo, Nandi, Auckland and Papeete ACCs) that handle traffic bound to or from the CEP.

### 5.3 Departure Operations

A local ATS unit issues the departure clearance to each flight. The unit checks the filed flight plan, amends it if necessary, and provides the clearance describing the entire route of flight to the destination airport. The pilot accepts the clearances with the understanding that the approved routings represent current plans and that subsequent clearance changes may be required.

When an aircraft actually takes off, an ICAO departure message reporting the takeoff time is normally forwarded by AFTN or computer data processing to ATS units along the route of flight. Receipt of a departure message initiates printing and delivery of flight strips to en route sector positions of the ATS units.

### 5.4 CEP Oceanic Entry

The procedures for entering the CEP oceanic airspace vary according to whether the aircraft is departing Hawaiian and North American West Coast airports, inland North American airports or overseas and Alaskan airports as well as whether the aircraft is on an ORS or non-ORS track. The various procedures are discussed in the following paragraphs.

#### 5.4.1 West Coast and Hawaii Departures

Aircraft departing the North American West Coast (excluding Alaska) and Hawaiian airports receive their approved oceanic route and flight level assignments before take-off. Gatehold procedures are in effect in Hawaii, which requires an aircraft to receive its clearance before gate pushback (ref. 7); otherwise, aircraft may receive clearance while taxiing to the runway. For example, at San Francisco the clearance process is initiated by a voice radio request for a clearance from the pilot to an airport tower controller. The tower controller issues an abbreviated clearance to the destination airport based on the filed flight plan. The pilot will request a runway release (i.e., take-off approval) at which time the tower controller will use the direct speech circuit to contact the Oakland ACC for the approved release time, route and altitude assignment. These arrangements are negotiated with the pilot before gate pushback or during taxi operations at San Francisco.

The Oakland ACC controller issuing the oceanic routing approvals for aircraft requesting entry to an ORS track is operating a domestic radar sector adjacent to the CEP. This person controls aircraft approaching and departing the oceanic airspace in the vicinity of the three northern ORS tracks (i.e., R63, R64 and R65) and uses radar display data and flight plan data displayed on flight strips to assess whether or not the requesting aircraft's flight plan is in conflict with those of other aircraft using these three ORS tracks. If a potential violation of separation minima is projected, the Oakland ACC controller identifies the flight path options for resolving the potential conflict which are relayed to the aircraft by the tower controller for pilot selection. The options include diversion to an alternative ORS track or flight level, delaying the release time (usually less than 15 or 20 minutes) or combinations thereof. In the event that there is no potential conflict, the oceanic track and flight level will be approved as filed.

Clearances for aircraft requesting non-ORS routes (e.g., a flight from San Francisco to Tokyo) would be coordinated with a non-radar oceanic sector controller of the Oakland ACC who uses flight strip data to assess potential conflicts in the Oakland oceanic CTA/FIR. In the event of a potential mid-ocean conflict (e.g., one Tokyo-bound flight overtaking another or a crossing conflict between a Tokyo-bound flight and a flight between Hawaii and the Pacific Northwest) the oceanic controller would identify the flight path options for relay to the aircraft while it is on the ground.

The pre-takeoff clearance procedures described in the preceding paragraphs for the Oakland ACC and airports in its vicinity (including Travis Air Force Base) are representative of the procedures used at Hawaiian and other West Coast airports. That is, ORS and non-ORS flights departing Honolulu and Hilo, Hawaii, receive their approved oceanic routings and flight levels from the Honolulu ACC as relayed by voice through the airport control towers. Random track flights departing the Pacific Northwest receive their oceanic clearances from an Oakland ACC oceanic sector as relayed through Seattle and Vancouver ATS units. The Los Angeles domestic ACC maintains two radar sectors that provide clearances (subject to approval by an Oakland ACC oceanic sector) to local departures that enter the three southern ORS tracks (i.e., R75, R77, R78). Departures from southern California airports that enter random or charted routes are provided by an Oakland ACC oceanic sector controller as relayed through the local ATS units.

Operations in the southern California area are sometimes complicated by the closure for military use of control extension areas (CEAs). The control extensions are airspace corridors through military warning areas off the West Coast and are normally open to civilian traffic transitioning between domestic airspace and oceanic gateways (such as the GATES, DINTY, ELKEY and FICKY fixes shown in Figure 9). Closure of a control extension requires rerouting of traffic (e.g., flights on R76 would be diverted through GATES and DONER if the control extension from Los Angeles to DINTY was closed). The CEA in the San Francisco area for the three northern tracks is not subject to closure.

5.4.2 Inland North America Departures

The approved oceanic routes and flight levels for westbound flights from inland North American airports are determined by the Oakland ACC or the Los Angeles ACC when the aircraft are in domestic airspace and approaching the CEP. For example, an aircraft from the midwest and planning an ORS flight (e.g., Chicago to Honolulu on R64) will be handled by the same Oakland ACC domestic radar sector that provides oceanic clearances to local West Coast departures. This sector receives a flight strip showing the aircraft's planned route and flight level about one hour before the estimated time of oceanic entry. About one-half hour before oceanic entry, the radar sector controller will assess the oceanic potential conflict situation and, if necessary, determine alternative route and flight level assignments. At this time the aircraft would be under the control of another domestic radar sector of the Oakland ACC, and any clearance revisions and attendant negotiations would be relayed by direct speech through the other sector controller. Pilot requests for a change to the planned oceanic flight level would be relayed similarly. If no potential conflicts exist, a formal oceanic reclearance is not necessary because the aircraft will proceed as planned. Note that the radar controller has the option to effect a delay of up to a few minutes by vectoring or speed change if such action would enable satisfaction of oceanic separation minima at CEP entry.

