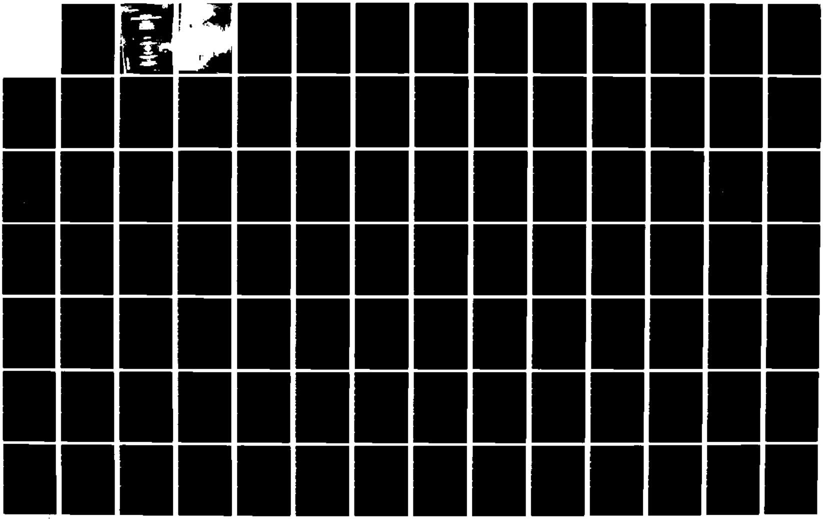
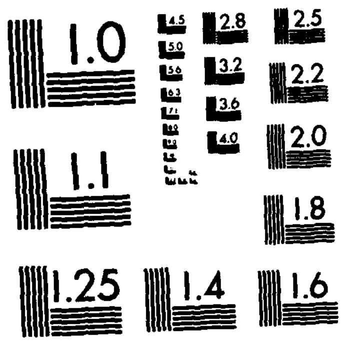
AD-A123 828 OCEANIC AREA SYSTEM IMPROVEMENT STUDY (OASIS) VOLUME IV 1/2
CARIBBEAN REGION..(U) SRI INTERNATIONAL MENLO PARK CA
G J COULURIS SEP 81 OASIS-CAR-ATS FAA-EM-81-17-4
UNCLASSIFIED DOT-FA79WA-4265 F/G 17/7 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-EM-81-17,IV	AD-A123828	

4. Title and Subtitle	
OCEANIC AREA SYSTEM IMPROVEMENT STUDY (OASIS) VOLUME IV: CARIBBEAN REGION AIR TRAFFIC SERVICES SYSTEM DESCRIPTION	5. Report Date: September 1981
	6. Performing Organization Code: SRI Project 8066
7. Author(s): G.J. Couluris	8. Performing Organization Report No.: OASIS-CAR-ATS
9. Performing Organization Name and Address: SRI International, 333 Ravenswood Ave, Menlo Park, CA 94025	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.: DOT-FA79WA-4265
12. Sponsoring Agency Name and Address: Department of Transportation, Federal Aviation Administration, Office of Systems Engineering Management, Washington, D.C. 20591	13. Type of Report and Period Covered: Final Report
	14. Sponsoring Agency Code: FAA-AEM

15. Supplementary Notes

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.

This report describes the present air traffic services (ATS) system in the CAR 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: Houston Area Control Center (ACC), Merida ACC, Miami ACC, San Juan ACC, Habana ACC, Kingston ACC, Curacao ACC, Piarco ACC, Maiquetia ACC, Santo Domingo ACC, and Port-au-Prince Flight Information Center (FIC).

17. Key Words	18. Distribution Statement
North Atlantic (NAT), Air Traffic Services (ATS), Oceanic Air Traffic Control (ATC)	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	112	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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.

TABLE OF CONTENTS

CONTENTS (Concluded)

ILLUSTRATIONS

ILLUSTRATIONS (Concluded)

TABLES

TABLES (Concluded)

EXECUTIVE SUMMARY

Air traffic services (ATS) provided to aircraft flying in designated areas of the Caribbean (CAR) region include: (1) air traffic control (ATC), (2) flight information and (3) alerting services. The designated areas include control areas (CTAs), where all three services are provided, and flight information regions (FIRs), where only flight information and alerting services are provided. The ATS units providing services in oceanic and domestic CTAs are area control centers (ACCs). Flight information centers (FICs) provide the non-ATC services in FIRs unless the responsibility of providing such services is assigned to ATS units. The designated areas and ATS units are established by international agreement under the auspices of the International Civil Aviation Authority (ICAO).

This study of the CAR addresses the ATS provided by the Curacao, Habana, Kingston, San Juan, Santo Domingo, Houston, Maiquetia, Merida, Miami and Piarco ACCs and the Port-au-Prince FIC. These ATS units use to varying extent the communication, navigation and surveillance systems that are common to most domestic airspace areas; these systems include very high frequency (VHF) air-ground voice radio, ground-based radionavigation aids and radar surveillance. The radionavigation aids support a system of fixed ATS routes which criss-cross the CAR and are commonly used by flights in the region.

The domestic systems do not provide complete coverage throughout the CAR. Long range communication systems are used in areas where long distances between island and continental transmitter/receiver land sites exceed the range limitations of domestic systems. In such situations, high frequency (HF) air-ground radio systems are used which, in general, are operated by communications (COM) stations. The COM stations relay messages between pilots and ATS units.

Communication between ATS units and with support units (such as COM stations, air carrier operating offices, meteorological stations) are available through the aeronautical fixed telecommunications network (AFTN) teletype and the ATS direct speech circuits. The AFTN and ATS direct speech circuits in the CAR include complicated networks of marine cables, land lines, satellite and HF radio links which are operated by numerous provider jurisdictions in the various states. AFTN teletype messages tend to experience delay and interruption in transmission. As a result, the ATS direct speech circuits generally are used for coordinating between ATS units and for forwarding of flight data.

The most heavily traveled traffic corridor in the CAR is that one between Florida and Puerto Rico which is a nonradar airspace under the control of the Miami and San Juan ACCs. This flow currently experiences diversions due to potential conflicts; diversions would increase significantly under present ATC circumstances as traffic increases in the future. However, the planned continued expansion of radar coverage in this corridor would eliminate the potential development of critical congestion is this area.

Another area of concern is that of the uncontrolled airspace of the Port-au-Prince FIR. This area is centrally located in the CAR and is crossed by north-south and east-west traffic; the occurrences of proximate traffic in this area could become a troublesome issue as traffic increases. No plans currently exist to provide future ATC service in the Port-au-Prince FIR, and, therefore, a dilemma exists as to the appropriate mechanisms for dealing with the potential need for separation service in the Port-au-Prince area. Elsewhere in the CAR, the dispersion of traffic and the moderate levels of projected traffic intensity are expected to avoid the development of serious traffic congestion situations in the future. Congestion situations that may occur in the CAR could be handled through the application of new technologies (e.g., satellite or HF data link and voice communications, advanced navigation and airborne separation assurance device systems) and old technologies (e.g., expanded radar and VHF communication services).

ACKNOWLEDGMENTS

We are highly appreciative of the guidance and support provided by the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation" and by the various participating states and authorities in the Caribbean Region. We also wish to thank Mr. V. E. Foose, FAA Program Manager, and Mr. N. Craddock and Mr. J. Loos of the FAA for their assistance.

This research was conducted by SRI International under the leadership of Dr. George J. Couluris with the support of Mr. Bjorn Conrad and Ms. Marika E. Garskis. Mr. Robert Lieberman, Ms. Janet Tornow and Ms. Mina Chan contributed to 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.

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 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 Caribbean (CAR) 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 a preliminary analysis of the effectiveness of current operations, future requirements and potential areas for system improvement. 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 various ATS facilities, consultations with air carrier and ATS operations and support personnel, ICAO reports (ref. 1 through 9) and data obtained from ATS provider organizations including the Mexican Airspace Navigation Services (S.E.N.E.A.M.) (ref. 10); the Service de L'Aviation Civile in the Republic of Haiti (ref. 11); the Ministry of Transportation and Communication of Venezuela (ref. 12); and the Federal Aviation Administration (FAA) in the United States (US) (ref. 13). The data obtained from Haiti, Mexico and Venezuela are written responses to special questionnaires issued by the ICAO regional office.

Responses to questionnaires submitted to the other CAR provider authorities have not been received and special descriptions by the other authorities concerning their operations are not available. Descriptions of ATS in areas other than those of the above respondents are based largely in ICAO documents (especially ref. 5) and discussions with air carrier, International Air Transport Association (IATA), Air Transport Association of America (ATA), ICAO and FAA personnel that are familiar with CAR operations.

This report consists of seven sections, as well as a number of appendices that provide supplemental descriptive data. Section 2.0 gives an overview of the ATS in the CAR 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 CAR. Section 7.0 presents a first-cut analysis of the operational performance and effectiveness of the present ATS system in the CAR.

2.0 ATS OVERVIEW--CAR OPERATIONAL ENVIRONMENT

2.1 General Requirements for ATS Provision

ATS in the CAR 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 the CAR areas addressed 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

The services are provided in ATS areas that are designated in relation to the particular services 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, except as limited by an upper flight information region (UIR).

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 CTAs in the CAR are higher, such as at flight level (FL) 25 (i.e., at an atmospheric pressure altitude of 2500 ft). An upper limit is established if ATC service is not provided above this limit, or if the CTA is situated below an upper control area (UTA).

2.1.2 Designation of ATS Units

Two general types of ATS units provide service in the CAR 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 a 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 (as in the CAR) 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 responsibility for transmitting meteorological 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 or UTAs 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 CAR oceanic areas offers at least one of the following forms of separation (ref 1):

(1) Vertical separation, obtained by assigning different levels of flight satisfying minimum vertical spacing specification.

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

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

2.2 Airspace Organization and ATS Facilities

The en route upper airspace jurisdictional structure in the CAR is shown in Figure 1, which identifies the CTAs, UTAs, FIRs and UIRs established by international agreement and described by the ICAO Air Navigation Plan (ref. 5). Note that the boundaries shown in Figure 1 delineating the CAR and non-CAR airspace are defined only for use in this study and are not strictly as designated by ICAO in reference 5. Table 1 lists the CAR designated oceanic areas; ATS operating units (unit responsibilities are noted); unit locations; and provider authorities and contracting states.

The solid boundary lines in Figure 1 define the CAR region addressed by this study. The San Juan and Miami CTA/FIRs are segregated into CAR and North Atlantic (NAT) components. The northerly areas of these two CTA/FIRs (as shown by the dashed boundary lines in Figure 1) are integral parts of the NAT operations and only the southerly areas of these two CTA/FIRs are integral parts of the CAR operations. The continental portion of the Maiquetia UTA/FIR is treated as part of the South America (SAM) region and only the oceanic part is included in the CAR.

The Miami CTA/FIR consist of two geographically separate areas: the Miami CTA/FIR (Gulf) in the Gulf of Mexico and the Miami CTA/FIR (East CAR) to the east of Florida. Both areas are under the jurisdiction of the Miami ACC. The other ATS units have jurisdiction over continuous airspace areas.

Full ATS is provided by ACCs in the upper airspace of their areas except in the Port-au-Prince FIR and the Piarco FIR where flight information and alerting services are provided. The Santo Domingo ACC was recently formally established in September 1979, and provides separation service on all ATS routes within the Santo Domingo CTA/FIR and only flight information and alerting services in off-route airspace. The upper airspace of the Piarco FIR in the Atlantic Ocean is recommended for change into a UTA (ref. 5). The upper airspace in the westerly Piarco area (see Figure 1) currently is a UTA/FIR and a part of the lower airspace under this UTA/FIR is a CTA/FIR. The current Piarco ACC would assume responsibility for ATC in the proposed Atlantic Ocean UTA/FIR. No formal plans for changes to the services provided by the Port-au-Prince FIC are noted.

Many of the CAR areas of jurisdictions include over-ocean and overland responsibilities. The many islands and states in the CAR and the nearness of continental areas obviate the meaning of strictly oceanic or strictly domestic airspace. As will be seen, the availability of land-based facilities in the CAR provides an operational environment in certain areas that more closely resembles domestic operations than the classical oceanic operations as exist in the NAT. Therefore, this

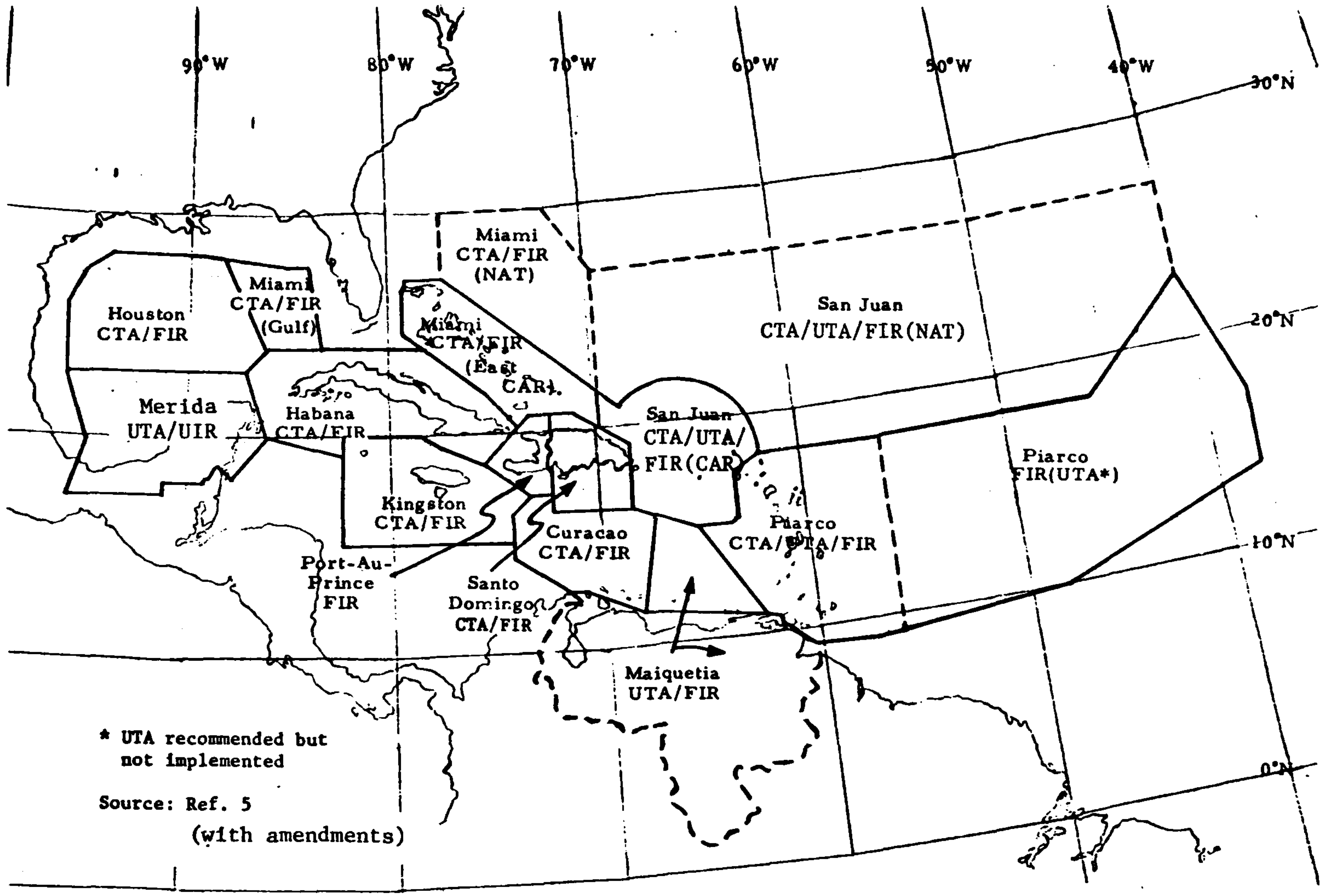


FIGURE 1. CAR AIRSPACE JURISDICTIONAL STRUCTURE

Table 1

CAR ATS ORGANIZATIONS AND FUNCTIONS

Designated Oceanic Area	ATS Operating Unit	Location	Provider Authority Contracting State
Curacao CTA/FIR	Curacao ACC[1]	Curacao, Netherlands Antilles	Netherlands Antilles
Habana CTA/FIR	Habana ACC[1]	Habana, Cuba	Cuba
Houston CTA/FIR	Houston ACC[1]	Houston, Texas, United States (US)	Federal Aviation Administration (FAA) Department of Transportation (DOT), US
Kingston CTA/FIR	Kingston ACC[1]	Kingston, Jamaica	Jamaica
Maiquetia UTA/FIR	Maiquetia ACC[2]	Maiquetia, Venezuela	Venezuela
Merida UTA/UIR	Merida ACC[2]	Merida, Yucatan, Mexico	Mexican Air Space Navigation Services (S.E.N.E.A.M.), Office of the Secretary for Communication and Transport, Mexico
Miami CTA/FIR	Miami ACC[1]	Miami, Florida, US	FAA, DOT, US
Piarco CTA/UTA/FIR	Piarco ACC/FIC[3]	Trinidad and Tobago	Trinidad and Tobago
Port-au-Prince FIR	Port-au-Prince FIC[4]	Port-au-Prince, Haiti	L'Administration de l'Aeroport International Francois Duvalier, Secretarie d'Etat des Travaux Publics et Communications (T.P.T.C), Haiti
San Juan CTA/UTA/FIR	San Juan ACC[1]	San Juan, Puerto Rico, US	FAA, DOT, US
Santo Domingo CTA/FIR	Santo Domingo ACC[1]	Santo Domingo	Santo Domingo

1. ATS responsibilities include ATC, flight information (FI) and alerting (ALERT) services.
2. ATS responsibilities include ATC, FI, ALERT services in the upper airspace and FI, ALERT in the lower airspace.
3. ATS responsibilities include FI, ALERT services with ATC service in parts of the upper and lower airspace; ATC service in the total upper airspace is recommended (by ICAO) but not implemented.
4. ATS responsibilities include FI, ALERT services.

report will address both oceanic and domestic ATS environments and no attempt will be made to emphasize strictly oceanic ATS operations even though the CAR intuitively may be considered to be an oceanic region.