Similar procedures are followed by the Los Angeles ACC for ORS flights. In the case of non-ORS flights (e.g., a westbound flight through REDOO) the oceanic route and flight level approvals would be made by an Oakland ACC non-radar oceanic sector controller and relayed through an ATS unit domestic controller in radio contact with the aircraft. However, westbound flights approaching the southerly oceanic airspace from the uncontrolled open area between the CEP and Mexico are not in direct radio contact with a domestic ATS unit. In that case, the aircraft must request and receive oceanic clearances by HF radio contact with the San Francisco ARINC COM station, which relays the messages to and from an Oakland ACC oceanic sector controller

5.4.3 Overseas and Alaska Departures

Flights from the Far East, South Pacific and Alaska pass through non-CEP oceanic CTA/FIRs (see Figures 1 and 2) before entering the CEP. Clearances for flights into the CEP must be coordinated by the upstream non-CEP ATS unit with either the Oakland or Honolulu ACCs before the aircraft enters CEP airspace. This coordination enables the CEP ACC oceanic controller to assess, using flight strip data, the potential conflict situation and to advise the upstream ATS unit of any clearance revision (e.g., altitude change, rerouting or time restriction) necessary to resolve a potential conflict if one exists. Otherwise, the flight would proceed as planned. The upstream ATS unit must implement the revised clearance before the aircraft enters CEP airspace.

The transfer of control coordination is required at least 30 min before the aircraft is estimated to cross a CEP CTA/FIR boundary and is conducted by forwarding pertinent flight data (e.g., aircraft identity, transfer point, estimated transfer time, altitude) to an Oakland ACC or Honolulu ACC oceanic sector. In practice, the message is normally sent about one hour before boundary crossing by ATS direct speech circuits. However, ATS direct speech service is not established with Tahiti and Auckland ATS units, and the transfer message must be forwarded by AFTN teletype at least one hour before boundary crossing. The Tahiti AFTN circuit, in the past, has experienced message delays which, at times, have been of sufficient duration to disrupt or prevent successful point-to-point coordination between the ATS units. A back-up procedure now is in effect by which the Honolulu ARINC COM station will routinely forward pertinent HF radio messages from approaching aircraft to the Honolulu and Oakland ACCs.

5.4.4 Clearance Decision Practices

Operational procedures normally require aircraft to be established on the approved cruising flight level (rather than climbing or descending) before entering a control area from an adjacent area (ref 2). The approved flight level issued with each clearance defines a single cruise altitude and does not provide for step climbs although higher altitudes may be approved later during the flight. The route and flight level approved at oceanic entry provides a conflict free flight path for all or part of the oceanic flight.

The clearance issued to an aircraft entering the ORS provides a conflict-free flight path to landfall (i.e., a "coast-in" or "coast-out" fix defined by a VOR/DME radionavigation aid) and therefore covers the flight through both the Oakland and Honolulu CTA/FIRs. In this case, the ORS structure automatically provides lateral and vertical separation between tracks and flight levels through both CTA/FIRs, but the controller must provide for proper longitudinal separation at landfall before the aircraft enters the ORS. In the case of an aircraft that is faster than its predecessor on the same track and flight level, the rule of thumb used for determining the longitudinal separation requirement between aircraft at ORS entry is to provide at least 15 minutes plus an additional 3 min for each 0.01 Mach difference in cruise speed. Otherwise, either the 15, 10 or 5 minute separation minimum is applied as conditions warrant.

In regard to random and charted routings, the oceanic sector controller has complete flight strip data only for flights within that controller's CTA/FIR. The oceanic controller cannot unilaterally assess potential conflict situations in downstream sectors, and, therefore develops conflict-free flight path clearances only for aircraft within his or her sector. The Oakland and Honolulu ACCs may issue entry clearances that provide conflict-free paths for all or part of the flight through their respective CTA/FIRs with the understanding that a later clearance revision to resolve a potential conflict may be issued while the aircraft is in oceanic airspace. This practice enables the aircraft to fly a preferred route and flight level until a diversion is required to satisfy separation minima rather than fly a less preferred path from oceanic entry.

## 5.5 Oceanic Airspace Operations

Control jurisdiction over an aircraft is transferred to an Oakland or Honolulu ACC oceanic en route sector controller when the aircraft enters CEP airspace. Given that clearances have been issued and that proper oceanic flight intentions have been established before the time of crossing the CEP boundary, the oceanic controllers' main responsibilities are to maintain separations in their CTA/FIR and provide separations for aircraft entering adjacent airspace.

### 5.5.1 Communications Procedures

The pilot position reports may be given in the form of AIREPS which, as prescribed by ICAO (ref. 2), include: (1) position information (i.e., aircraft identification, position, time, flight level or altitude, and next positions and associated time estimates); (2) operational information (i.e., estimated time of arrival, endurance); and (3) meteorological information (i.e., air temperature, wind, turbulence, aircraft icing, and supplementary information). The pilot position reports and other communications are relayed to Oakland ACC oceanic controllers through HF radio operators at the San Francisco ARINC COM station and to the Honolulu ACC from the Honolulu ARINC COM station. Communications between controllers and radio operators are normally conducted by means of ATS direct speech circuits, although position reports from the San Francisco COM station are received by teleprinter at the Oakland ACC.

Position reports on the ORS (see Figure 3) and other fixed routes are given at designated reporting points. These fixed reporting points roughly conform to the following position reporting requirements stipulated in Ref. 7 for random tracks.

(1) Flights whose routes are predominantly east and west shall report over each 5 degrees or 10 degrees (10 degrees will be used if the speed of the aircraft is such that 10 degrees will be traversed within 1 hr + 20 min or less) meridian longitude extending east and west from 180 degrees.

(2) Flights whose routes are predominantly north and south shall report over each 5 degrees or 10 degrees (10 degrees if traversed within 1 hr + 20 min) parallel of latitude extending north and south of the equator.

Additional position reporting requirements are stated in Ref. 7 as follows.

(1) Air traffic service may require specific flights to report more frequently than each 5 degree fix (each 2 1/2 degrees) for aircraft with slow ground speeds.

(2) The position report shall be transmitted at the time of crossing the designated reporting line or as soon thereafter as possible.

Selective calling (SELCAL) radio communications systems are carried by aircraft flying in the CEP airspace and enable radio operators to selectively signal a pilot by a tone identification when an HF transmission is to be initiated from the ground. This procedure relieves the pilots from constantly listening to the sometimes noisy HF channels.

ATS direct speech communications between the Oakland and Honolulu ACCs are largely to carry out transfer of control of aircraft at their mutual boundary. The flight information passed between the two ATS units is similar to those described in preceding paragraphs concerning coordination between CEP and non-CEP units.