2.3 Air Traffic Flow Patterns

The CAR 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 CAR 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. The Figure 1 data does not include short range flights--less than 200 nautical miles (nmi)--that would not climb into the upper airspace. Comprehensive data describing the daily patterns of charter air carrier, general aviation and military flights in the CAR are not available and the flow patterns for such flights are not shown.

The flows shown in Figure 1 are based on selective groupings of trips with similar routing patterns and therefore are approximate descriptions of the CAR flight patterns.

Of the total 393 daily flights shown, 73 percent (i.e., 288 flights) pass through the airspace east of Florida. The area southwest of Cuba excluding the Gulf of Mexico accounts for 14 percent (i.e., 56 flights) of the CAR scheduled traffic. The remaining 12 percent (i.e., 49 flights) of the CAR scheduled traffic is over the Gulf of Mexico.

A concentraion of east-west flights travel daily between southern Florida and Puerto Rico through the Miami and San Juan CTA/FIRs. These flights are significant because they must compete for a restricted number of routes in the Miami-San Juan traffic corridor. The north-south flights to or from airports in North America (NAM) spend much of their time in non-CAR airspace but contribute to potential congestion in the Miami-San Juan corridor as well as in the Port-au-Prince and Santo Domingo FIRs and the Habana CTA/FIR. The east-west flight patterns passing through the Port-au-Prince and Santo Domingo FIRs could conflict with the north-south traffic. North-south flights over Cuba are restricted to two flight corridors which are potential congestion points. Note, however that the heavy traffic flows between Puerto Rico and non-Florida North America are largely in NAT airspace and are not a major contributor to CAR congestion.

The traffic flow between Puerto Rico and SAM through the Piarco UTA/FIR includes disperse island hops and is not as concentrated as is inferred from Figure 2. The flights to and from Europe passing through the Piarco FIR could be on any number of routings.

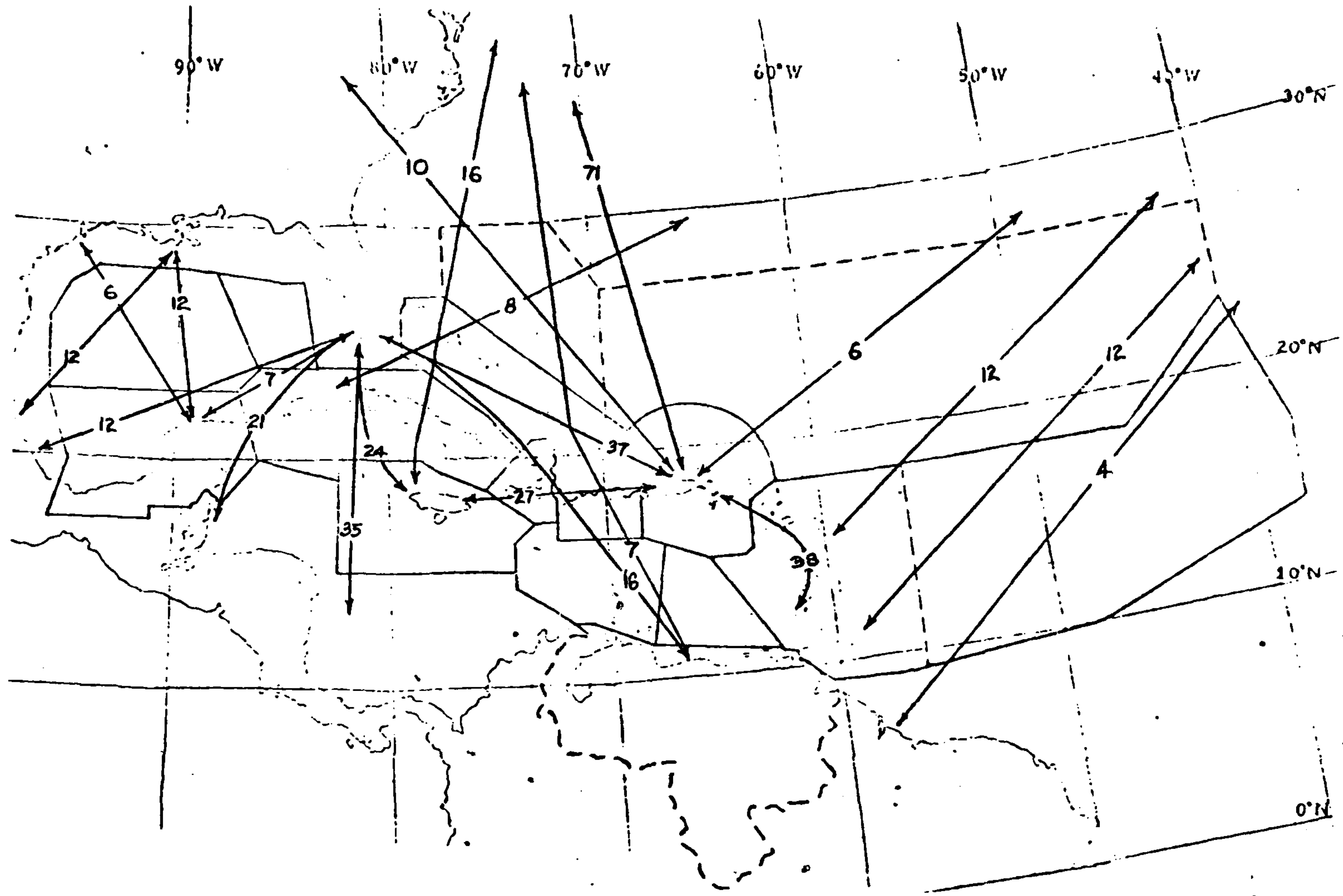


FIGURE 2. CAR DAILY SCHEDULED AIR CARRIER FLOW PATTERNS, JULY 1979

The flight patterns through the airspace southwest of Cuba tend to be geographically disperse, spread over time and not necessarily congested. The north-south traffic through the Kingston CTA/FIR, for example, usually is geographically separated from the east-west traffic in the area.

Traffic on route patterns in the Gulf of Mexico is not as intense as on other CAR routes. Crossing congestion inherent in these traffic flows through the Houston CTA/FIR and Merida UTA/UIR are mitigated by the dispersion of traffic over time and origin and destination patterns.

2.4 Technical System Overview

The communication, navigation and surveillance systems currently in use in the domestic areas also are used to provide ATS in parts of the CAR oceanic airspace. The domestic technical systems generally have limitations on their service range, but most are effective where suitable land sites exist to provide continuous area coverage. Such coverage is based on a network of ground transmitter and receiver equipment. Apart from the Atlantic Ocean area of the Piarco FIR, the numerous islands and continental coastal land sites in the CAR region enable the extension of domestic systems coverage over many areas of the CAR. However, the current state of deployment of the technical facilities is such that complete coverage by domestic systems is not realized, and alternative technologies are employed where necessary.

For example, most domestic air-ground radiotelephony contacts between pilots and ATS units are conducted by means of very-high frequency (VHF) communications systems. VHF communications are used in the CAR when aircraft are in range of transmitter and receiver sites. However, VHF systems cannot satisfy long-range transmission requirements, and a high frequency (HF) radiotelephony system is used when aircraft are in gaps between VHF coverages. The HF A/G communications usually are conducted through COM stations because most (but not all) ATS units in the CAR are not HF equipped. Short range ultra-high frequency (UHF) is used by some military operators.

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 CAR are integrated with those in use in other areas and are part of a multi-regional interfacility communication network. ATS direct speech interphone connections are established between most adjacent ATS units (but not all adjacent units) while the AFTN connects all units. However, AFTN telegraph transmissions between any of the various ATS units in the CAR involve circuitous routings and are subject to interruption; as a result, ATS direct speech is the primary means of communication between units. Advanced computerized data processing systems that are used in some domestic areas are not used extensively in CAR.

Aircraft navigation in domestic airspace normally uses ground-based systems of VHF omnidirectional range (VOR) and distance measuring equipment (DME) radionavigation aids or nondirectional beacon (NDB) aids and automatic direction finding (ADF) equipment. In the CAR, NDB/ADF systems are used extensively to navigate many of the routes through oceanic airspace while VOR/DME is available in some parts of the CAR. Neither the VOR/DME nor the NDB/ADF systems can meet the long-range navigation requirements of trans-Atlantic flights through the FIR portion of the Piarco area and a large portion of the eastern San Juan CTA/FIR area. Long range navigation commonly is accomplished by such means as 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 of limited (i.e., line-of-sight) range and are not feasible for long-range surveillance. Currently, a limited number of radar sites provide coverage in parts of the CAR, but the coverage is not extensive.

2.5 Oceanic Route Structures

The flight operation environments in the various parts of the CAR airspace vary according to differences in traffic density, navigational services and associated procedures. Because of the differences in operating conditions, two oceanic route structures are in use. These route structures are categorized as follows for the purposes of this study:

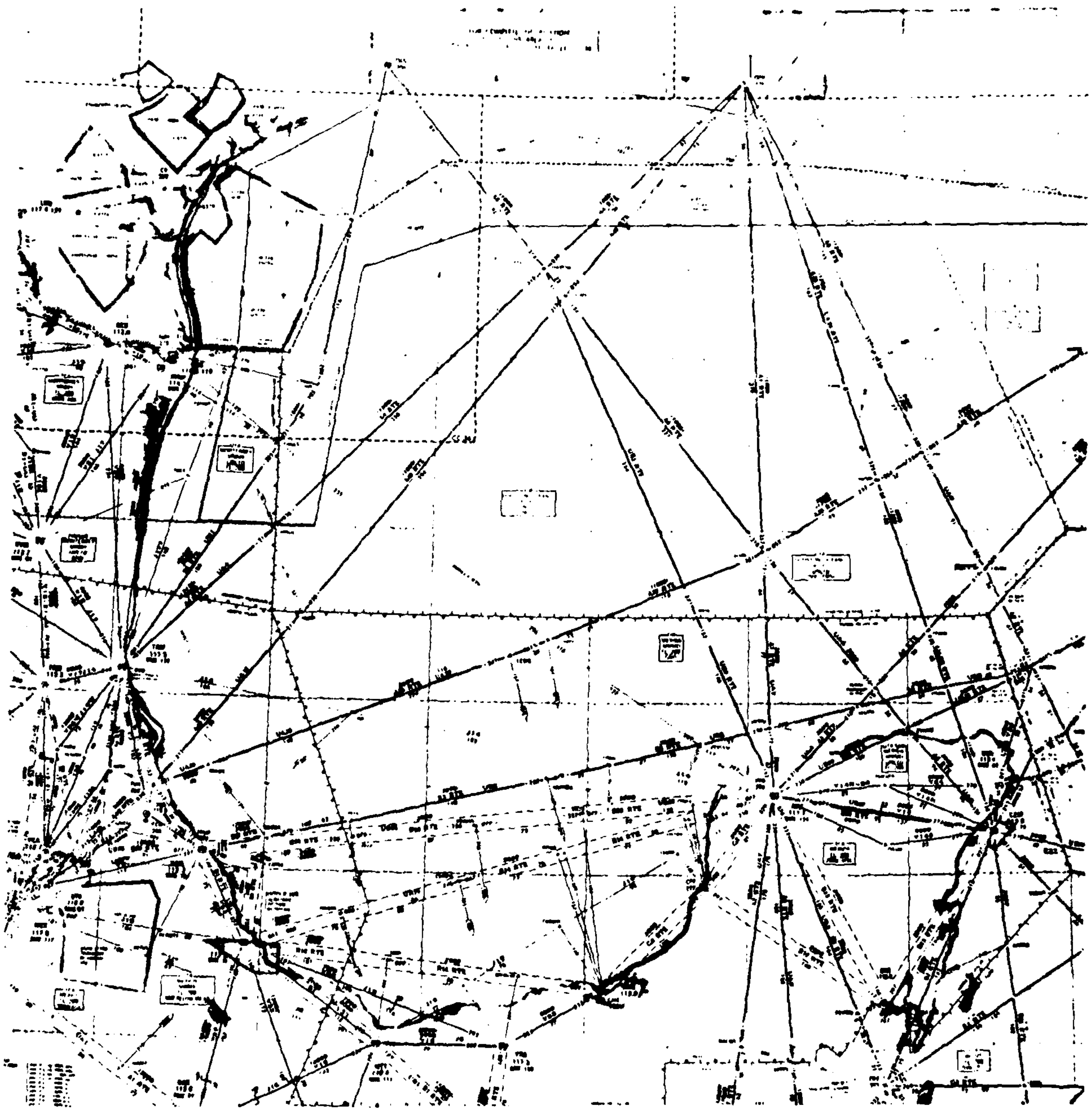
(1) ATS routes
(2) Random tracks,

and are briefly reviewed in the following paragraphs.

2.5.1 ATS Routes

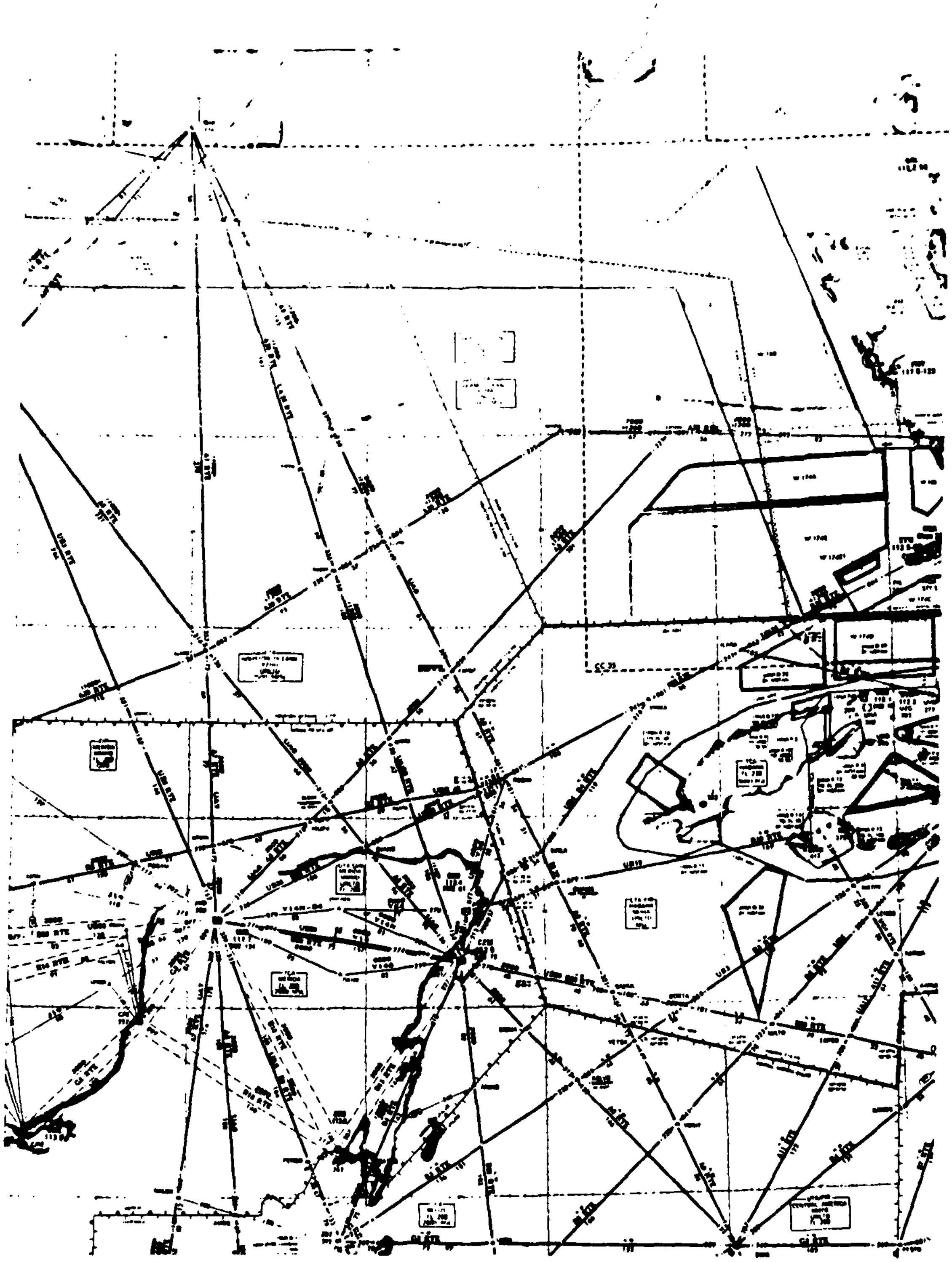
The VOR/DME and NDB/ADF navigation techniques require aircraft to fly directly to or from a ground based radionavigation aid or an intersection based on a system of aids. A VOR/DME or NDB/ADF track often is formally designated between two fixes for the purpose of organizing traffic flow. The track is geographically stationary and is identified as a fixed route in aeronautical charts. A charted track is a single route between two fixes and normally is not part of a set of offset parallel tracks. Such a parallel track structure is precluded by the technical navigational requirement for aircraft to head to or from a VOR/DME or NDB/ADF site. However, offset parallel tracks may be flown by aircraft equipped with special avionics systems such as area navigation (RNAV) systems including INS.

The charted tracks normally not only are published but also are physically maintained by ATS provider authorities who routinely flight-check the radionavigation aids. Such ATS routes often employ smaller lateral separation minima than those generally used on non-ATS tracks. Figure 3, 4 and 5 show the major ATS routes established in the CAR.