5.5.2 Separation Maintenance Procedures

As part of their separation maintenance responsibilities, the oceanic sector controllers respond to clearance or reclearance requests initiated by aircraft in their CTA/FIRs. Normally, such activities involve requests for an altitude change to a higher flight level and occur when aircraft burn off enough fuel to attain a more fuel-efficient altitude. However, requests for track or altitude change may be initiated to avoid severe weather or for emergencies. Each request is relayed to an oceanic sector controller who reviews the flight strip data for potential conflicts. The requested flight path is checked for projected violations of the 20 min longitudinal separation minima along the remainder of an ORS track or, in the case of a random or charted route, along the next legs of the flight through the current oceanic sector and into the next downstream sector. If an altitude or route change is approved, the pilot is expected to initiate the climb upon receipt of the approval message.

The one-way structure on four of the six ORS tracks facilitates mid-ocean step climbs. The one-way design precludes the need to climb aircraft through opposite direction traffic and increases the number of flight levels attainable by a flight on each track relative to a two-way design.

Hemispheric vertical separation rules are routinely applied on all non-ORS routes and in domestic airspace. These rules assign westbound flights to FL280, 310, 350, 390, etc. and eastbound flights to FL290, 330, 370, 410, etc.

Potential conflict situations on non-ORS routes that arise after oceanic entry normally require a flight level change, a time restriction (involving a delay of less than a few minutes) or a lateral reroute. In some cases, such as those that may occur when Far East-North America flights cross traffic between Hawaii and the Pacific Northwest or Alaska, an aircraft may be diverted and then returned to its desired flight path after the conflict point is passed.

The point of greatest congestion for CEP random traffic is at ZIGIE and APACK (see Figure 9) near Hawaii. Flight plans from the Pacific Northwest to Hawaii generally include ZIGIE and, to a lesser extent, APACK, which is the western gateway to northernmost ORS track R63. ZIGIE is 50 nmi from APACK and, because 100 nmi lateral separation is required at a given altitude, flights into ZIGIE may be in conflict with random flights into APACK. The random track altitude assignments are compatible with the even level altitude assignments (FL300, 320, 340 to 400) on the track R63 in that random track traffic through ZIGIE on hemispheric odd levels are separated from R63 traffic by the composite rules (i.e., 50 nmi laterally and 1000 ft vertically).

Westbound random track flights joining R63 or crossing ZIGIE or APACK are allowed to use composite separation relative to flights on R63 and R64 after converging from random routes that use nominal vertical and lateral separation standards. Note that such flights must change from odd to even flight levels to join R63 or cross APACK, as even flight levels are not routinely used in the CEP outside the ORS. Potential conflicts are resolved by changing flight levels or by rerouting the random track flights to R63 at ABSOL at an even westbound flight level. Eastbound random track flights leaving R63 or crossing APACK or ZIGIE are allowed to use composite separation relative to flights on R63 and R64, provided that their routes diverge from R63 to a degree sufficient to achieve nominal vertical and lateral separation at a later point.

The southernmost ORS track R78 applies non-standard odd level altitude assignments (i.e., westbound flight levels 290, 330, 370 and 410 and eastbound flight levels 310, 350 and 390) which are opposite to those of the hemispheric rule. For example, charted route flights from the South Pacific to North America cross the FICKY gateway at the eastern end of R78. In accordance with hemispheric rules, these flights may be at the same flight level as opposite direction ORS flights on R78 also passing through FICKY. Similar situations occur at FITES, the Hawaiian gateway of R78, and SCOON, less than 50 nmi from FITES. In these cases, aircraft must be diverted vertically or laterally to avoid violations of separation minima. Controllers report that the opposite direction traffic situations are cumbersome to deal with and that they would prefer standard hemispheric altitude assignments on R78. One airline reported that their flights to and from SCOON actually fly the opposite-direction flight levels of R78 until those aircraft are laterally separated from R78, at which point they climb to the proper hemispheric-type flight levels. It should be noted that the current ORS altitude assignments are based in part on past analyses of track system collision risk and economic benefits (ref. 8) and efforts to change the flight level structure should include a review of these analyses.

5.5.3 In-Flight Contingencies

Contingencies, such as cases where aircraft are unable to maintain their assigned flight level due to weather, aircraft performance or pressurization failure, may require rapid descent, turn-back or both (ref. 7). The following contingency procedures are provided in ref. 7 as guidance to pilots who must decide the specific sequence of actions appropriate for the prevailing circumstances:

(1) If an aircraft is unable to continue flight in accordance with its ATC clearance, a revised clearance shall, whenever possible, be obtained prior to initiating any action, using the radiotelephony distress or urgency signal as appropriate.

(2) If prior clearance cannot be obtained, an ATC clearance shall be obtained at the earliest possible time, and, in the meantime, the aircraft shall broadcast its position (including the ATS route designator) and intentions on frequency 121.5 MHz at suitable intervals until ATC clearance is received.

(3) If unable to comply with the provisions of (1), the aircraft should leave its assigned route by turning 90 degrees to the right or left whenever this is possible. The direction of the turn should be determined by the position of the aircraft relative to the track system, e.g., whether the aircraft is outside, at the edge of, or within the system, and the levels allocated to adjacent routes.

(4) An aircraft able to maintain its assigned level should, nevertheless, climb or descent 500 ft while acquiring and maintaining in either direction a track laterally separated by 25 nmi from its assigned route.

(5) An aircraft not able to maintain its assigned level should start its descent while turning to acquire and maintain in either direction a track laterally separated by 25 nmi from its assigned route. For subsequent level flight, a level should be selected which differs by 500 ft from those normally used.

## 5.6 Oceanic Exit Operations

Aircraft departing CEP en route airspace into domestic airspace pass from a non-radar into a radar ATC environment. The domestic radar environment has less stringent separation requirements than those of the CEP airspace and more flexibility in flight maneuvering is afforded to aircraft. However, because some of the ORS tracks use non-standard flight levels, controllers must restore the aircraft to proper hemispheric (i.e., odd) flight levels after oceanic exit.