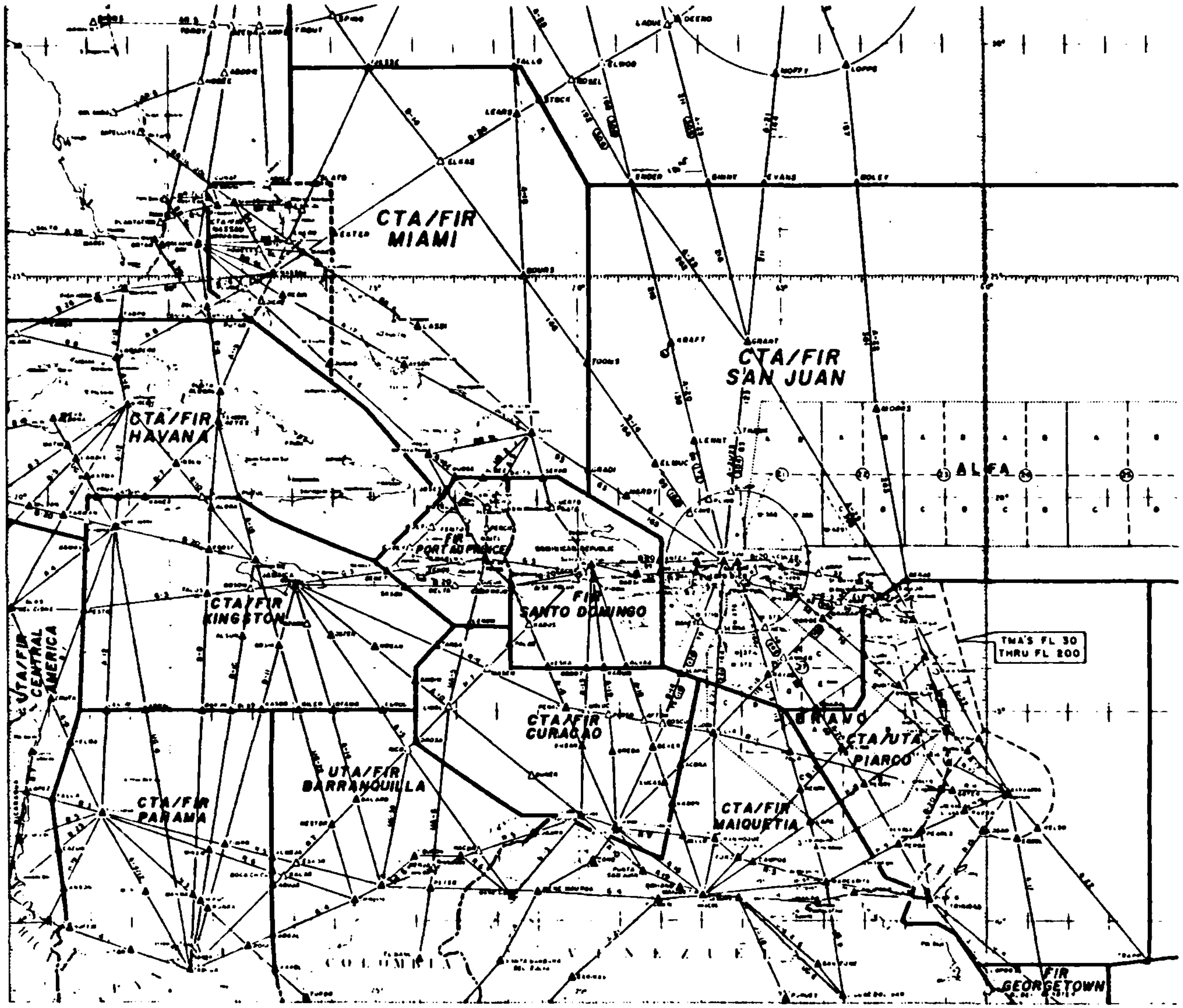
Source: Houston ACC

FIGURE 3 WESTERN CAR ATS ROUTES



Source: Houston ACC

FIGURE 4 CENTRAL CAR ATS ROUTES



Source: San Jose ACC

FIGURE 5. EASTERN CAR ATS ROUTES

2.5.2 Random Tracks

Aircraft are not required to fly the ATS routes but often do so when constrained by navigational capabilities, procedural restrictions or to take advantage of the reduced aircraft separation requirements on the ATS routes. Aircraft fly on random tracks when conditions warrant flying off ATS routes or when flying between points where no formal tracks are defined (such as south of 27 degrees North between Europe and the Caribbean). 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 necessarily retained for subsequent flights.

2.6 ATS Operations

The provision of full ATS service in CTAs and UTAs 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 the 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. The communication practices include the transmittal of flight information--position reports and air reports (AIREPs)--by pilots and the dissemination of pertinent aeronautical information by ATS units, such as broadcasts of significant meteorological data (SIGMETs) and traffic advisories (i.e., alerts describing nearby aircraft).

The airspace areas are divided into sectors on the basis of facilities, routes and workload. The ATC operational environment within each sector is determined by the local surveillance, communication and navigation capabilities. Those sector controllers who are supported by radar, VHF communications and VOR/DME facilities generally provide separation services based on considerably closer spacings than are permitted where these facilities are not available. Most sectors in the CAR do not have radar surveillance capability but many do have VHF air-ground radio capability. NDB/ADF navigation is possible on routes through most sectors except in the FIR portion of the Piarco area and a large portion of the eastern San Juan CTA/FIR. VOR service, although not as extensive as NDB/ADF, is also available along some routes. The separation minima in the CAR generally are more restrictive than those used in domestic continental radar environments but, in various areas, are less restrictive than those used in classical oceanic environments where domestic services are non-existent. In many areas of the CAR, the operational environment is similar to that of domestic continental non-radar areas.

Pilot position reports are the only means of assessing and monitoring aircraft movement through the non-radar sectors. The position reports may be transmitted directly from pilots to sector controllers or, in cases where the sector airspace is not within VHF coverage, may be relayed through an HF radio operator. These same VHF or HF communication systems are used to transmit controller clearances to pilots to proceed along the route of flight as well as other air-ground control-related messages (e.g., pilot altitude change requests, controller responses, advisories, etc.)

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 estimate for the next fix crossing on to a flight strip. The reporting fixes are strategically located along the ATS 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. Aircraft on random tracks are monitored similarly except that individual tracks may need to be hand drawn on an oceanic plotting map to identify points of potential conflict.

The controller issues clearances that provide for a conflict-free flight through the sector. The clearance review process is repeated on a sector by sector basis as the flight continues along the route of flight. Flight data is forwarded and coordination is carried out between ATS units largely by means of the ATS direct speech circuits.

3.0 ATS TECHNICAL STRUCTURE

3.1 Introduction

The primary ATS technological components--communication systems, navigation systems, and surveillance systems--are described in this section.

3.2 Communications Systems

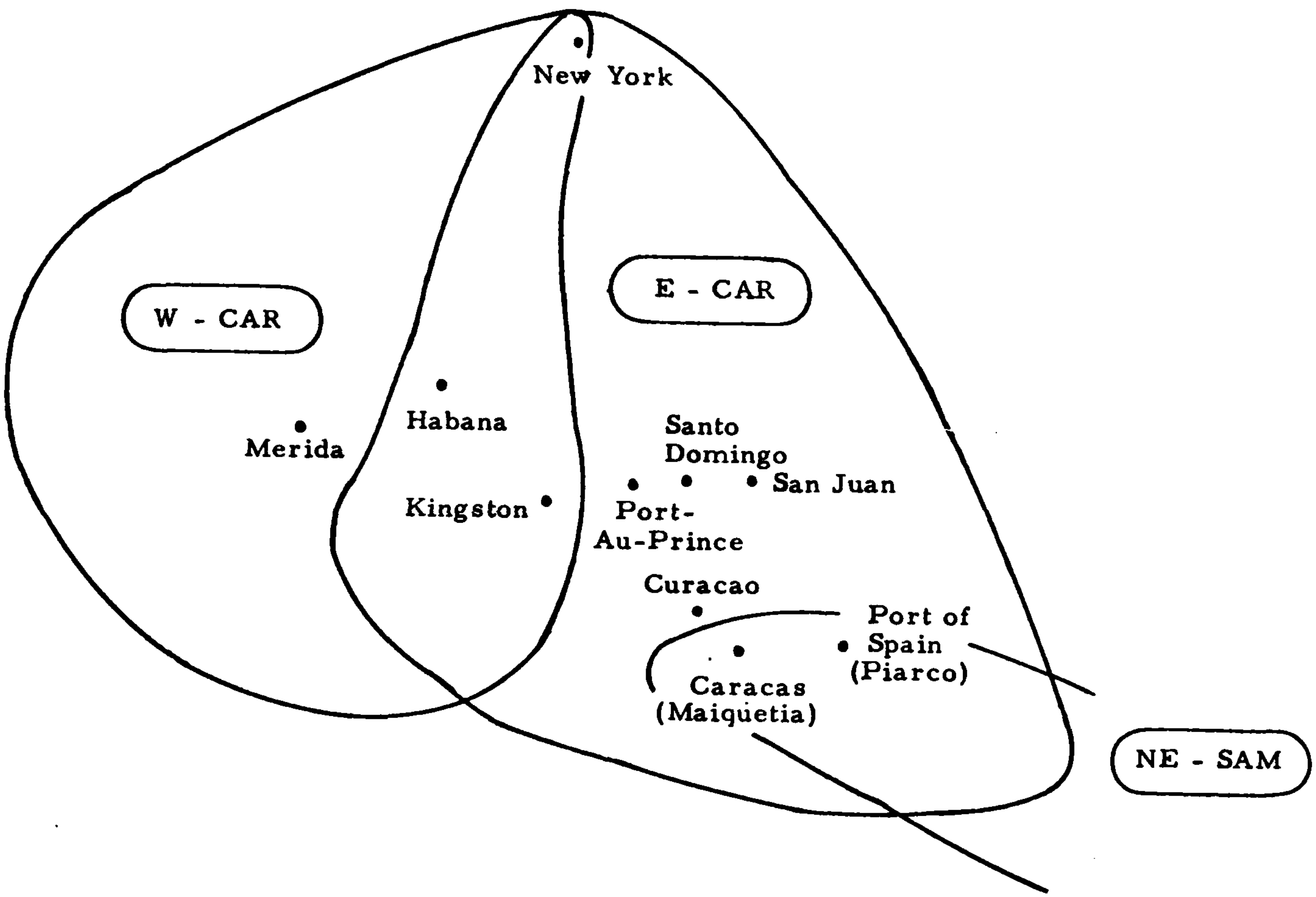
ATS information is distributed by aeronautical mobile and aeronautical fixed communications systems. The mobile systems provide air-ground voice communications between aircraft and ground stations whereas the fixed systems provide voice and teletype and other data link communications between various 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 large part by the line-of-sight nature of the transmissions and also 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 where coverage is provided.

HF transmission characteristics enable over-the-horizon voice transmissions between aircraft and HF ground stations. 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. HF equipment is carried by many but not all aircraft flying in the CAR; HF is carried by those aircraft routinely flying through airspace where VHF service is not available.

The locations of the major COM stations providing HF service in the CAR as described by ICAO (ref. 5) are shown in Figure 6. The stations may be government operated or operated by contract such as the New York Aeronautical Radio, Inc. (ARINC), San Juan ARINC and Port of Spain (Piarco) International Aeroradio Limited facilities.



Source: Ref. 5

FIGURE 6. CAR HF EN-ROUTE RADIOTELEPHONY NETWORKS

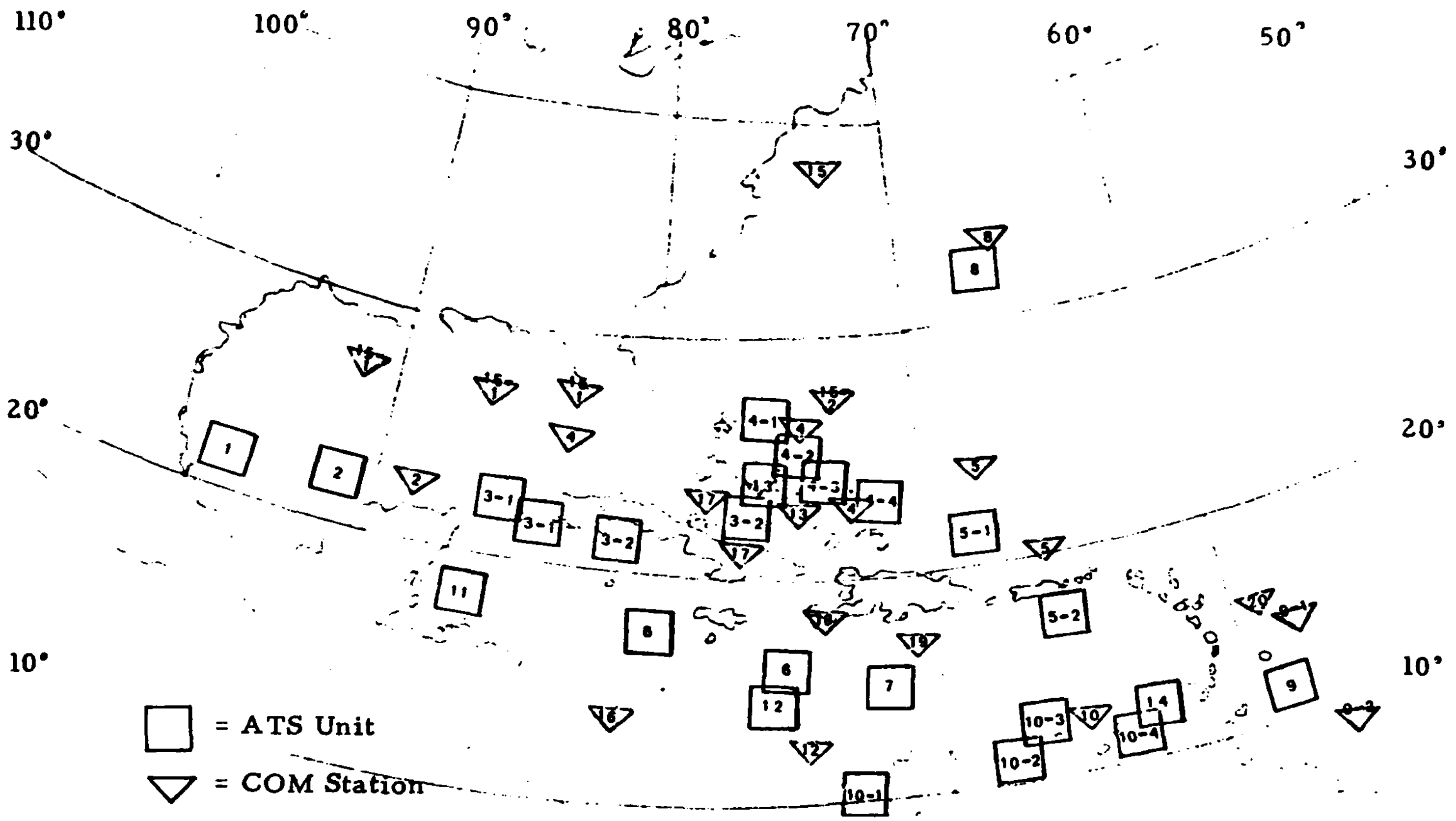
The government operated facilities likely are flight service stations that are separate from their associated ACCs (e.g., Merida Radio operates in parallel with the Merida ACC). Radio operators in each COM station may relay messages between pilots and controllers if aircraft are not within the coverage of the ACC. In addition, at least one private airline communication network-- Eastern Airlines TACS-- provides VHF service in the CAR. The service is established for company communications purposes but may be used to relay data by other flights on a fee basis. The CAR is also served by military communications networks such as MacDill Airways of the U.S. Air Force.

Various VHF and HF services are provided in the CAR by the numerous authorities who have jurisdiction in the area. In some areas VHF and HF are available while elsewhere only HF is available. The complexity of the CAR air-ground radio system is illustrated in Figure 7 which shows in part the communications services as published on some of the aeronautical charts (i.e., JEPCO Avigation Charts) used by pilots flying in the area. The ATS units and COM stations providing each service and the type of service--VHF and HF--are listed in Tables 2 and 3.

The symbololgy used in Figure 7 is intended to show the general areas where each service is provided; the precise coverage area of each service, both HF and VHF, is not defined. However, a few key observations that contribute to an overall understanding of the air-ground radio capabilities and limitation in the CAR can be derived as follows. First, much of the CAR airspace is within air-ground radio voice contact range of ACCs. The voice communication between pilot and controller normally is by VHF, although voice contact with the Curacao ACC may be by VHF or HF; Table 2 shows that Curacao Control operates both VHF and HF frequencies.

Second, voice relay of air-ground messages through a COM station radio operator is required over parts of the Gulf of Mexico and in the Piarco Atlantic Ocean jurisdiction. Direct voice contact is not possible with the Houston ACC or the Miami ACC (Gulf of Mexico sectors only), and air-ground messages are relayed through New York ARINC or a flight service station (e.g., Miami Radio); HF and VHF voice radio service is provided in the Houston, Miami (Gulf) and Santo Domingo CTA/FIRs by their COM stations. The Merida ACC operates VHF service in its UTA/UIR and pilots may contact the unit's controller when in range; otherwise Merida Radio would relay HF voice messages. Similarly the Piarco ACC has VHF voice contact with pilots within range, but HF voice relay through Piarco Radio is required for trans-Atlantic flights in the Piarco FIR.

Third, flight information services in the Port-au-Prince FIR are available through VHF and HF voice radio as provided by Port-au-Prince Radio.



Source: JEPCO A. igation Charts LA(H/L) 3, 4, 5 and 6

FIGURE 7. CAR AERONAUTICAL MOBILE COMMUNICATION SERVICES

TABLE 2. ATS UNITS--CAR AERONAUTICAL MOBILE COMMUNICATION SERVICES

No.	ID - Name	VHF Frequencies		HF Frequencies	Coverage
1	Mexico Center	126.6	120.1		
2	Merida Center	125.8	128.2		
3-1	Havana Center	128.8			
3-2	Havana Center	123.7[1]	128.7[2]		
4-1	Miami Center (R)	134.2[3]			(Grand Bahama)
4-2	Miami Center (R)	125.7[4]			(Nassau)
4-3	Miami Center (R)	132.9[3]	134.8[3]		(Eleuthera)
4-4	Miami Center (R)	132.3[3]			(Grand Turk)
5-1	San Juan Center (R)	135.2			(Grand Turk)
5-2	San Juan Center (R)	128.6 *	135.7		*
6	Kingston Control	128.1	126.9G		
7	Curacao Control	124.1[5](R)	127.1[6]	8959 (Day-5484) SELCAL	E - CAR
8	Bermuda Control	132.2			
9	Piarco Control	123.7			
10-1	Maiquetia Control	128.7	126.6		
10-2	Maiquetia Control (R)	128.5			
10-3	Maiquetia Control (R)	125.2			
10-4	Maiquetia Control	126.0	128.3		
11	Cenamer Control	123.9[7]			B - 5 & NW
12	Barranquilla Control	128.6[7]			
13	Nassau Approach	121.0[5]			
14	Margarita Approach	128.1[8]			

1 = FL 240 or above
2 = FL 230 or below
3 = High altitude
4 = Low altitude
5 = TMA
6 = Extended range
7 = UTA
8 = (0900 - 0400Z)

(R) = Radar capability

* = All aircraft on an IFR flight plan in the San Juan CTA and within 200 NM radius of San Juan are requested to contact San Juan Center on the following frequencies: 119.9 - A20 (north) clockwise thru A21-23. 125.0 - East of A21-23 clockwise to north of B20. 125.3 - B20 clockwise thru A20 (south)/UG-9. 134.3 - West of A20 (south)/UG-9 clockwise thru B14.