Radar coverage enables domestic sector controllers to record Oceanic Navigation Error Reports (ONERs) which are based on radar-observed lateral deviations of 20 nmi or more from an assigned oceanic routing as monitored at the track exit fix. Those deviations of 25 nmi or more would be investigated to determine cause factors (ref. 7). The following explanation of monitoring of navigational performance in oceanic errors is given in ref. 7:

> In any air traffic control environment, there is a need to ensure that aircraft adhere to the centerline of the cleared route. Demonstrated navigational accuracy provides the basis for determining the lateral spacing and separation minima necessary with respect to traffic which may be operating outside but adjacent to the airspace protectd for a given route. To sustain or refine the separation minima, adherence to cleared route must be demonstrated. The best available measurement of such adherence is obtained by radar observation of each aircraft's proximity to centerline prior to its coming into coverage of short range navigation aids at the end of the oceanic navigated portion of the flight. If an observation indicates that an aircraft was not reasonably within airspace normally protected, the reasons for the apparent deviation from centerline must be determined and steps taken to prevent recurrence and to improve overall navigational performance.

## 6.0 ATS COSTS--PRELIMINARY ESTIMATES

A first-cut estimate of the annual cost of providing en route ATS services at the CEP ATS units is presented in Table 3. The annual operating and maintenance costs for the ATS units are based to the extent possible on estimates developed by the FAA and on assumptions concerning the level of expenditures at sites where cost data were not available. The data shown in Table 5 are presented as a strawman description of ATS costs and are intended as a basis for future discussion. Data describing the individual ATS unit operations are presented in Appendix A, and the derivations of the cost estimates are described in Appendix B along with the data sources.

An estimated total annual ATS cost of 1979 US $ 3.6 million is shown in Table 3 for the CEP. This cost includes staff cost, other direct operating cost and indirect operating cost. The staff cost category refers to the annual personnel costs associated with ATS. The other direct operating cost category refers to the nonstaff annual expenditures required to maintain ATS and includes such items as parts and supplies, leases, electricity, etc. The indirect cost category includes such items as depreciation, interest payments, and insurance premiums. Interfacility communications and general navigation systems costs are not included as part of these ATS cost estimates.

Table 3

CEP ATS ANNUAL COST PRELIMINARY ESTIMATES

| ATS Unit | Annual Cost (1979 US $000) |
|---|---|
| Honolulu ACC | 1,785 |
| Oakland ACC | 1,785 |
| TOTAL | 3,570 |

APPENDIX A

# CEP ATS UNITS--AVAILABLE SUPPLEMENTAL DESCRIPTIVE DATA

## A.1 Introduction

This appendix presents brief descriptions of the Oakland and Honolulu ACC's based on available data. These descriptions supplement the system information given in the main text and provide data to support the cost estimates given in Appendix B.

### A.1.1 Information Sources

The following information is based on visits to the Oakland ACC in early 1980 and subsequent consultations with Oakland and Honolulu ACC personnel as well as other FAA personnel.

## A.2 Honolulu ACC

### A.2.1 Airspace Structure

The Honolulu ACC is a US FAA en route Air Route Traffic Control Center (ARTCC) providing domestic and oceanic ATS; oceanic area control service is provided from FL55 and above. Six non-radar control sectors provide air traffic services for the oceanic area under the jurisdiction of the Honolulu Center; three of these sectors (9, 11, and 13) lie wholly within the CEP region and a minor portion of another (12) falls within CEP airspace but is rarely used. The airspace jurisdiction of the Honolulu Center is shown in Figure A-1.

The Honolulu Center is divided into two areas of specialization: east and west. Only the east area controllers provide ATS in the CEP. Controllers regularly alternate daily between oceanic and domestic controller positions, as a matter of center policy, to maintain proficiency in domestic and oceanic control operations.

### A.2.2 General Accomodations

Figure A-2 shows the layout of the Honolulu ACC Control room including control positions. The Sector 7 radar position (indicated by R7) provides radar service for CEP traffic making oceanic entry and exit. The CEP oceanic Sectors (9, 11 and 13) have only a data (D) position; other sectors also include assistant controller (A) positions. Assistant controllers may be shared by adjacent sectors. Note that a flight strip printer is located adjacent to the CEP oceanic controller position. From 8 p.m. to 8 a.m. each day the Sector 9 position is combined with the sector 11 position. All other sectors are active on a 24-hour basis as reported by controller personnel.