TABLE 3. COM STATIONS--CAR AERONAUTICAL MOBILE COMMUNICATION SERVICES

COM Stations No.	ID - Name	VHF Frequencies	HF Frequencies	HF Coverage
5	San Juan (ARINC)	130.4	2952 5484 6540 8959 11367 17925# SELCAL	E - CAR
15-1	New York (ARINC)	129.4[1 + 2]	5568 8840 10017 13320 17925# SELCAL	W - CAR
15-2	New York (ARINC)	130.85	2952 5484 6540 8959 11367 17925# SELCAL	E - CAR
2	Merida Radio	123.0 126.9 127.3	(Day-5568 10017) (Night-2966)	W - CAR
4	Miami Radio	118.4 126.7 126.9 127.9		
8	Bermuda Radio	129.9		
9-1	Piarco Radio*		2952 5484 6540 8959 11367 17925	E - CAR
9-2	Piarco Radio*		8847 11327 17925	NE - SAM
10	Maiquetia Radio	126.9	2952 5484 6540 8959 11343 13320 SELCAL	E - CAR
12	Barranquilla Radio	126.7[3 +4] 128.6	2952 6540 8959	E - CAR
13	Nassau Radio	124.2 126.9	2952 5484 6540 8959	E - CAR
15	New York Radio	126.7		
16	San Andres Radio	126.7	6540 8959 10017	E - CAR W - CAR
17	Boyeros Radio	126.9	5484 (Day-6540 + 8959) (Night-2952)	E - CAR
18	Port-Au-Prince Radio	124.5[1] 126.9	6540 8959 (Night-2952)	E - CAR
19	Caucedo Radio (Santo Domingo)	124.3 126.9	2952 6540 8959	E - CAR
20	Guadeloupe Radio	128.4		

1 = Extended range (ER) VHF
2 = High altitude
3 = (Night 128.4)
4 = FIR

= SSB available to all frequencies listed
* = International Aeradio Limited
(ARINC) = Aeronautical Radio Inc. -Paid service

Fourth, except for the mid-Atlantic Ocean area of the Piarco FIR, complete VHF coverage of the CAR upper airspace appears possible. Currently, VHF services are provided by the various ATS units and COM stations in practically all areas of the CAR with gaps in the VHF coverage filled by HF. The theoretical coverage at FL300 obtainable by locating 200 nmi range VHF transmitters and receivers at continental and island sites is shown in Figure 8; the coverage shown does not account for possible terrain constraints that would restrict siting. Assuming that a sufficient number of usable sites actually are available, only two gaps in standard VHF coverage appear: one in the mid-Gulf of Mexico and one between Jamaica and South America. However, both gaps could be covered by ERVHF.

3.2.2 Aeronautical Fixed Communications

ATS units, COM stations, aircraft operations offices and supporting units communicate with each other by means of the specially provided aeronautical fixed communications networks. The networks include landlines and marine cables, HF and VHF 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, telephone and telegraph (PTT) services. The fixed communications system includes the AFTN, ATS direct speech circuits and miscellaneous circuits used as circumstances warrant for interfacility computer data exchange, meteorological data distribution and the like.

The AFTN distributes teletype messages between facilities. As described in ICAO (ref. 5) and shown in Figure 9, the CAR facilities are linked through a switching center in Kansas City, U.S.. AFTN messages sent from and received at teletype terminals located in each facility pass through the switching center and outlets at U.S. terminals; for example Miami and San Juan are collector and distributor points for other CAR sites. The CAR AFTN links mainly are leased PTT landlines and marine cables supported by radio circuits.

ATS personnel report that teletype messages involving CAR operations are subject to delay and sometimes are not delivered. The disruptions could be due to the long distance, multiple switching routings, and potentially unreliable local PTT service in various areas. Also, data processing mechanisms at some locations may not be fully developed in terms of terminal equipment modernization, personnel training and experience, and maintenance practices.

The ATS direct speech interphone circuits provide for voice communication between the ATS, COM and associated operating units. The basic ATS direct speech circuits in the CAR as described by ICAO (ref. 5) are shown in Figure 10. The circuits generally are leased landlines and marine cables, but a SSB HF radiotelephony link connects the Merida and Habana ACCs. This HF link is described by Merida ACC personnel as

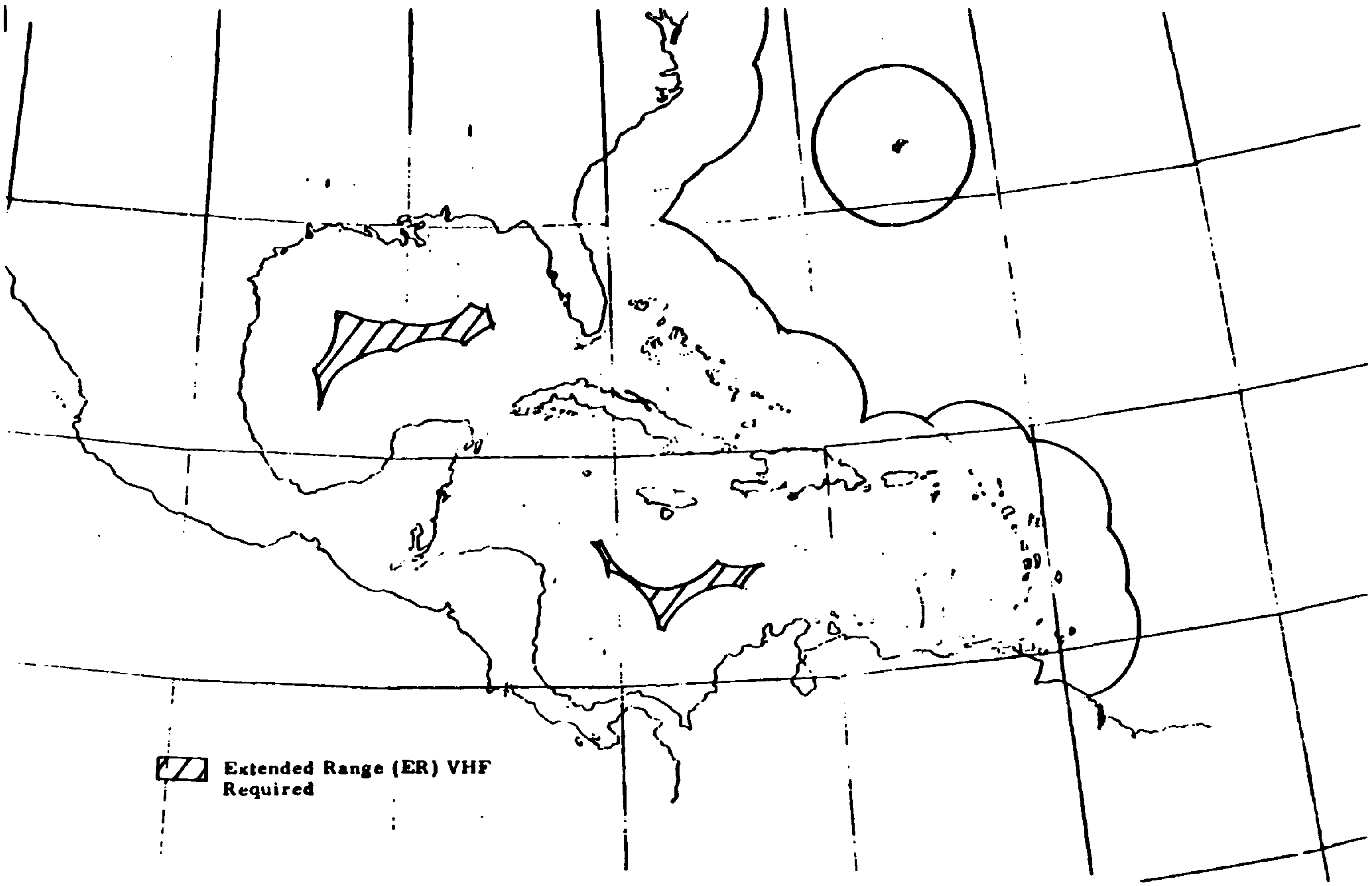
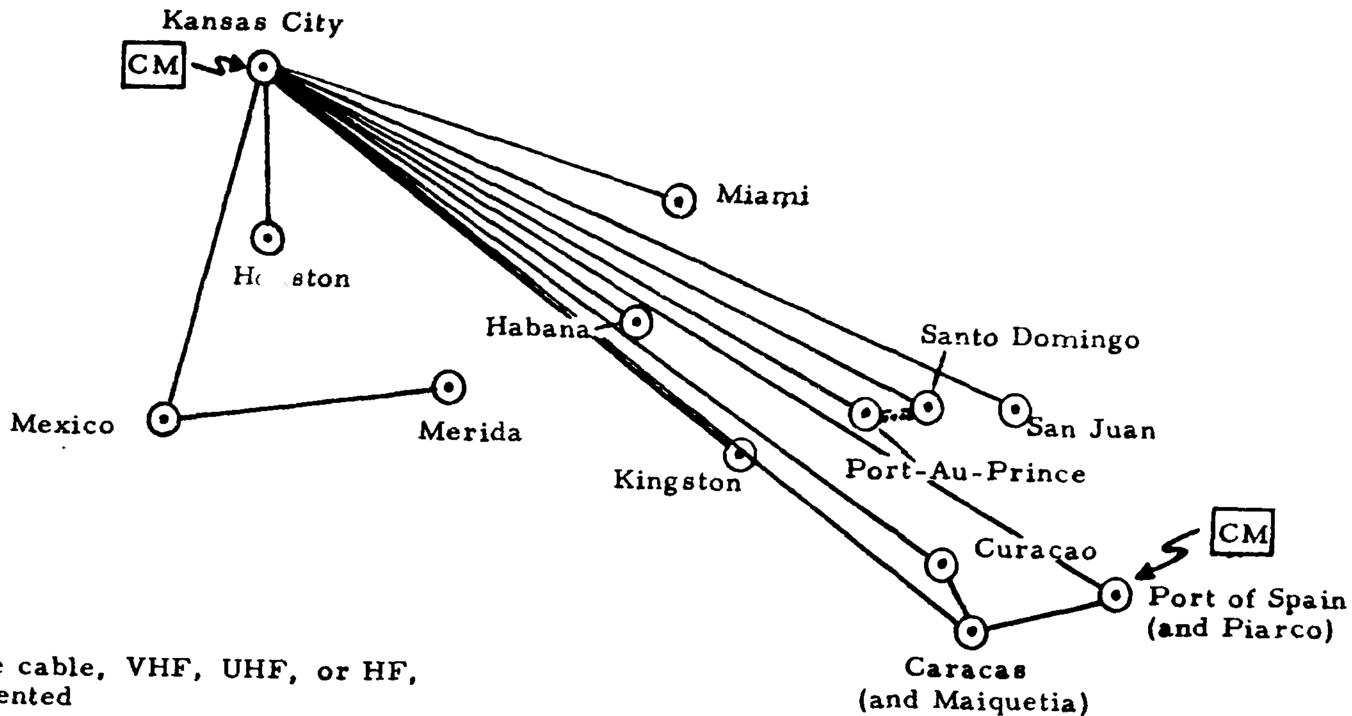


FIGURE 8. CAR VHF THEORETICAL COVERAGE AT FL300

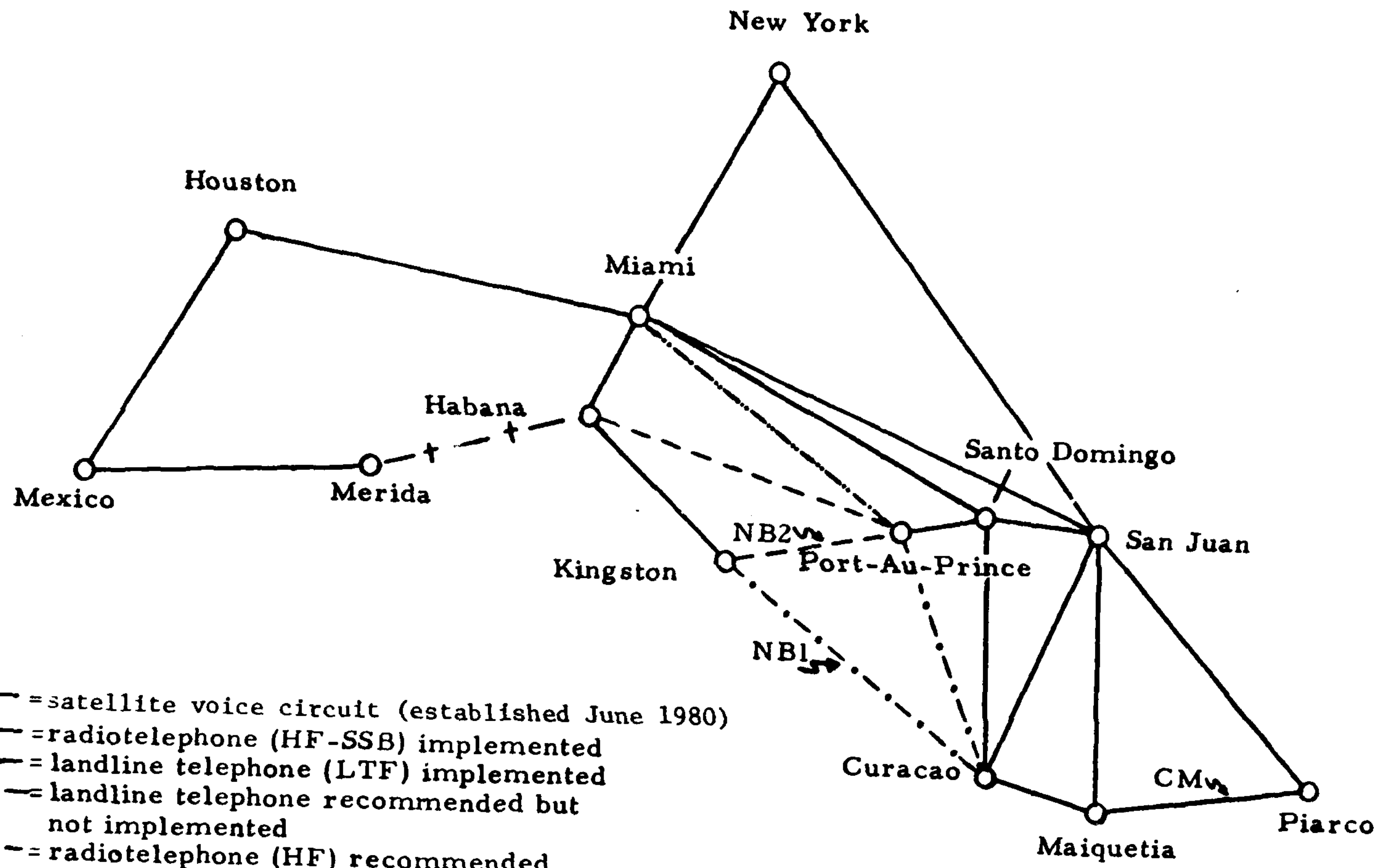


—— = landline cable, VHF, UHF, or HF, implemented
– – = landline cable r . mmended but not implemented
••••• = radioteletypewriter (HF)
CM = multipoint circuit

Source: Ref. 5

FIGURE 9. CAR BASIC AFTN CIRCUITS

Note: San Juan and Santa Monica are linked via voice circuit switching at New York



—·— = satellite voice circuit (established June 1980)
—+— = radiotelephone (HF-SSB) implemented
——— = landline telephone (LTF) implemented
– – – = landline telephone recommended but not implemented
·–·– = radiotelephone (HF) recommended but not implemented
NB1 = network between: Baranquilla-Curacao-and Kingston
NB2 = network between: through a Kingston-Miami voice circuit
CM = a multipoint circuit including: Georgetown, Maiquetia, Piarco, Rochambeau, and Zanderij

Source: Ref. 5

FIGURE 10. CAR BASIC ATS DIRECT SPEECH CIRCUITS

unreadable during certain times of the day (ref.10). Message connection reliability is compromised by technical characteristics in certain links such as one where a single-ring signal (as at the Maiquetia ACC, reportedly) decreases the likelihood of being heard and answered or where noise is a problem (as observed on the ATS circuit between the Houston and Merida ACCs).

In most cases ATS interphone links directly connect adjacent ATS units. However, only indirect voice interphone communications are available between the Houston and Merida ACCs and between the Houston and Habana ACCs. In these two cases, the Houston ACC controller must call a flight data position in the Mexico City ACC or a specific sector in the Miami Center for a line switch to the Merida or Habana ACCs, respectively, in order to conduct voice coordination with the two ACCs. The Houston to Habana interphone situation is further complicated because the line is shared by Miami, Habana, and Houston ACCs and MacDill Airways. This party line reportedly is subject to congestion and delay when more than one sector wish to use the circuit. The Port-au-Prince FIC has ATS direct speech circuits with the Santo Domingo ACC and the Miami ACC (as of June 1980); and the Kingston ACC is not linked directly with the adjacent Curacao ACC. As indicated in Figure 10, completion of the ATS direct circuit network is recommended by the ICAO plan.

In addition to the AFTN and ATS direct speech circuits, an FAA computerized flight data processing system distributes flight information between U.S. domestic ATS units including the Miami and Houston ACCs.

3.3 Navigation Systems

Short-range radionavigation aids--NDBs and VOR/DMEs--provide navigation service along most routes in the CAR. Some routes such as the trans-Atlantic random tracks through the FIR portion of the Piarco area require a long-range navigation capability as provided by such means as INS or OMEGA.

3.3.1 Short-Range Navigation

The NDBs provide a ground-reference navigation service of longer range but less precision than the VOR/DME system and 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.

The en route VOR/DME radionavigation aids typically have an effective range of approximately 200 nmi at FL300 based on VHF line-of-site and transmission power limitations. Because the aids are the basis for most domestic systems of airways, virtually all aircraft flying oceanic routes are equipped with VOR/DME avionics units.

CAR radionavigation aid ground sites are shown in Figure 11 and are identified in Table 4. The range and current location of each of the VOR/DMEs is such that VOR service is not continuous throughout the CAR, and NDB/ADF navigation often is necessary. The theoretical coverage potential of the current VOR ground sites is illustrated in Figure 12 which assumes that the VOR sites shown previously in Figure 11 are en route aids, each with a 200 nmi range at FL300; the coverage does not account for possible terrain obstructions or the possibility that some of the VORs may be terminal aids of restricted range. Figure 12 indicates that gaps in the current theoretical coverage exist in the Gulf of Mexico and in the airspace south of Cuba and Haiti. Note that the VHF coverage exclusive of ERVHF capabilities previously shown in Figure 8 is indicative of the theoretical coverage potential of an expanded VOR network (i.e., one with more sites than the current system) since both are limited by VHF transmission range. Figure 8 indicates that the expanded VOR system would have coverage gaps similar to but smaller than the current network.

3.3.2 Long-Range Navigation

Aircraft flying outside the range of the short-range radionavigation aids generally use INS or OMEGA navigation systems. However, aircraft may use the long-range navigation technique of their selection including doppler and celestial navigation.

3.4 Surveillance System

Radar surveillance may be provided only where suitable land sites exist for system location. The systems typically used for ATC surveillance include primary radar--which tracks aircraft skin reflections ("skin paint") of the radar signal--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. The effective coverage area on an en route radar normally extends 200 nmi at FL300 around the land-based sites.

Figure 13 shows the coverage of the known and planned operational en route radar sites in the CAR. These sites are located along the coastal U.S. and near Merida, Mexico City and San Juan. SSR service is being planned in the corridor between Miami and Puerto Rico. Two installations are under consideration: one on Grand Turk Island and one on another site to be determined. An additional radar site is proposed by S.E.N.A.A.M. for establishment between Merida and Mexico City (ref. 10). An experimental secondary radar with a range of 200 nmi at FL400 is operated by the Maiquetia ACC (ref. 12). Short range terminal radar systems that may exist in the CAR are not included in Figure 13.

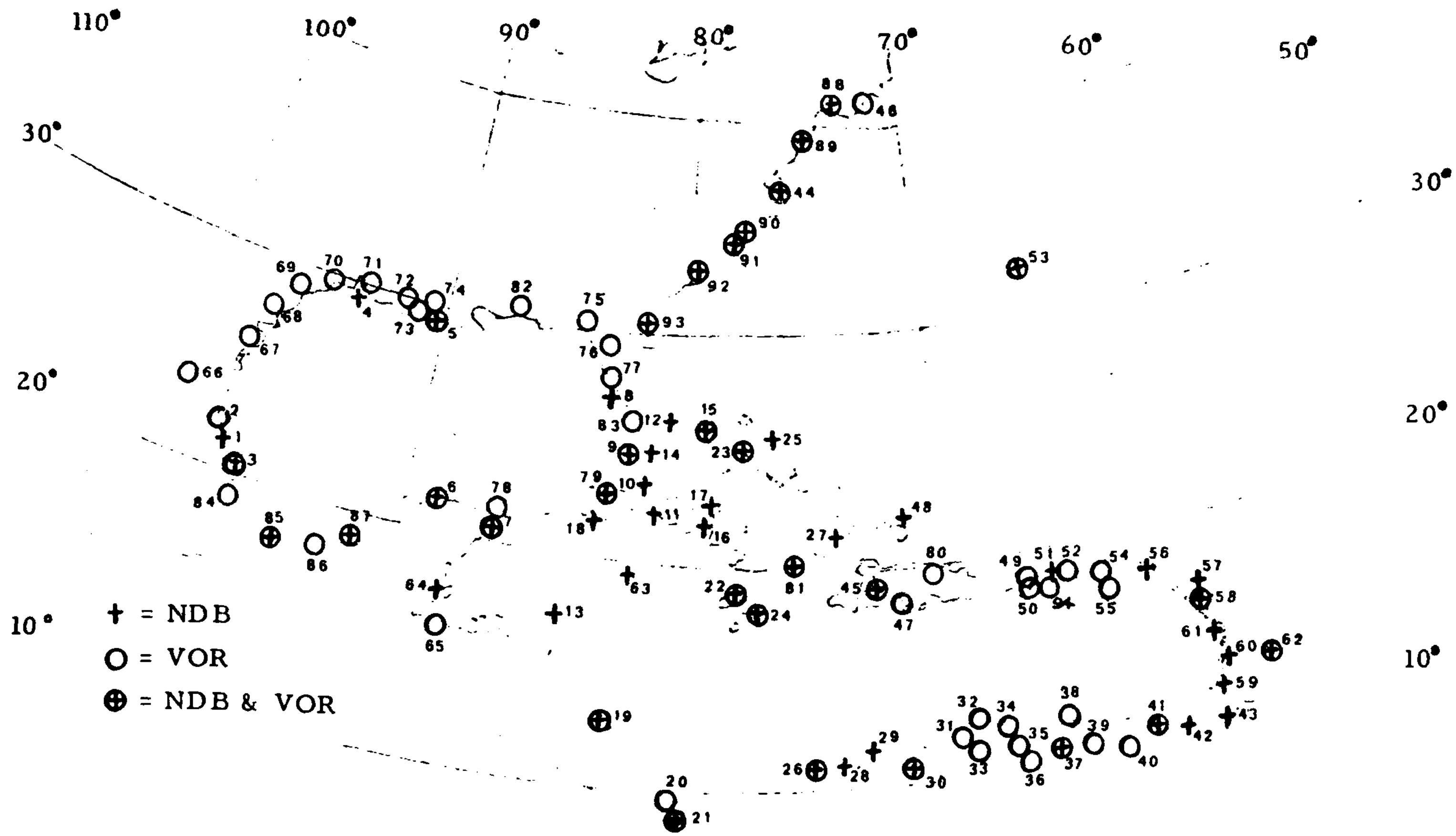


FIGURE 11. CURRENT RADIONAVIGATION AID GROUND SITES

Table 4

CURRENT RADIONAVIGATION AID GROUND SITES

				NDB		FREQUENCY		VOR	
	NDB	VOR	LOCATION	LATITUDE	LONGITUDE	NDB	VOR	LATITUDE	LONGITUDE
1	TUX		TUXPAN	N20 56.9	W097 23.2	262.5			
2		TAM	TAMPICO				117.5	N22 17.0	W097 51.0
3	NAU	NAU	NAUTLA	N20 12.5	W096 45.9	392	112.3	N20 11.9	W096 44.9
4	GLS		GALVESTON	N29 20.0	W094 45.4	206			
5	GNI	LEV	GRAND ISLE- LEEVILLE	N29 11.5	W090 04.5	236	113.5	N29 10.5	W090 06.2
6	MID	MID	MERIDA	N20 55.8	W089 41.0	280	117.7	N20 56.4	W089 39.3
7	CZM	CZM	COZUMEL	N20 29.3	W086 57.0	201	112.6	N20 29.0	W086 57.0
8	H		EGMONT KEY	N27 36.0	W082 45.7	310			
9	FIS	EYW	FISH HOOK- KEY WEST	N24 32.9	W081 47.2	332	113.5	N24 35.1	W081 48.0
10	UVR		VARDER	N23 05.4	W081 22.0	272			
11	UGN		GIRON	N22 04.4	W081 02.2	230			
12	MF		ORTAN	N25 47.8	W080 23.1	365			
13	SWA		ISLAS DEL CISNE	N17 25.0	W083 56.0	407			
14	MTH		MARATHON	N24 42.7	W081 05.7	260			
15	ZBB	ZBV	BIMINI	N25 42.5	W079 16.6	396	116.7	N25 42.3	W079 17.7
16	USR		SIMONES	N21 44.8	W078 48.7	315			
17	UPA		ALEGRE	N22 22.4	W078 46.4	382			
18	UNG		GERONA	N21 45.2	W082 52.9	412			
19	SPP	SPP	SAN ANDRES	N12 35.0	W081 42.0	387	113.3	N12 35.1	W081 42.3
20		FTD	FRANCE				109.0	N09 21.7	W079 52.0
21	TBG	TBG	TABOGA ISLAND	N08 47.2	W079 33.7	311	110.0	N08 47.4	W079 33.9
22	6YM	6YS	MONTEGO BAY	N18 30.1	W077 55.2	248	115.7	*N18 30.0	W077 55.0
23	ZQA	ZQA	NASSAU	N25 02.4	W077 28.2	251	112.7	N25 01.7	W077 27.0
24	6YK	6YC	KINGSTON	N17 57.8	W076 52.6	360	115.9	*N18 00.0	W076 55.0
25	ELJ		ELEUTHERA	N25 15.9	W076 19.0	224			
26	BAQ	BAQ	BARRANQUILLA	N10 47.6	W074 51.9	244	113.7	N10 47.8	W074 51.7
27	ZIN		GREAT INAGUA	N20 57.6	W073 40.7	376			
28	SMR		SANTA MARTA	N11 01.0	W074 16.0	287			
29	RHC		RIOHACHA	N11 31.0	W072 55.0	295			
30	MAR	MAR	MARACAIBO	N10 34.4	W071 42.0	267.5	115.7	N10 35.1	W071 42.8
31		PRG	PARAGUANA				113.6*	N11 46.0	W070 10.0
32		PJH	ARUBA				112.5	N12 30.5	W069 56.5
33		CRO	CORO				117.3	N11 24.9	W069 41.6
34		PJG	CURACAO				116.7	N12 12.0	W069 00.6
35		PS	PUNTA SAN JUAN				112.9	N11 10.2	W068 24.9
36		PBL	PUERTO CABELLO				117.7	N10 29.2	W068 04.6
37	MIQ	MI	MAIQUETIA	N10 36.5	W066 59.0	292	114.8	N10 36.8	W066 59.3
38		LRS	GRAN ROQUE				113.1	N11 57.1	W066 40.2
39		CBC	CABO CODERA				113.5	N10 34.6	W066 02.9
40		BC	BARCELONA				115.9	N10 08.0	W064 42.5
41	MTA	MTA	MARGARITA	N10 55.3	W063 57.4	206	114.1	N10 55.4	W063 57.7
42	CUP		CARUPANO	N10 39.6	W063 15.6	278			
43	POS		PIARCO	N10 35.5	W061 25.4	382			
44	EKV	ECG	WEEKSVILLE- ELIZABETH CITY	N36 13.8	W076 07.5	254	112.5	N36 15.4	W076 10.6
45	HHP	PAP	PORT AU PRINCE	N18 34.6	W072 19.9	270	115.3	N18 35.0	W072 18.0
46		HTO	HAMPTON				113.6	N40 55.1	W072 19.0
47		CRO	CABO ROJO				114.3	N17 55.9	W071 39.0
48	GT		GRAND TURK	N21 26.0	W071 08.7	232			
49		BQN	BORINQUEN				113.5	N18 30.0	W067 06.5
50		MAZ	MAYAGUEZ				110.6	N18 15.5	W067 09.1
51	DDP		DORADO	N18 28.2	W066 24.8	391			
52		SJU	SAN JUAN				114.0	N18 26.9	W065 59.4
53	NWU	KBV	BERMUDA	N32 16.0	W064 52.0	375	113.9	N32 21.8	W064 41.7
54		STT	ST. THOMAS				108.6	N18 21.5	W065 01.5
55		COY	ST. CROIX				108.2	N17 44.2	W064 42.1
56	PJM		ST. MAARTEN	N18 02.2	W063 07.1	308			
57	ZDX		COOLIDGE	N17 09.0	W061 47.0	369			
58	FXG	PPR	POINTE A PITRE	N16 15.7	W061 31.7	300	115.1	N16 16.1	W061 31.4
59	ZGT		PEARLS	N12 09.0	W061 36.0	362			
60	SV		ST. VINCENT	N13 08.0	W061 12.0	403+			
61	FXF		FORT DE FRANCE	N14 36.0	W061 05.7	314			
62	8PV	8PV	ADAMS	N13 04.1	W059 29.5	345	112.7	N13 04.4	W059 29.1
63	ZIY		GRAND CAYMAN	N19 17.2	W081 23.2	344			
64	ZDZ		BELIZE	*N17 32.0	W088 18.0	392			
65		LMS	LA MESA				113.1	*N15 20.0	W088 00.0

Table 4 (Concluded)

66		CVM	CIUDAD VICTORIA				113.7	N23 42.8	W098 58.1
67		MAM	MATAMOROS				114.3	N25 46.0	W097 32.0
68		CRP	CORPUS CHRISTI				115.5	N27 54.2	W097 26.7
69		PSX	PALACIOS				117.3	N28 45.8	W096 18.4
70		HUB	HOBBY				117.6	N29 39.0	W095 16.7
71		BPT	BEAUMONT				114.5	*N29 55.0	W094 05.0
72		LFT	LAFAYETTE				110.8	*N30 05.0	W092 00.0
73		TBD	TIBBY				112.0	*N29 45.0	W090 50.0
74		MSY	NEW ORLEANS				113.2	N30 01.8	W093 10.3
75		TLH	TALLAHASSEE				117.5	N30 33.4	W084 22.4
76		CTY	CROSS CITY				112.0	N29 35.9	W083 02.9
77		PIE	ST. PETERSBURG				116.4	N27 54.4	W082 41.1
78		CUN	CANCUN				113.4	N21 01.0	W036 52.0
79	UHA	UHA	HAVANA	N22 58.3	W082 25.9	348	116.1	*N23 05.0	W082 20.0
80		PTA	PUERTO PLATA				115.1	N19 43.8	W070 38.6
81	NBW	NBW	GUANTANAMO BAY	*N19 57.0	W075 05.0	323	114.6	*N19 55.0	W075 10.0
82		NUN	SAUFLEY				108.8	*N30 30.0	W087 20.0
83		FMY	FT. MYERS				117.6	*N26 35.0	W081 55.0
84		VER	VERACRUZ				112.9	*N19 20.0	W096 40.0
85	MTT	MTT	MINATITLAN	*N17 59.0	W094 31.0	300	116.4	*N17 59.0	W094 31.0
86		VSA	VILLAHERMOSA				117.3	+N17 59.0	W092 55.0
87	CME	CME	CO. DEL CARMEN	*N18 38.0	W091 50.0	288	113.0	*N28 38.0	W091 50.0
88	GKQ	JFK	PROGRESS-KENNEDY	N40 40.9	W074 11.5	379	115.9	N40 38.0	W073 46.4
89	RNB	SIE	RAINBOW-SEA ISLE	N39 25.1	W075 08.1	363	114.8	N39 05.7	W074 48.0
90	HAH	HAH	HAW	N34 42.3	W077 35.7	198	116.0	N34 42.3	W077 35.7
91	CLB	ILM	CAROLINA BEACH-WILMINGTON	N34 06.4	W077 57.7	216	117.0	N34 21.1	W077 52.5
92	CH	CHS	ASHLEY-CHARLESTON	N32 58.6	W080 05.9	329	113.5	N32 53.6	W080 02.3
93	JA	JAX	DINNS-JACKSONVILLE	N30 27.9	W081 48.1	344	114.5	N30 27.0	W081 33.9
94		PSE					109.0		

*APPROXIMATION
+ON REQUEST

NOTE: ID NUMBERS CORRESPOND TO FIGURE .