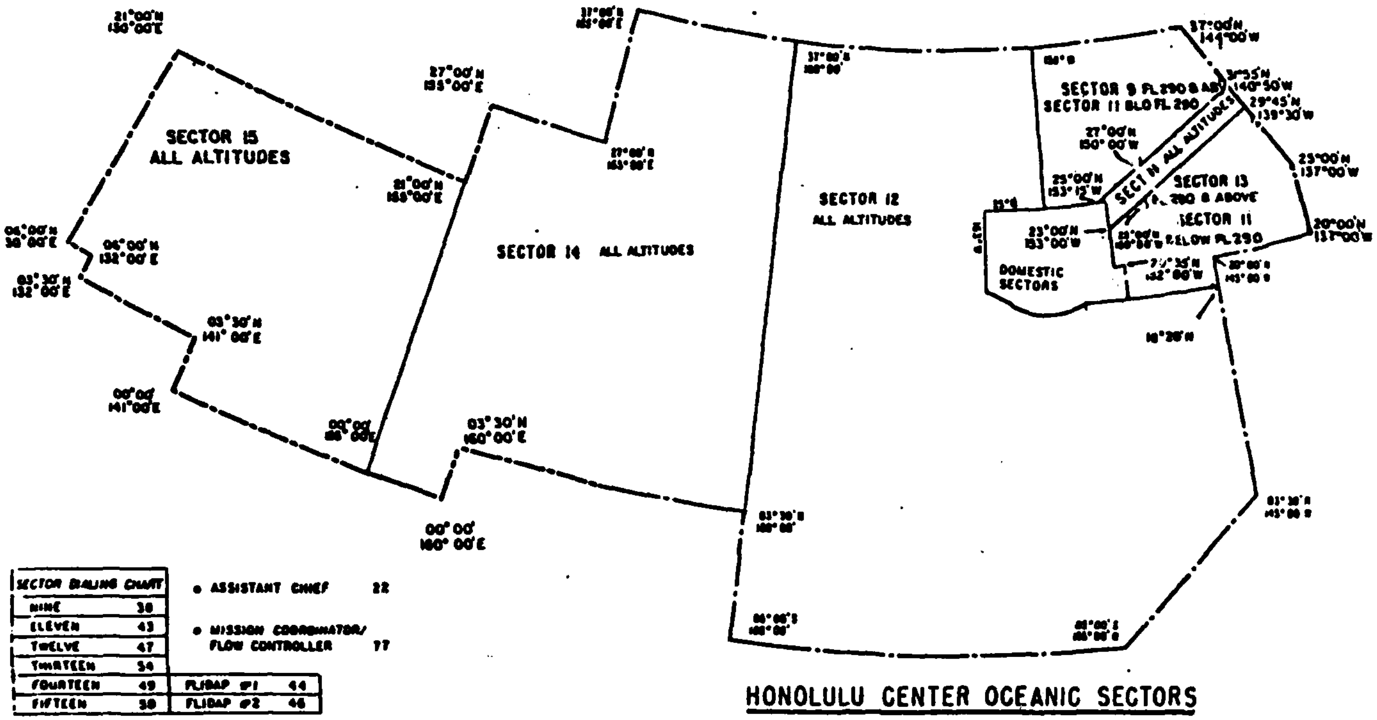



Figure A-1. Honolulu Center Oceanic Sectors

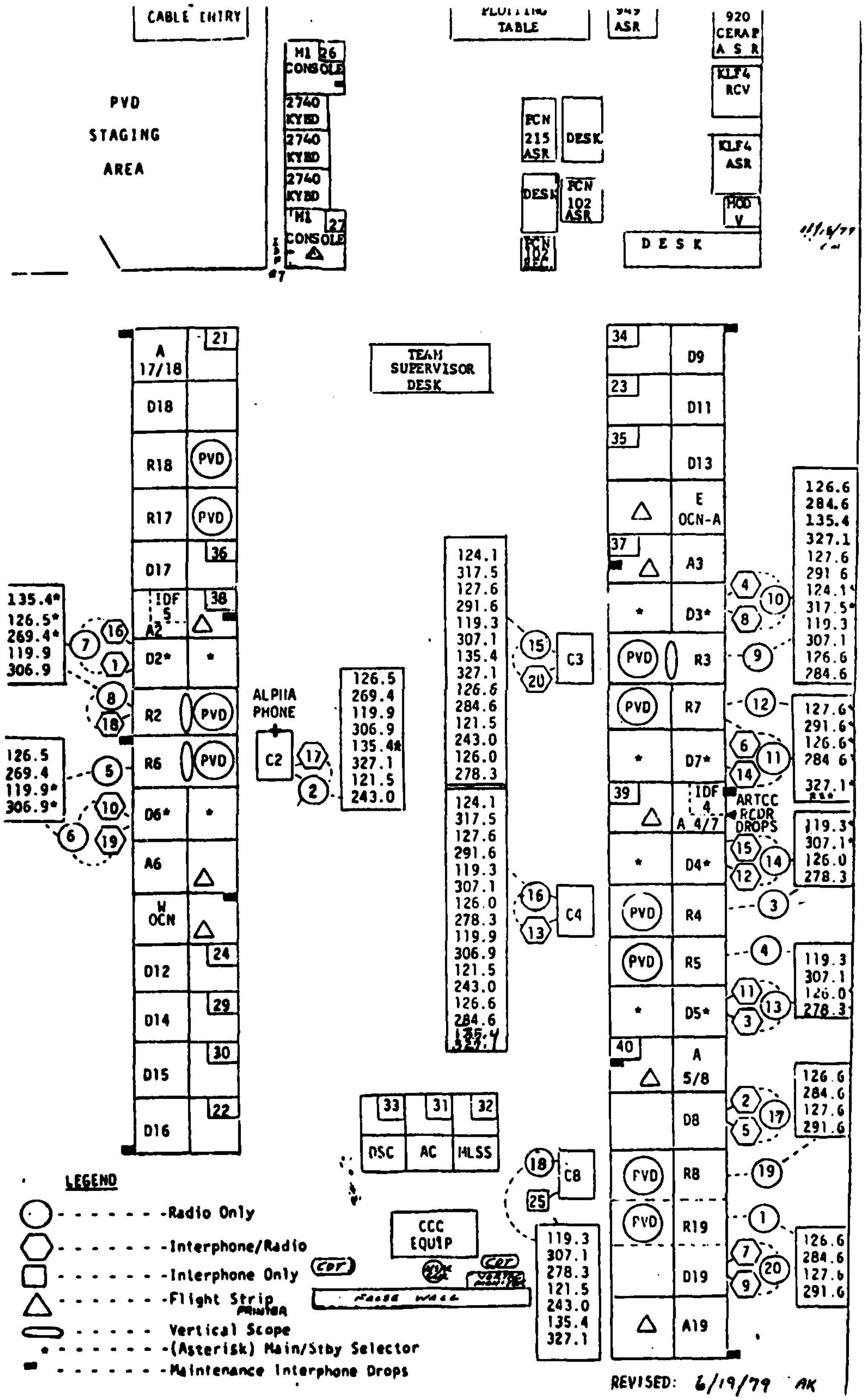



FIGURE A-2 HONOLULU ACC CONTROL ROOM LAYOUT

## A.3 Oakland ACC

### A.3.1 Airspace Structure

The Oakland ACC is a US FAA en route National Airspace System (NAS) Stage A Air Route Traffic Control Center (ARTCC) providing domestic and oceanic ATS; oceanic area control service is provided from FL55 and above. Four non-radar control sectors provide air traffic services for the oceanic area under the jurisdiction of the Oakland Center. All four of these sectors, 60, 61, 63 and 64, are within the CEP region. The airspace jurisdiction of the Oakland Center is shown in Figure A-3.

The Oakland Center has an oceanic area of specialization that includes the four oceanic sectors as well as Sector 51, the radar position for controlling aircraft making oceanic entry and exit. Controllers rotate through the different positions within the oceanic area of specialization, as a matter of Center policy, if they are qualified in both oceanic and radar control procedures.

### A.3.2 General Accommodations

Figures A-4a and A-4b show the layout of the Oakland ACC control room including control positions. The oceanic area of specialization includes only those controller positions in Figure A-4a. According to informal discussions with Center personnel, Sectors 60 and 61 are combined into one position about 60 percent of the time, and sectors 63 and 64 are combined into one position about 90 percent of the time. Each of the oceanic Sectors has a controller position (D) and an assistant controller position (A). In addition to these, the radar sector (51) has a radar position (R).