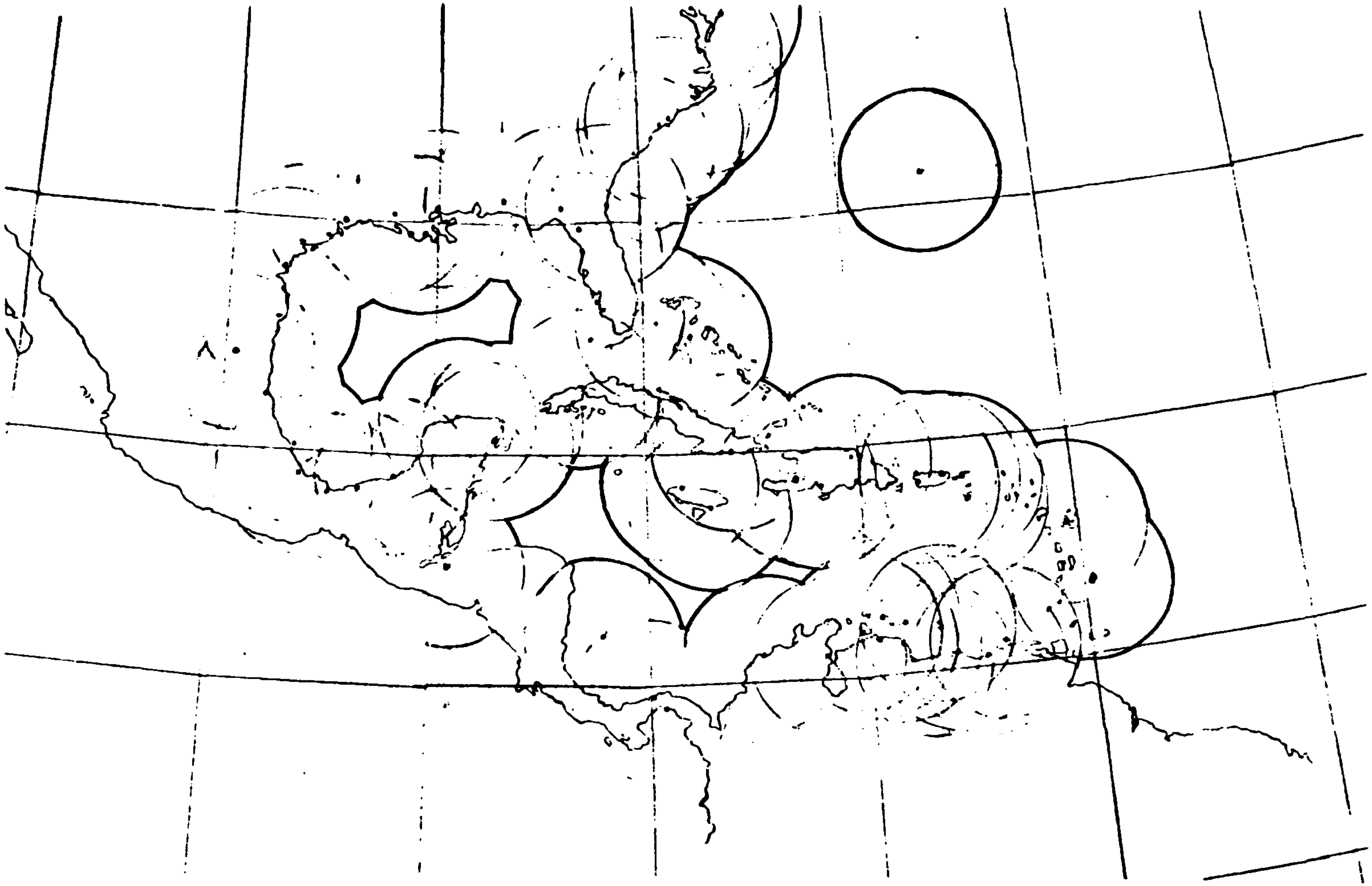


FIGURE 12. CAR CURRENT VOR THEORETICAL COVERAGE AT FL300

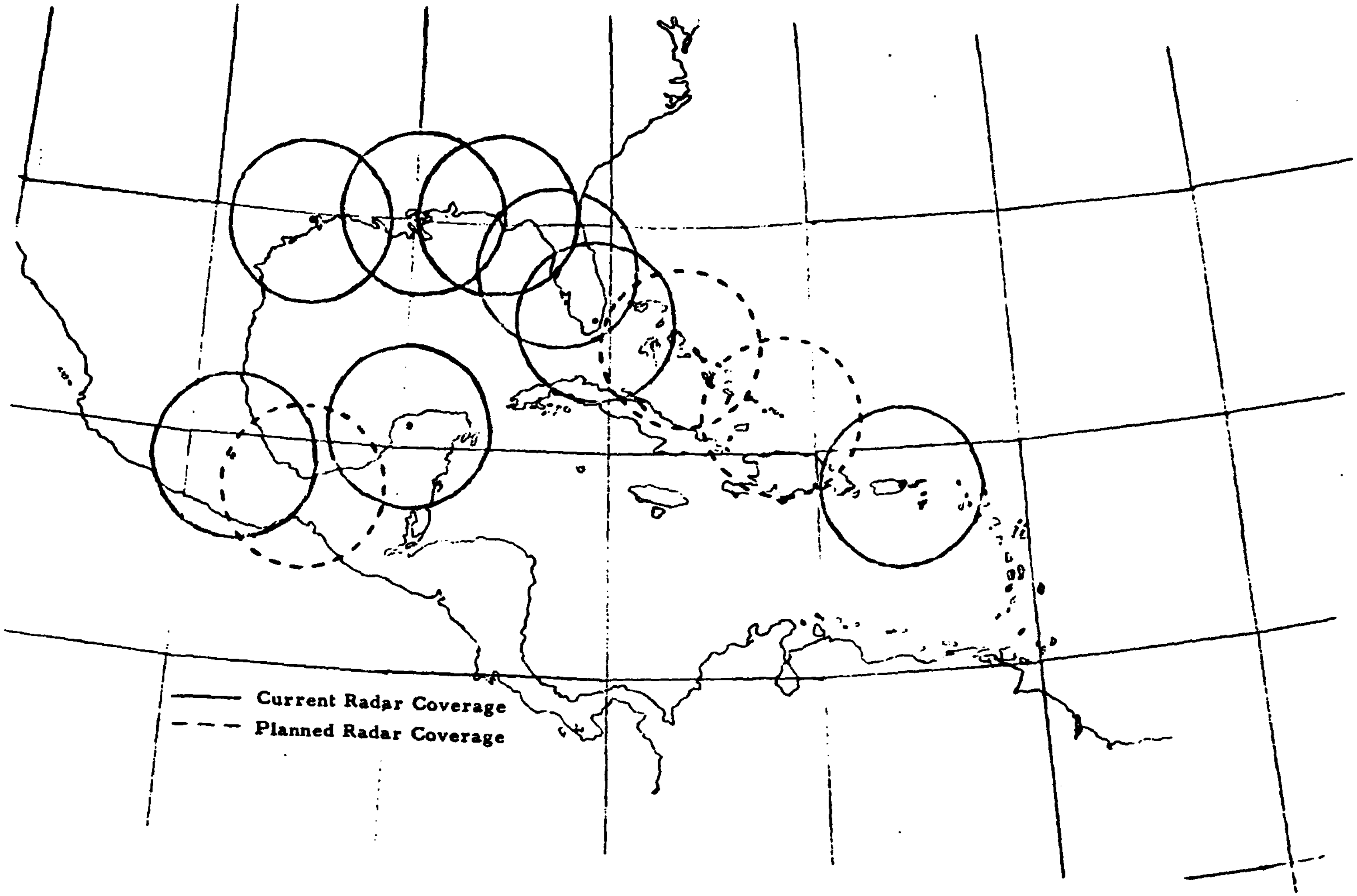


FIGURE 13. CAR EN ROUTE RADAR COVERAGE

The VHF theoretical coverage excluding ERVHF previously shown in Figure 8 also shows the theoretical limits of an expanded CAR radar network assuming ground sites are not obstructed by terrain. The gap in the Gulf of Mexico conceivably could be covered by radars on existing oil rigs although the technical, operational and economic feasibility of such a plan has not been determined.

4.0 SEPARATION MINIMA

4.1 CAR Separation Standards

The separation minima applied in the CAR 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 CAR 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 minima 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 (i.e., FL180, 190, 200...280) below FL290 and odd flight levels (i.e., FL290, FL310, 350, 370) above FL290; aircraft may step climb between such flight levels when cleared to do so. Standard hemispheric rules are usually applied except where special direction of flight assignments by altitude are defined for individual routes by local ATS authorities. The hemispheric rules reserve even flight levels below FL290 and higher flight levels at 4,000 ft increments at and above FL310 (e.g., 240, 260, 280, 310, 350, 390, etc.) for westbound flights; odd levels at and below FL290 and higher odd levels at 4,000 ft increments (e.g., 250, 270, 290, 330, 370, 410, etc.) are reserved for eastbound flights with no one-way routes.

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 airspace west of 55 degrees West longitude (which covers the majority of the CAR) and is 120 nmi in the airspace east of 55 degrees West longitude (which is part of the Piarco FIR). Lower minima may be applied when warranted by navigation and surveillance capabilities. Such reduced separations are determined by the appropriate regional ATS authority.

In airspace under the jurisdiction of the US FAA, the following reduced lateral separations are prescribed on flight checked routes in the vicinity of radionavigation aids such as NDBs and VORs, as follows (ref. 12):

(1) At or above FL240, the protected route airspace is reduced to 10 n.m. on both sides of the route centerline to a distance of 114.29 n.m. from the navigation aid, then increasing in width on a 5 degree angle from the route centerline, as measured from the navigation aid, to the maximum width of the prescribed oceanic lateral separation (i.e., 100 n.m.).

(2) Below FL240, the same rules apply except that the airspace width is 5 n.m. on both sides of the route centerline to a distance of 57.14 n.m. from the navaid, and then increasing at 5 degrees to the 100 n.m. oceanic route width.

The reduced lateral separation minima are particularly useful in the case of ATS routes converging at a single radionavigation aid. Aircraft on different converging routes may be at the same altitude while in a CTA/FIR, but without the above reduced separation rule would need to be altitude separated or time delayed in the vicinity of the radionavigation aid. The reduced separation rule enables each such aircraft to proceed at the same altitude until some other separation rule (i.e., radar separation) is effected.

The separation reductions apply only on the established routes and may not be used on other routes flown by aircraft equipped with self-contained airborne independent navigation systems (i.e., INS, Omega). Therefore, those aircraft (e.g., some military flights) that are flying random tracks are subject to more severe separation rules than are aircraft on the ATS route system. Commercial aircraft generally adhere to the established route structure, even though not required to do so, and thereby take advantage of the reduced separation service.

4.4 Longitudinal Separation

The general rules defined in ICAO Document 4444 (ref. 3) specify a 15 min longitudinal minimum between aircraft flying on the same or crossing tracks or a 10 min minimum if navigation aids permit frequent determination of position and speed. In practice, conditions enable the Miami and San Juan ACCs to apply the 15 min and 10 min separation minima as circumstances warrant, while the Merida ACC (ref. 10) and the Houston ACC apply the 15 min minimum without reduction to 10 min. The following paragraphs describe the longitudinal separation rules specified by the available documentation. Descriptions of the application of longitudinal separation minimum by each of the ACCs other than those of the US and Mexico has not been provided and are not specifically addressed.

ICAO Document 7030 (ref. 4) specifies a 15 min longitudinal separation between aircraft operating at the same flight level at or above FL200 and west of 55 degrees West within the Miami, Houston, and San Juan CTA/FIRs 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, or the aircraft have not reported over the same entry point but are established with proper time intervals on same or diverging oceanic courses under radar coverage.

The Mach number technique requires aircraft to adhere within a tolerance of 0.01 Mach to the Mach number approved by an ATC unit and to request ATC approval before making any change in speed (ref. 4).

The 15 min separation applied under the Mach number technique and track requirements stated above may be reduced to the following separations (ref. 4):

(1) 10 min 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.

(2) 5 min 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.

In practice, the 5 and 10 min Mach number reduced separation minima are applied in the CAR in the Miami (East CAR) and San Juan CTA/FIRs to traffic operating between the jurisdictions of the Miami, San Juan and New York ACCs. Coordination mechanisms and procedural agreements between these facilities have been established to manage the reduced separation operations, but no such agreements are established elsewhere in the CAR. For example, the Mach number 5 and 10 min reduced separations are not applied in the Gulf of Mexico where joint procedural agreements between the Houston, Merida, Habana and Miami ACCs have not been established for the use of such minima.

The US FAA procedures (ref. 12) specify 10 min separations between aircraft operating on same, converging or crossing routes between radionavigation aids. In the Miami (East CAR) and San Juan (CAR) CTA/FIRs, the 10 min longitudinal minima is applied between aircraft operating on the ATS routes in the area between Florida and Puerto Rico where NDBs and VORs are available. Note that aircraft on routes crossing this airspace (e.g., flights from South America to New York that intersect the east-west traffic between San Juan and Miami over Grand Turk) require the establishment of 15 min separations before departing the CAR (e.g., northbound aircraft separated by 10 min over Grand Turk must be separated by 15 min before entering the New York CTA/FIR). Also, the 15 min separation minimum is applied to southbound aircraft entering uncontrolled airspace of the Port-au-Prince FIR.

A 20 min separation minimum is specified between aircraft operating below FL200 West of 55 degrees W and between aircraft operating at all levels east of 55 degrees W within the Piarco FIR (ref. 4).

In regard to supersonic flight, a 10 min longitudinal separation is applied to aircraft in the CAR tracks provided that (ref. 4):

> both aircraft are in level flight at the same Mach number or the aircraft are of the same type and are both operating in cruise climb; and the aircraft concerned have reported over the same entry point into the oceanic controlled airspace with a time interval of at least 12 minutes confirmed by radar obsevation and follow the same or continuously diverging tracks until another form of separation is established.

The 10 min rule also applies to SST aircraft not reporting over the same entry point but that are established on oceanic courses under radar coverage with a proper time interval. Clearance to begin a deceleration/ descent phase of flight may be issued to an SST while the 10 min separation minimum is in effect.

5.0 ATS OPERATING 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, and reserve fuel requirements between origin and destination airports. Airlines normally use flight planning computer programs to evaluate the data compiled for an individual flight and determine the preferred tracks 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, including fuel, crew and maintenance costs. However, due to the overriding influence of fuel costs on direct operating costs, it is believed that 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.

5.2 Flight Plan Processing

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)

In the CAR, an aircraft operator submitting a flight plan before departure typically files the flight plan with the local ATS unit by teletype using the AFTN or by telephone. The flight plan often is filed several hours before estimated departure time (EDT) and is distributed to the appropriate CAR ATS units by AFTN as addressed by the aircraft operator or the local ATS unit. The AFTN may require considerable time to deliver long distance teletype messages through the Kansas City switching center, particularly those messages originating in or destined to South American, Central American or remote CAR sites. Flight plans generally are distributed as required to the appropriate ATS units for flights within the CAR, but, because of message delay, flight plans for flights originating in distant locations often are not distributed in a timely manner to ATS units along the route of flight. That is, aircraft may arrive in a CTA/UTA/FIR without being preceded by a AFTN delivery of the flight plan. As will be noted subsequently, operational procedures between adjacent oceanic ATS units normally call for the transmittal of flight plan data by ATS direct speech before aircraft cross airspace boundaries to prevent surprise intrusion.

A flight plan submitted during flight is filed with an ATS unit by A/G voice communications. Such a procedure may be conducted by an aircraft departing an uncontrolled area and entering a CTA. For example, an aircraft entering the Miami CTA/FIR from the Port-auPrince FIR may arrive at the CTA/FIR boundary before the Miami ACC has received an AFTN-forwarded flight plan and an in-flight filing may be appropriate. In 1979, an international notice to airmen (NOTAM) advised pilots to contact the Miami ACC at least ten minutes before entry or to contact an associated COM station if radio contact with the Miami ACC could not be established. Note that coordination capabilities between the Miami ACC and the Port-au-Prince FIC have been improved by the recent establishment of a voice communication link between these facilities.

5.3 Departure Operations

A local ATS unit issues departure clearances 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 aircraft accept the clearances with the understanding that the approved routings represent current plans, that subsequent clearance changes may be required, and that a clearance revision may be issued before entering the oceanic airspace. The clearances are read verbatim (or receive a "cleared as filed" message) to the pilot by a controller before takeoff. When an aircraft actually takes off, an ICAO departure message reporting the takeoff time normally is forwarded by AFTN to ATS units along the route of flight; departure messages are sent between the Miami and Houston ACC's by means of a computerized data processing system. ATS direct speech may be used to forward such messages between adjacent ATS units.

5.4 CAR Entry Operations

A departing flight proceeds along the domestic airways route in accordance with the departure clearance except in cases where circumstance--such as adverse weather, potential conflicts, traffic congestion, radionavigation aid outages, and the like--require revisions. Flights departing from airports in North America or South America may fly through considerable domestic airspace, passing through a series of en route domestic control sectors before entering the CAR. In some cases, domestic control sectors are distinctively separated from oceanic sectors. For example, certain oceanic control sectors of the Houston and San Juan ACC's have geographic areas of jurisdiction separate from their associated domestic sector counterparts.

On the other hand, aircraft that are departing airports in the CAR or its vicinity typically enter oceanic airspace soon after takeoff. In these cases, en route control sectors may not be designated according to strictly oceanic and domestic jurisdictions, but combinations of the two operations may occur. For example, an individual en route control sector at the Merida ACC has responsibility for both domestic and oceanic airspace.

The basic procedures for controlling aircraft entering oceanic airspace are essentially the same regardless of whether or not the oceanic sectors share domestic control responsibilities. The en route sector controllers assess the potential for conflict in oceanic airspace using flight progress strip data showing time estimates along projected oceanic route and altitude of flight. The flight strip data are based on the flight plans filed by the operator, normally at the departure airport, and subsequent updates. In the case of domestic-to-oceanic entry operations, the departure airport often would be one being served by the same ATS authority that is providing ATS at oceanic entry, and delays in delivery of flight plans by AFTN would not be a factor because long distance international message routing would not be involved.

The flight strips may be automatically generated by computer processing of the flight plan data or manually prepared. The Miami and Houston ACC's make use of a sophisticated nationwide domestic flight data processing system to distribute and print flight strips while the other ACC's make use of local data processing systems. Flight strips generally are printed and delivered to the en route sector positions on receipt of an airport departure message.

If a potential violation of oceanic separation minima is projected, the en route sector controller sometimes determines the clearance revisions necessary before the aircraft enters the oceanic airspace. For these cases, the clearance revision is issued while the aircraft is in direct VHF voice radio contact with a controller. The controller who is actually communicating with an aircraft is not necessarily controlling the oceanic airspace and may be manning either a strictly domestic en route sector or a combined domestic and oceanic en route sector; there also is the possibility that this controller may be manning a domestic terminal control sector if the aircraft is departing from an airport in the immediate vicinity of the oeanic airspace.

Regardless of who is communicating directly with the aircraft, clearance revision decisions are coordinated with the controller responsible for oceanic airspace. Consider, for example, the case of the Houston ACC where domestic en route sectors are adjacent to a single strictly oceanic en route sector which is not equipped with radar surveillance or VHF A/G radio facilities. The domestic radar sector controllers are in radar and direct A/G radio voice contact with flights approaching the oceanic CTA/FIR, and issue clearance revisions as necessary so that such flights are in conformance with the oceanic separation minima when entering the oceanic airspace. The controllers of these domestic transition sectors are familiar with the oceanic separation requirements and initiate the A/G radio control instructions required to resolve obvious potential violations of oceanic entry rules. These domestic controllers also coordinate by interphone with the oceanic sector controllers to receive and act on clearance instuctions from the oceanic sector controllers concerning the resolution of potential conflicts downstream in the CTA/FIR. Such a situation, for example, may involve aircraft on conflicting crossing routes in the area of the CTA/FIR for which the domestic controller has no data display and must receive guidance from the oceanic controller who has the oceanic flight strip data. The clearance revisions are designed to establish aircraft on potentially conflict-free flight paths through the CTA/FIR.

A combined domestic and oceanic en route sector operation is used at the Merida ACC where two such sectors exist. The domestic radar and VHF A/G radio coverage overlaps a portion of the Merida over-ocean airspace, and oceanic separation minima are applied because the domestic coverage does not extend completely over the CTA/FIR. The en route sector controller is in a position to assess domestic and oceanic potential conflict situations using radar and flight strip data, and issues clearance revisions to aircraft entering the oceanic airspace from domestic areas. Where necessary, conflict resolution instructions may be relayed to a terminal control sector or an adjacent en route ATS unit for transmittal to an aircraft.

The techniques used to resolve potential conflicts generally involve the application of:

(1) an altitude change.

(2) a time delay, normally less than 2 min.

(3) holding.

Controllers report that an altitude increase is effective in maintaining separation requirments through long oceanic flight, normally results in improved fuel efficiency, is simple to apply and therefore is the first preference. However, aircraft often are flying at their optimum fuel burn altitude for their weight and immediate altitude climbs may not be feasible; instead an altitude descent or time delay may be applied. A time delay, generally of less than a few minutes, can be achieved before oceanic entry by vectoring an aircraft under radar coverage or by issuing time restrictions to pilots such as "lose time to cross ARGUS intersection not before 2102 hours," and thereby allow the pilot a degree of discretion in accomplishing a time delay. Speed control may also be used as a means to achieve delay. Holding is considered to be a last resort if the other techniques are not feasible.

The application of a lateral diversion by placing an aircraft on a route parallel to an established oceanic ATS route generally is not used as means of resolving potential conflict because of the impracticality of navigating offset routes with NDB/ADF equipment. Even in the case of aircraft equipped with independent airborne navigation (i.e., INS, Omega), lateral diversions may not be effective because the capability to apply reduced separation minima would not be permitted where aircraft operate off the established flight-checked routes.

Operational procedures normally require aircraft to be established on a cruising flight level (rather than climbing or descending) before entering a control area from an adjacent area (ref 2). If an altitude (or track) revision is required, the ACC unit handling the clearance ensures that the change is accomplished within its area of jurisdiction or conducts the necessary coordination with the adjacent unit prior to issuing the clearance to the aircraft.

The nearness of international CTA boundaries to departure airports in the CAR may require special handling of aircraft that routinely would not reach cruising levels before the boundary crossing. For example, a heavily loaded southbound flight departing Miami and routed on a corridor (i.e., Giron or Maya) over Cuba may be vectored up to a cruising flight level while under domestic radar control by the Miami ACC. The Miami domestic radar controller must watch for northbound aircraft from Cuba which may conflict with the climbing southbound traffic. Each corridor is 10 nmi wide and radar vectoring within the corridor is not possible; therefore the Miami controller must establish altitude or longitudinal separation before releasing aircraft to the Habana ACC.

If no oceanic conflict is projected before entry, the clearance previously received by the aircraft (e.g., before takeoff or during domestic flight) remains in effect, and no action is required to confirm the route clearance to destination. Formal oceanic entry clearances are not required in the CAR. This procedure differs from that at certain ATS facilities serving the North Atlantic where oceanic clearances are routine (e.g., oceanic clearances are issued to each aircraft entering the organized track system between Europe and North America).

5.5 Oceanic Airspace Operations

The en route control procedures in the CAR area are based on pilot position reporting and flight strip data updating except in those parts of the Merida UTA/FIR, San Juan CTA/FIR and possibly the Maiquetia UTA/FIR that are under radar coverage. The 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 position and associated time estimate); (2) operational information (i.e., estimated time arrival, endurance); and (3) meteorological information (i.e., air temperature, wind, turbulence, aircraft icing, and supplementary information).

5.5.1 Air-Ground Communications Procedures

The pilot position reports may be transmitted directly to controllers or relayed to controllers through COM station radio operators. Based on an examination of navigation charts for the CAR (see Figure 7), the sector controllers without direct air-ground voice communications and requiring message relay appear to be those controlling the Houston CTA/FIR and the Miami (Gulf) CTA/FIR. The other ATS units appear to have direct air-ground voice communications capabilities in all or at least parts of their CTAs, UTAs and FIRs, and message relay is assumed to be used only as necessary.

The Houston and Miami (Gulf) ATS communications operations are supported primarily by the New York ARINC HF and VHF, Eastern Airlines TACS VHF and MacDill Airways Military COM stations. An aircraft departing domestic airspce may contact one of the COM stations by VHF or HF communications. Most aircraft equiped with HF radio contact New York ARINC; HF equipped Eastern airlines aircraft also may use New York ARINC even though the company's TACS VHF service is available. Because of the location of TACS VHF radio transceivers, consistent line-of-sight TACS communications service in the Houston CTA/FIR is available only above FL290, and lower level flights require HF service. However, at least one airline, including Texas International, does operate some aircraft equipped only with VHF radio; such aircraft routinely use TACS for A/G communication.

Communications between controllers and radio operators normally are conducted by means of ATS direct speech circuits. The AFTN may be used to send teletype confirmations of the voice transmissions.

Those ATS units in direct voice contact with aircraft operate VHF communications systems, although the Curacao ATS unit also operates an HF system. The ATS units employ remote transmitter/ receivers located at strategic sites. For example, the Miami and San Juan ACCs make use of VHF island ground sites along the traffic corridor between Miami and Puerto Rico to contact high altitude aircraft. However, parts of the lower airspace (e.g., the southeastern part of the Miami (East CAR) CTA/FIR near Haiti) are not within the VHF coverage range of these two ATS units, and message relay through a COM station (e.g., Eastern Airlines TACS) is required.

The use of alternative communications systems without formal networking (i.e., multiple distribution or exchanging) of messages between COM stations may cause missed reports especially when aircraft are crossing from one CTA/FIR to another and dual position reporting is required. For example, aircraft southbound on A7 (see Figure 3) to Merida are required to report crossing ALARD to the Houston and Merida ACCs. In practice, aircraft approaching Merida may be concerned with receiving descent clearances from ALARD to Merida (a relatively short distance) and first contact Merida. In some cases, the aircraft may neglect to also contact the Houston ACC's telecommunications service, and the final position report to Houston Center's Oceanic sector is missed because the Merida facilities are not required to transmit a copy of the position report to Houston. A missed report in this case would delay or complicate the coordination between Houston and Merida Centers regarding the flight status of the aircraft and may affect subsequent operations.

Separation service by ATS units is not required in the uncontrolled airspace of FIRs such as those under the jurisdiction of the Port-au-Prince FIC, Piarco ACC/FIC, and San Juan ACC east of 60 degrees West below FL 200. However, aircraft will receive traffic advisories by air-ground voice from the ATS units if such services are provided. Furthermore, aircraft in an FIR could broadcast their position by radio and maintain radio contact with other aircraft in their vicinity in order to enhance separation.

5.5.2 Separation Maintenance Procedures

As part of the separation maintenance responsibilities, the oceanic sector controllers respond to clearance or reclearance requests initiated by aircraft in their CTA/FIR. 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. Situations occasionally may arise where potential violations to separation minima require conflict resolution action by the oceanic sector controller. Differences between actual and forecast winds or in-flight flight plan filings may cause projected conflicts at oceanic entry points or at downstream points along the track. The options used by controllers to resolve the conflict may involve the application of:

(1) an altitude change.

(2) a time delay, normally less than 2 min.

These techniques are the same as those discussed above for the oceanic entry operations except that holding is not considered. As is the case of the entry operation, lateral deviations normally are not applied in the NDB/ADF navigational environment.

In control areas where radar coverage extends into over-ocean airspace, radar surveillance is maintained on the oceanic routes, and, as previously noted, is useful for establishing proper separations between aircraft entering the non-radar airspace. The Houston ACC's oceanic sector is equipped with a radar plan view display (PVD) that presents simulated oceanic aircraft positions and data blocks based on projections of the computerized flight plan data, but does not track aircraft in real time because aircraft in the Houston CTA/FIR are outside of the coverage range of the ground based radar. This PVD is not authorized for use for separation maintenance and surveillance purposes, but may be used by the oceanic controllers to visually maintain cognizance of the overall traffic situation in the CTA/FIR. Controllers are strictly instructed not to rely on the display to estimate aircraft positions and tracks and, as a result, some controllers tend to ignore the PVD.

Houston ACC personnel stated that the PVD simulation may not be technically workable at some other sites because of sizing difficulties in adapting the data display processing capabilities of the current computer system to larger or more complex oceanic areas. (Note, however, that the New York ACC currently is developing a simulated display covering part of its oceanic area.)

5.5.3 ATS Coordintion

A major concern in the CAR is the possible occurrence of a surprise intrusion into controlled airspace by an aircraft (i.e., a "pop-up"). A pop-up is an aircraft that arrives unexpectedly and may be or may be projected to be in violation of separation minima. A pop-up is recognized when the aircraft reports position or is observed on radar, and could require an immediate clearance revision. The pop-up problem largely is caused by the cumbersomeness of the flight data processing systems in use. Apart from the Miami and Houston ACC's which are part of a large-scale computerized ATC data processing network connecting the FAAs ATS units in the U.S., there are no such automated systems in the CAR dedicated to the distribution of flight data between ATS units. Recall that flight plans are submitted and entered into the AFTN several hours before aircraft departure and often are received by the ATS units before aircraft takeoff. Unfortunately, the time estimates and flight profile specified by the flight plan is subject to revision en route and, without timely updates, cannot be used as an absolutely accurate basis for determining an aircraft's entry time into a CTA/FIR and its flight level. Also a departure message sent by AFTN is in danger of arriving at an ATS unit after the aircraft enters the unit's airspace, in which case the unit would not have planned a specific conflict-free flight path for that aircraft.

The procedure currently used to prevent pop-ups is to forward flight data by means of voice coordination between adjacent ATS units using the ATS direct speech circuits. The information transmitted includes flight plan data (e.g., flight identity, aircraft type, avionics equippage, route, flight level, speed), position reports, time estimates, restrictions, and the like, and normally is sent at least 30 minutes before boundary crossing; departure messages would be sent at takeoff. The information is manually recorded by the receiving controllers, and is encoded into flight strips. For example, flight data sent by ATS direct speech from the Merida ACC to the Houston ACC is manually entered into Houston's computerized flight data processing system which prints a flight strip at the oceanic sector position.

The emphasis on ATS direct speech voice coordination does not mean that the AFTN circuits are not used. Flight plan and related data are forwarded by AFTN although ATS is used as a means to ensure that the data is properly distributed. The degree of reliance on AFTN or ATS direct speech circuits depends on local procedural preferences. In some cases, extensive voice coordination is not necessary. For example, flight plan data and departure message forwarding between the Miami and Houston ACCs and between the San Juan and the Miami and New York ACCs usually are accomplished without voice coordination. A departure message sent by AFTN from the Miami or New York ACC automatically activates flight strip printing at the San Juan ACC. However, an AFTN flight plan message for a Merida departure received by the Houston ACCs teletype office generally will not be delivered (i.e., hand carried) to the oceanic sector under the assumption that the flight plan has already been received by voice coordination; in fact, the aircraft may have already entered the Houston CTA/FIR.

Where ATS direct speech is the primary means of forwarding flight data, pop-ups may occur when a voice communication is not sent, not received or misunderstood. Such disruptions in coordination may be due to a temporary outage in an ATS direct speech circuit, poor voice quality in transmission, or a missed communication by a controller.

The geographic closeness of the heavily travelled Miami-San Juan routes to the uncontrolled airspace of the Port-au-Prince FIR provides little time on the part of the Miami ACC controllers for pre-planning clearances for the northbound traffic and requires special attention. Because of the possibility of pop-ups, the Miami ACC is concerned with protecting the busy routes. Even in the case of a northbound aircraft reporting to the Miami ACC before boundary crossing, the handling of northbound traffic intersecting or merging with busy routes is complex. Because of the difficulty in working crossing traffic during the periods of heavy traffic congestion, a northeast-bound flight (such as one from Kingston to Europe) might be cleared to a relatively low flight level (e.g., below FL310) until clear of the crossing routes in the Miami and San Juan CTA/FIRs.

In general, the number of different control jurisdictions and the proximity of routes to jurisdictional boundaries in the CAR often requires the establishment of special coordination procedures. Such procedures are designed to enable an ATS unit to be aware of aircraft in adjacent airspace that need to be separated from aircraft in its airspace. For example, with reference to Figure 4 aircraft on Route A9 through the Habana CTA/FIR may be in violation of separation minima with aircraft in the Merida UTA/FIR and corrective action would be required. Therefore, the Habana and Merida ACCs advise each other by voice coordination of proximate traffic even though an aircraft in question may never enter the other unit's airspace. Because Route A9 passes through the Houston CTA/FIR, the Houston ACC distributes flight plan data and time estimates for southbound aircraft to both the Habana and Merida ACCs. The Houston ACC will forward by voice a time estimate to the Merida ACC at the time a transfer of control message is forwarded to the Habana ACC (i.e., at least 30 minutes prior to boundary crossing).

Although ATS units exchange data for flights crossing their CTA/FIR boundaries, controllers normally do not formally transfer control (i.e., handoff) of aircraft from one unit to another unit; the Habana ACC is an exception. Except for the case of aircraft entering the Habana CTA/FIR, a controller normally does not negotiate and confirm the transfer of control jurisdiction for a specific aircraft to another unit. Control jurisdiction effectively is transferred when the pilot first reports at a position fix at the boundary or in a designated airspace and A/G radio communications is established with the ATS unit or its associated COM station.

Note that due to the language differences involved when coordinating across international boundaries, controllers are instructed to use only those phraseologies contained in pertinent handbooks and ICAO manuals when communicating on the interphone circuit. Non-standard phraseologies could easily lead to misinterpretation by either controller.

5.6 Oceanic Exit Operations

Aircraft departing CAR enroute airspace enter domestic radar or non-radar airspace. The domestic non-radar airspace may be operating under essentially the same procedures as those used in CAR airspace and no significant impact on flight operations may be noted. The domestic radar environment has less stringent separation requirments than those of the CAR airspace and more flexibility in flight maneuvering is afforded to aircraft. Also, the reduced lateral separation of the established NDB/ADF routes also simplifies the transition operation by obviating the need for applying altitude separation to inbound aircraft on some of the oceanic ATS routes merging in the domestic airspace.

6.0 ATS COSTS--PRELIMINARY ESTIMATES

A first-cut estimate of the annual cost of providing en route ATS services at the various ATS units is presented in Table 5. The annual operating and maintenance costs for the ATS units are based to the extent possible on estimates developed by a few of the CAR provider authorities and to a large extent on assumptions concerning the level of expenditures at sites where cost data were not made 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 $ 10.7 million is shown in Table 5 for the CAR. 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.

The Houston, Miami and San Juan ACC costs are based on informal preliminary expenditure estimates provided by the FAA and on assumptions concerning CAR cost allocation. The Port-au-Prince FIC cost is based on an estimate provided by the Republic of Haiti with an adjustment assumed for the en route allocation of expenditures. Limited cost data were available for the remaining ATS units, and the estimates shown in Table 5 for these facilities are very rough judgemental approximations.

Table 5

CAR ATS ANNUAL COST PRELIMINARY ESTIMATES

	Annual Cost (1979 US $ Thousand)
Curacao ACC	500
Habana ACC	500
Houston ACC	875
Kingston ACC	500
Maiquetia ACC	600
Merida ACC	875
Miami ACC	3,137
Piarco ACC/FIC	500
Port-au-Prince FIC	130
San Juan ACC	2,934
Santo Domingo ACC	130
Total	10,681

7.0 PRELIMINARY ANALYSIS OF AIR TRAFFIC FLOW AND ATS IMPROVEMENT POTENTIAL

7.1 General

The main issues concerning air traffic operations in the CAR are safety and efficiency. The safety issue arises out of the possibility of missed coordinations between ATS units and the associated aircraft pop-ups that may lead to potential violations of separation minima. The safety issue is a concern in an FIR where ATC service is not provided and in which case the violations would not be detected nor prevented. Similar instances of undetected potential conflicts may occur in controlled airspace if pilots do not follow ATS procedures, especially in regard to position reporting practices and adhering to clearances. The efficiency issue arises out of the need to divert or delay aircraft in order to resolve the potential conflicts. Such diversions or delays from the requested flight paths imply additional direct operating costs, especially fuel costs.

The degree of significance of both the safety issue--potential violations of separation minima--and the efficiency issue--additional direct operating costs--depends on the inherent likelihood that aircraft will conflict with each other in the CAR. That is, the frequency of occurrence of potential conflicts determines the level of exposure to unsafe situations and the severity of diversion and delay costs. Therefore, an analysis of potential conflicts is deemed important and is addressed in the remainder of this section.

The potential conflict analysis is restricted to the data available and consists of a preliminary assessment of the general air traffic flow patterns for scheduled CAR air traffic in the CAR upper airspace. This data was previously introduced in Section 2.0 of this report and is supported by the hourly departure schedules for the various origin and destination flows as described in Appendix C. This appendix also reviews analysis procedure used, analysis which was based on manual graphical replications of the schedule data. This analysis technique "eye balled" the geographic location of each scheduled flight during each hour of the July 1979 sample day and compared aircraft positions and separation minima to identify potential conflicts. The results of this rough, first-cut analysis approach are summarized in the following paragraphs.

7.2 Air Traffic Density

The general origin and destination flow patterns previously presented in Figure 2 include the basic CAR upper airspace traffic and peripheral flights that terminate in or pass through the CAR but spend much of their flight time in other regions. Figure 14 presents the basic

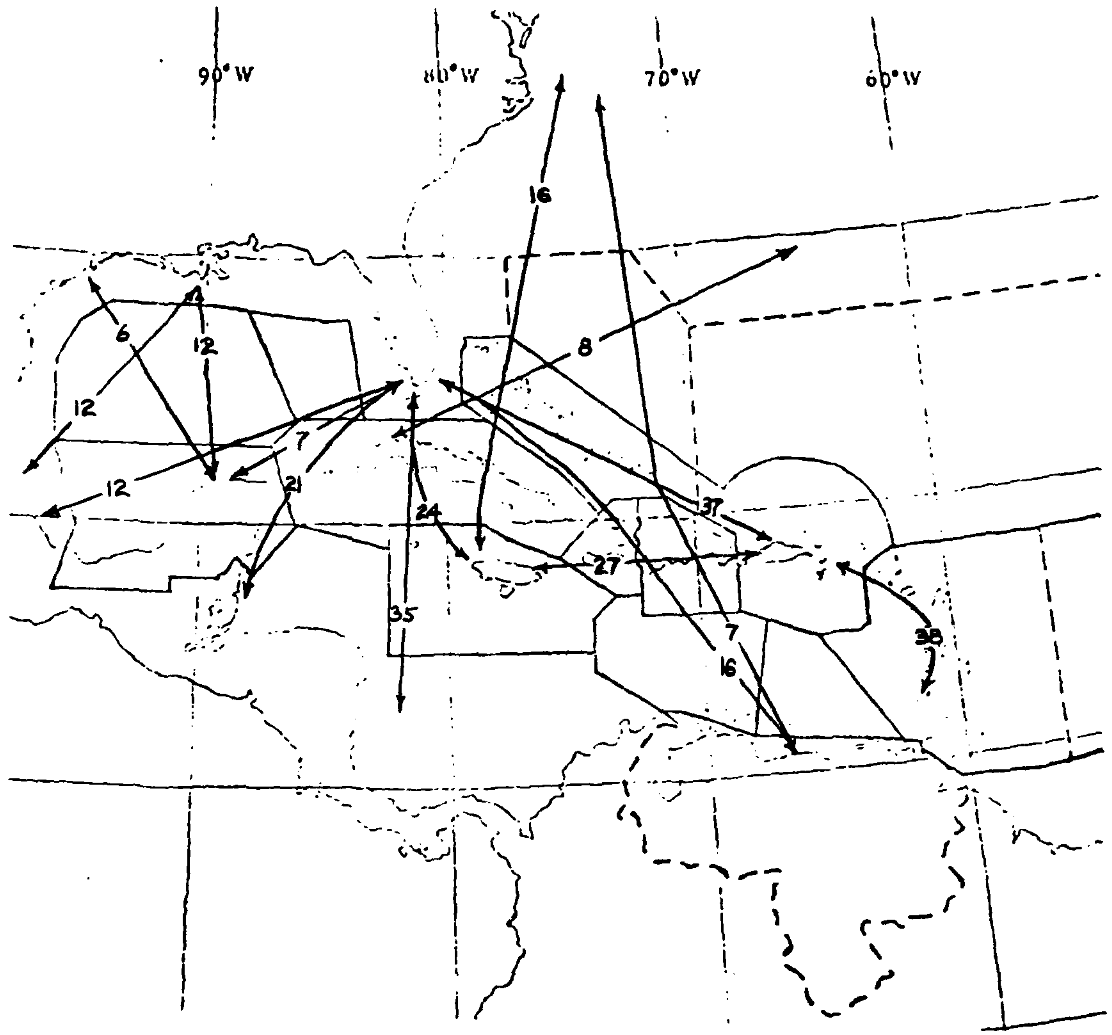


FIGURE 14. CAR BASIC DAILY SCHEDULED AIR CARRIER FLOW PATTERNS, JULY 1979

CAR upper airspace scheduled air traffic flow patterns as extracted from Figure 2. The basic CAR traffic includes those flights that are an integral part of the region's operations but excludes the flights to and from North America that terminate in the San Juan CTA/FIR (under radar coverage) and the South America-Europe flights on random tracks through the Piarco Atlantic Ocean FIR.