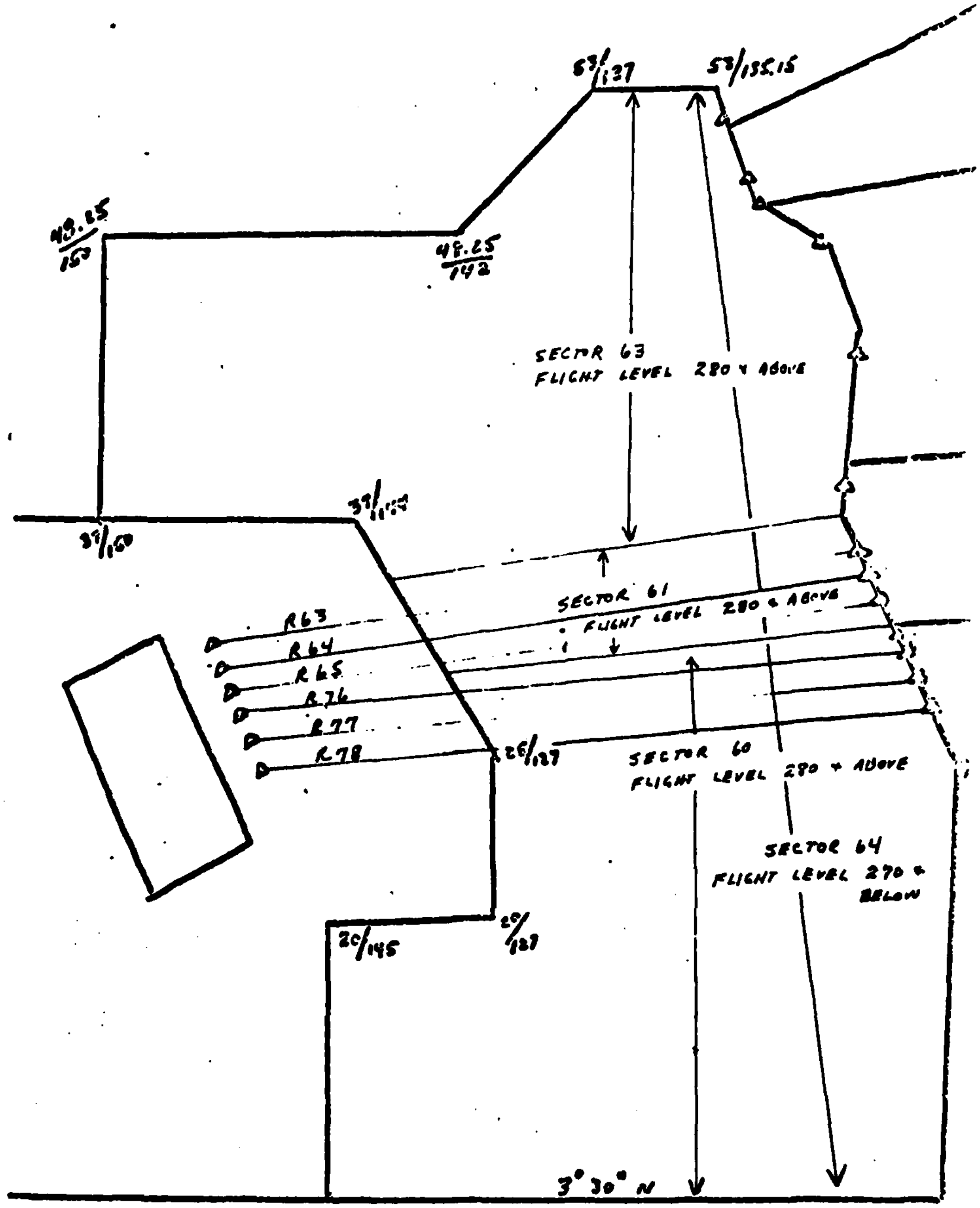



**Figure A-3. Oakland Center Oceanic Sectors**

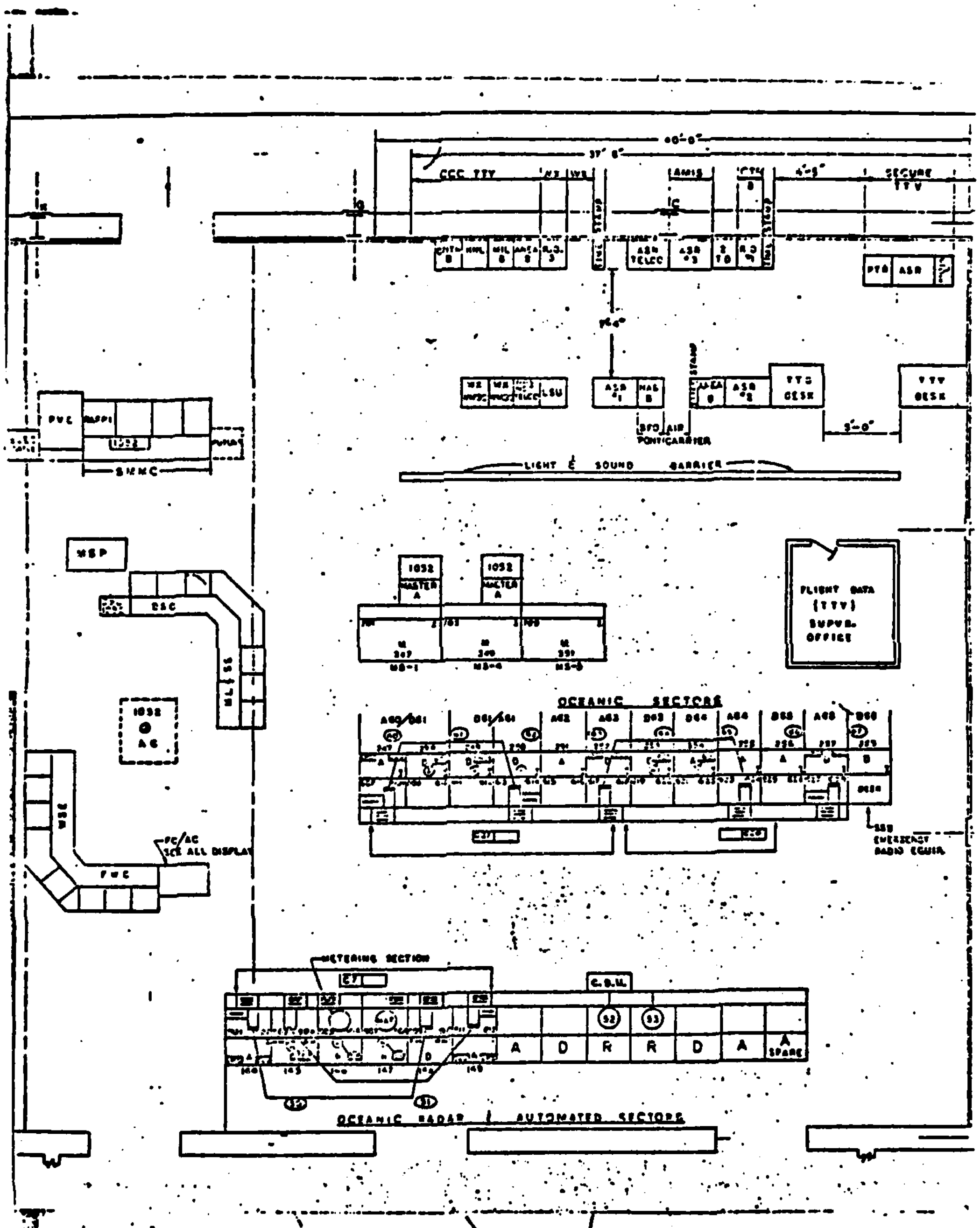



Figure A-4a. Oakland ACC Control Room (P. 1 of 2)

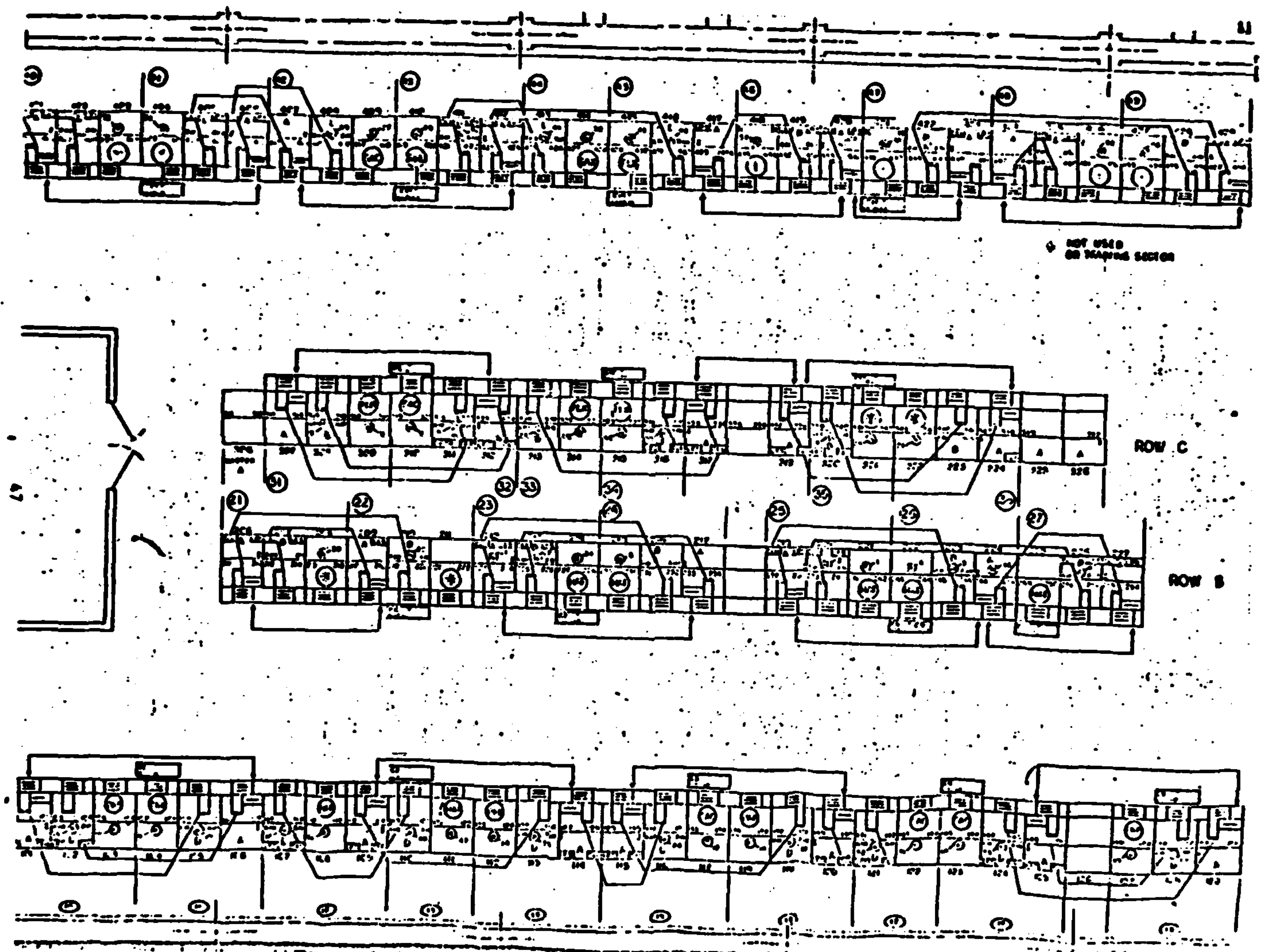



Figure A-4b. Oakland ACC Control Room (p. 2 of 2)

# APPENDIX B

## ATS ANNUAL COST CALCULATIONS

### B.1 Introduction

This appendix describes the calculation of ATS provider annual costs for the CEP. The estimates include staff cost, other direct operating cost and indirect operating cost. Cost estimates are developed for the Oakland and Honolulu ACC's based on informal data provided by the US FAA.

### B.2 Honolulu and Oakland ACC Annual Costs

#### B.2.1 Annual Staff Cost Estimates

At the Oakland ACC, four sectors are involved in CEP oceanic operations. Sectors 60 and 61 are combined 60% of the time; however, and Sectors 63 and 64 are combined 90% of the time. This computes to the equivalent of 2.5 oceanic sectors. Oakland Center personnel indicated that oceanic controllers spend 60 percent of their time at radar control positions, and 40 percent at oceanic control positions. FAA informal preliminary estimates of the controller staff show 60 oceanic controllers at the Oakland Center. The allocation of personnel to CEP oceanic positions computes to 40 percent of 60 persons or 24 persons.

At the Honolulu ACC, three sectors handle CEP oceanic traffic with one of them (Sector 9) operating on a half-time basis. This is equivalent to a total of 2.5 oceanic sectors dedicated to the CEP. In addition, there are 3 non-CEP sectors, for a total equivalent to 5.5 oceanic sectors. Informal preliminary estimates of the Honolulu ACC's oceanic controller staff were made by the FAA and resulted in a count of 45 persons. This staff is active in CEP oceanic control operations 2.5/5.5 (or 45 percent) of the time, and alternates daily between oceanic and domestic control assignments. Thus only half of 45 percent of the controllers' time is spent on CEP oceanic control, equivalent to 11 controllers. This staffing estimate does not seem high enough, either for the manning of 2.5 sectors round-the-clock (plus allowances for vacation and sick leave), or in light of the staffing estimate calculated for the Oakland ACC. Subject to subsequent FAA reevaluation of oceanic controller staffing estimates and calculation procedures, the figure of 24 controllers obtained for Oakland ACC's 2.5 sectors is used for the Honolulu ACC's 2.5 sectors.

The following tabulation summarizes the CEP controller staffing allocations and associated annual costs assuming an average annual wage per person of 30 thousand 1979 US$:

| Unit | CEP Controller Staff (persons) | Controller Annual Staff Cost 1979 US$ (000) |
|---|---|---|
| Honolulu ACC | 24 | 720 |
| Oakland ACC | 24 | 720 |
| Total | 48 | 1440 |

In addition to the controller staff, the FAA units include ATC support (including administrative) and maintenance personnel. Detailed descriptions of the complete CEP staff at each facility are not available. An FAA domestic en route center typically employs about 100 ATC support personnel, and 120 maintenance personnel, and typically is responsible for 30 to 35 domestic and oceanic sectors. Therefore, roughly 7 persons per sector (exclusive of controller staff) are employed. However, the oceanic sectors are not equipped with radar and A/G communication services and require considerably less support and maintenance than the domestic radar sectors. A first-cut estimate of 2 noncontroller persons per CEP oceanic nonradar sector is used to account for the lower level of support and maintenance complexity of the oceanic sectors relative to domestic radar sectors.

Based on the discussions above, the Honolulu ACC has the equivalent of 2.5 CEP oceanic sectors and 1 CEP domestic radar sector, and the Oakland ACC also has the equivalent of 2.5 CEP oceanic sectors and 1 CEP domestic radar sector. Using the staffing estimates derived above and assuming an average annual wage per person of 30 thousand 1979 US$, the estimated noncontroller staffing costs are:

| Unit | Number of CEP Equivalent Sectors | CEP Noncontroller Staff (persons) | Noncontroller Annual Staff Cost 1979 US$ (000) |
|---|---|---|---|
| Honolulu ACC | 2.5 oceanic | 5.0 | 150 |
| | 1.0 radar | 7.0 | 210 |
| Oakland ACC | 2.5 oceanic | 5.0 | 150 |
| | 1.0 radar | 7.0 | 210 |
| Total | 7.0 | 24.0 | 720 |

B.2.2 Other Annual Direct Operating Cost Estimates

The following annual costs of operating and maintaining a single oceanic sector are based on informal discussions with the FAA:

| Sector Cost Element | Annual Direct Operating 1979 US$ (000) |
|---|---|
| Nonradar spare parts and supplies | 3 |
| Key equipment (Telco) | 10 |
| Leased lines | 10 |
| Miscellaneous items | 2 |
| Total Nonradar | 25 |
| Radar (PVD) spare parts and supplies | 5 |
| Total Radar | 30 |

The above list includes costs allocated to interphone communications between FAA domestic and oceanic sectors. Costs for international interfacility oceanic communications are not included in the above list but are treated as part of the COM system cost and are assumed to be external to ATS costs. The nonstaff annual direct operating costs estimated for each FAA ATS unit based on 25 thousand 1979 US$ per nonradar sector and 30 thousand 1979 US$ per radar sector are:

| ATS Unit | Number of CEP Equivalent Sectors | Other Annual Direct Operating Costs 1979 US$ (000) |
|---|---|---|
| Honolulu ACC | 2.5 nonradar | 62.5 |
| | 1.0 radar | 30.0 |
| Oakland ACC | 2.5 nonradar | 62.5 |
| | 1.0 radar | 30.0 |
| Total | | 185.0 |

B.2.3 Indirect Annual Operating Costs

Based on informal discussions with the FAA, the annual procurement and installation cost is assumed to be 100 thousand 1979 US$ for an oceanic sector (excluding radar and A/G communications) and 250 thousand 1979 US$ for a domestic radar sector (including A/G communications). Assuming a 10 percent annual discount rate and a 15-year life, each oceanic nonradar sector's annual depreciation and interest cost is US$

13,000 and each domestic radar sector's corresponding cost is US$ 33,000. Allowing an additional US$ 2,000 per sector for miscellaneous indirect costs (insurance premiums, etc.) the annual indirect operating costs for each ATS unit are:

| ATS Units | Number of CEP Equivalent Sectors | Annual Indirect Operating Cost 1979 US$ (000) |
|---|---|---|
| Honolulu ACC | 2.5 nonradar | 37.5 |
| | 1.0 radar | 35 |
| Oakland ACC | 2.5 nonradar | 37.5 |
| | 1.0 radar | 35 |
| Total | | 145.0 |

B.2.4 Total Cost

The total annual cost for the FAA facilities, based on the above calculations and adjusted for overhead expenses, are summarized in the following listing. A preliminary overhead factor of 50 percent of staff cost is assumed to represent labor overhead and FAA headquarters, regional and logistics support.

Annual Cost (1979 US$ Thousand)

| Cost Item | Honolulu ACC | Oakland ACC | All |
|---|---|---|---|
| Controller Staff | 720 | 720 | 1440 |
| Noncontroller Staff | 360 | 360 | 720 |
| Total Staff | 1080 | 1080 | 2160 |
| Other Direct Operating | 92.5 | 92.5 | 185 |
| Indirect Operating | 72.5 | 72.5 | 145 |
| Subtotal | 1,245 | 1,245 | 2,490 |
| Overhead | 540 | 540 | 1,080 |
| Total | 1,785 | 1,785 | 3,570 |

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