The daily number of scheduled flights passing through each airspace jurisdiction in accordance with the routings shown in Figure 14 are listed in Table 6. The busiest CTA/UTA/FIRs are the Habana, Kingston, San Juan (CAR) and Miami (East CAR) CTA/FIRs. However, the level of daily busyness is not necessarily an indicator of the frequency of potential conflicts because the traffic flows through each airspace may be geographically separated and spread over time. The east-west traffic does not necessarily cross the north-south traffic in each area and potential conflicts between these two flow patterns do not necessarily occur. The spread of traffic over time is reflected in the estimated maximum instantaneous aircraft count (IAC) data presented in Table 7 which shows that the highest IAC's occur in the Kingston CTA/FIR, Miami (East CAR) CTA/FIR, Merida UTA/FIR and Habana CTA/FIR during different hours of the sample day.

The maximum IAC for the entire CAR (excluding the peripheral NAT flights) shown in Table 7 is 49 scheduled aircraft. Discussions with ATS operations personnel and a review of analagous traffic flow through the NAT region indicates that the scheduled traffic may account for 75% of the total upper airspace CAR flights. Therefore, the maximum IAC expected in the CAR for the July 1979 sample day may be 65 aircraft with a maximum of about 20 aircraft in any one CTA/UTA/FIR.

7.3 Potential Conflicts

The impacts of the spatial and temporal distribution of traffic are shown in Table 8, which presents the estimated expected daily number of overtaking and crossing conflicts for the July 1979 sample day in the CAR upper airspace. The potential conflict estimates were produced by the first-cut graphical analysis which assumed that: aircraft follow the routes shown in Figure 14; all flights in an origin-destination flow are on a single track at a single altitude (actual route and altitude data are not available for each flight); and that each flight takes off during the hour of its scheduled departure time. The potential conflict estimates were identified by applying "back-of-the-envelope" mathematics to evaluate closure distances between plotted aircraft trajectories. The above assumptions tend to cause an overestimate of potential conflict occurrences because the dispersion of aircraft across alternative routes and altitudes is not considered. However, the overestimation is offset by the fact that non-scheduled flights (i.e., charter, general aviation and military) are not included in the graphical analysis and their inclusion would have increased the potential conflict estimates (data for individual non-scheduled flights are not available). The

Table 6

ESTIMATED DAILY SCHEDULED AIR TRAFFIC FLOW, JULY 1979, UPPER AIRSPACE

CTA/UTA/FIR/UIR	Daily Scheduled Air Traffic (flights/day)		
	East-West	North-South	Total
Houston CTA/FIR	12	30	42
Merida UTA/UIR	19	39	58
Miami (Gulf) CTA/FIR	12	--	12
Habana CTA/FIR	8	96	104
Port-au-Prince FIR	27	16	43
Santo Domingo CTA/FIR	27	23	50
Miami (East CAR) CTA/FIR*	61	23	84
Kingston CTA/FIR	27	75	102
San Juan (CAR) CTA/UTA/FIR*	64	38	102
Curacao CTA/FIR	--	23	23
Piarco UTA/FIR*	--	38	38
Maiquetai UTA/FIR	--	38	38

*Excludes Piarco Atlantic Ocean FIR, Miami NAT and San Juan NAT air traffic.

Table 7

MAXIMUM INSTANTANEOUS AIRCRAFT COUNT ON THE HOUR, UPPER AIRSPACE

CTA/UTA/FIR	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	Maximum
	Hour (GMT)																								
Houston	2													3	4	5	[7]	[7]	4	2	2	3	1	1	7
Merida	2	2										1	2	1	5	4	6	6	8	[15]	4	4	3	1	15
Miami-Gulf		1											1	1		2		2	2	1		1	2	1	2
Habana	4	3	1	4	1	1		1		1	1	3	4	4	4	7	[13]	8	11	11	12	9	11	6	13
Port-Au-Prince	1		2	2						1		1	1	2	2	4	5	[6]	4	5	4	1	3	1	6
Santo Domingo	1	2	3	2						1		1	2	3	3	6	8	8	5	10	[11]	7	5	4	11
Miami- East CAR	1	1	5	5	2	1						1	4	6	9	9	14	[15]	13	11	13	9	8	3	15
Kingston	6	3	2	3	4	2	1	1	1	2	4	3	4	5	5	6	11	7	13	13	[16]	9	12	4	16
San Juan- CAR	2	3	1	2		1			1	1		4	7	10	5	6	2	9	10	[11]	9	6	8	8	11
Curacao		1	2	2	1								1	1	1	3	[4]	2	2	3	[4]	3			4
Piarco UTA	2	2	3	3	1							1	6	7	3	1	1		1	4	2	3	[9]	5	9
Maiquetia		1	1	1	1								1	1	1	2	3	1	1	2	[4]	3			4
All FIR's*	14	11	12	13	8	3	1	1	2	3	4	8	18	23	29	36	39	43	43	[49]	41	33	35	22	49

*The data shown in this row excludes double-counting of aircraft that could have been in two (or more) CTA/UTA/FIR/UIRs, based on the graphical analysis assumptions.

Table 8

FIRST-CUT ESTIMATE OF DAILY NUMBER OF POTENTIAL CONFLICTS, JULY 1979 SCHEDULED AIR TRAFFIC, UPPER AIRSPACE, PRESENT ATS SYSTEM

CTA/UTA/FIR/UIR	Expected Number of Potential Conflicts Per Day Based on a 15/10 min Minimum†		
	Overtaking	Crossing	Total
Houston CTA/FIR	2.1	0.6	2.7
Merida UTA/UIR	1.6	2.0	3.6
Miami (Gulf) CTA/FIR	.1	-	.1
Habana CTA/FIR	8.7	2.3	11.0
Port-au-Prince FIR	.8	4.2	5.0
Santo Domingo CTA/FIR	1.1	2.3	3.4
Miami (East CAR) CTA/FIR*	8.3	5.2	13.5
Kingston CTA/FIR	3.2	-	3.2
San Juan (CAR) CTA/UTA/FIR*	7.7	-	7.7
Curacao CTA/FIR	.6	-	.6
Piarco UTA/FIR*	5.4	-	5.4
Maiquetia UTA/FIR	-	-	-
TOTAL	39.6	16.6	56.2

*Excludes Piarco Atlantic Ocean FIR, Miami NAT and San Juan NAT air traffic.

†Overtaking and crossing conflicts are based on a 15 min separation minimum except on the Miami-San Juan routes where a 10 min minimum is applied.

potential conflict data are "ballpark" estimates whose range of accuracy may be at least a factor of 2 above and below the values indicated in Table 8, but are useful as rough indicators of the level of air traffic interaction and interference.

The expected daily numbers of potential conflicts shown in Table 8 are based on a 15 min minimum separation requirement between aircraft except in the case of overtaking and crossing situations on the Miami-San Juan route airspace as 10 min separation minimum currently is applied. The longitudinal minimum is used in the analysis to represent longitudinal and lateral separation requirements because a 15 min spacing requirement corresponds to about 120 nmi at cruising speed and is critical relative to a 100 nmi spacing.

Table 8 shows that the highest expected number of potential conflicts occurs in the Miami (East CAR) CTA/FIR where the heavy east-west traffic experiences potential overtaking conflicts on the Miami-San Juan route and potential crossing conflicts with the north-south traffic. This east-west traffic also accounts for the high number of potential overtaking conflicts in the San Juan (CAR) CTA/FIR.

The Habana CTA/FIR is shown to have the second highest expected number of potential conflicts due mainly to the concentration of north-south traffic in two corridors through Cuba. This traffic experiences potential overtaking conflicts while in the Cuba corridors and potential crossing conflict with the east-west flights to and from Europe.

The combined airspace of the Port-au-Prince FIR and Santo Domingo CTA/FIR also has a moderately high potential conflict count due mostly to potential crossing conflicts. The east-west traffic between the Kingston and San Juan CTA/FIRs cross the north-south traffic passing through the Port-au-Prince and Santo Domingo areas.

The number of potential conflicts shown for the Piarco UTA/FIR may be higher than that actually experienced because the analysis assumed all flights are on a single route although a number of flights actually may be island-hopping on disperse routes that do not intersect.

A relatively few number of potential conflicts is estimated in the Merida UTA/FIR and Houston CTA/FIR even through several crossing situations exist in these areas. The light level of traffic on each of the crossing routes causes the modest potential conflict count estimate.

The lack of crossing situations and light traffic results in a very small to negligible expected number of potential conflicts in the Curacao CTA/FIR, Miami (Gulf) CTA/FIR and Maiquetia UTA/FIR.

7.4 Improvement Potentials

Reductions in the separation minima would reduce the estimated number of potential conflicts as shown in Tables 9 and 10 for a 10 min and 5 min separation requirement respectivly. The separation minima reductions could be predicated on improvements in communication, navigation and surveillance; and associated procedural rules range in content from rule changes (i.e., navigation precision requirements) to advanced technology applications including satellite based systems.

However, current improvement plans may circumvent in part the need for extensive applications of new technology improvements. Recall there is current planning to establish new secondary radar sites that would provide radar services in the upper airspace of the Miami-San Juan corridor in conjunction with the currently available pilot-controller VHF communications. This service would allow a substantial reduction in the horizontal separation minima (e.g., to 5 nmi) and effectively would reduce the expected frequency of potential conflicts and the severity of diversions and delays in the Miami (East CAR) and San Juan (CAR) CTA/FIRs. The planned US radars would alleviate 38 percent of the estimated potential conflicts shown in Table 8 for the CAR present ATS system under July 1979 traffic loadings.

Radar implementation in other CAR areas having pilot-controller VHF communications and radionavigation coverage would further moderate potential conflict situations. For example, radar service in the Habana CTA/FIR would alleviate 20 percent of the estimated number of present system potential conflicts in the CAR, while radar services in the Kingston CTA/FIR would alleviate 6 percent of the estimated potential conflicts in the CAR. The effectiveness of further expansion of radar services depends on the availability of VHF air-ground communications and ATC services which are prerequisites for the application of reduced separation minima. Radar services in the Port-au-Prince and Santo Domingo areas would alleviate an additional 15 percent of the estimated potential conflicts in the CAR, but would require the establishment of ATC units with VHF communications capabilities. Full radar coverage of the Gulf of Mexico (possibly from oil rigs in addition to the Merida CAR's current radar) would alleviate another 12 percent of the CARs potential conflicts in the Merida UTA/FIR and Houston and Miami (Gulf) CTA/FIRs. Such potential conflict reductions presume that compatible VHF coverage would be provided, either by ERVHF from continental transmitter and receiver sites or standard VHF from oil rig sites; ERVHF currently is provided in high altitudes by the New York ARINC COM station serving part of the Gulf of Mexico.

7.5 Improvement Impacts

The flight diversions and delays resulting from conflict resolution actions determine system operating efficiency. Under the non-radar ATC procedures that characterized much of present CAR operation, potential conflicts are resolved at or before the time aircraft enter a CTA/UTA/

Table 9

FIRST-CUT ESTIMATE OF DAILY NUMBER OF POTENTIAL CONFLICTS, JULY 1979 SCHEDULED AIR TRAFFIC, UPPER AIRSPACE, 10 MIN SEPARATION

CTA/UTA/FIR/UIR	Expected Number of Potential Conflicts Per Day Based on a 10 min Minimum		
	Overtaking	Crossing	Total
Houston CTA/FIR	1.5	0.2	1.7
Merida UTA/UIR	1.3	0.7	2.0
Miami (Gulf) CTA/FIR	.1	-	.1
Habana CTA/FIR	6.9	.9	7.8
Port-au-Prince FIR	.8	1.7	2.5
Santo Domingo CTA/FIR	1.1	.9	2.0
Miami (East CAR) CTA/FIR	8.3	5.2	13.5
Kingston CTA/FIR	2.5	-	2.5
San Juan (CAR) CTA/UTA/FIR	7.7	-	7.7
Curacao CTA/FIR	.3	-	.3
Piarco UTA/FIR*	4.0	-	4.0
Maiquetia UTA/FIR	-	-	-
TOTAL	34.5	9.6	44.1

*Excludes Piarco Atlantic Ocean FIR, Miami NAT and San Juan NAT air traffic.

Table 10

FIRST-CUT ESTIMATE OF DAILY NUMBER OF POTENTIAL CONFLICTS, JULY 1979 SCHEDULED AIR TRAFFIC, UPPER AIRSPACE, 5 MIN SEPARATION

CTA/UTA/FIR/UIR	Expected Number of Potential Conflicts Per Day Based on a 5 min Minimum		
	Overtaking	Crossing	Total
Houston CTA/FIR	.8	-	.8
Merida UTA/UIR	.8	.1	.9
Miami (Gulf) CTA/FIR	-	-	-
Habana CTA.FIR	3.8	.4	4.2
Port-au-Prince FIR	.5	.5	1.0
Santo Domingo CTA/FIR	.4	.2	.6
Miami (East CAR) CTA/FIR	4.6	1.3	5.9
Kingston CTA/FIR	1.6	-	1.6
San Juan (CAR) CTA/UTA/FIR	4.3	-	4.3
Curacao CTA/FIR	.3	-	.3
Piarco UTA/FIR*	2.3	-	2.3
Maiquetia UTA/FIR	-	-	-
TOTAL	19.4	2.5	21.9

*Excludes Piarco Atlantic Ocean FIR, Miami NAT and San Juan NAT air traffic.

FIR. The resolution action most often results in moving an aircraft to a secondary flight level which typically is 4,000 feet below its planned flight level because of hemispheric altitude assignments. The aircraft may be expected to be maintained at the diverted altitude for much of their flight through the CTA/UTA/FIR.

Radar operations employ less restrictive conflict resolution techniques than do non-radar operations and enable aircraft to be diverted temporarily until the potential conflict situation is passed. The duration of the radar-based diversions is, for practical purposes, very small in comparison to those experienced under non-radar procedures. For example, potential crossing conflicts may be resolved by vectoring aircraft or temporarily changing altitude in the vicinity of the conflict. Potential overtaking conflicts may be resolved in many cases by vectoring aircraft in order to obtain and maintain radar spacing. In certain situations an altitude change may need to be applied for the entire duration of the flight through a CTA/UTA/FIR/UIR, but such cases would be nearly eliminated by the low frequency of occurrence of potential conflicts in a radar environment at these traffic densities.

Rough approximations of the daily duration (aircraft-min) of conflict resolution diversions experienced under the various operating system alternatives are hypothesized in Table 11. The data in this table are developed under the assumptions that altitude diversion strategies rather than delay strategies are employed, that non-radar diversions (e.g., 4,000 ft altitude changes) remain in effect for the duration of the flight through the CTA/UTA/FIR/UIR in which the potential conflict is identified, and that the occurrence rate and duration of radar diversions are negligible relative to non-radar diversions. The CTA/UTA/FIR/UIR estimated flight times shown in Table 11 were obtained by graphical analysis of the scheduled traffic flow patterns, and the non-radar diversion duration entries are obtained by applying the estimated flight times to the corresponding potential conflict frequency data given in Tables 8, 9 and 10 for separation minima of 15/10, 10 and 5 min, respectively.

The daily diversion data shown in Table 11 are very rough estimates and great care should be taken in interpreting their absolute values. However the relative values of these data should be reasonably realistic descriptors of the real world situation. For example, the Miami (East CAR) and San Juan (CAR) CTA/FIRs jointly account for the sizable majority of diversion duration shown in the 15/10 min separation minima system. The remaining diversion duration is distributed among the other airspace areas in proportion to their respective expected potential conflict frequency and flight time. A moderate degree of diversion durations is shown for the Port-au-Prince FIR although such diversion durations are hypothetical because ATC service is not provided in this area. The Alternative (ALT) 1 shown in Table 11 represents the present system except for the above FIR operation.

Table 11

FIRST CUT ESTIMATE OF DAILY AIRCRAFT TIME SPENT IN DIVERSION, JULY 1979, UPPER AIRSPACE

		Daily Duration of Divergence (Aircraft-Min)					
CTA/UTA/FIR/UIR	Estimated Average Flight Time (Min)	Alt. 1: 15/10 min Separation	Alt. 2: 10 Min Separation	Alt. 3: 5 Min Separation	Alt. 4: Miami (E. CAR), San Juan (CAR) CTA/FIR Radar	Alt. 5: Alt. 4 plus Habana CTA/FIR Radar	Alt. 6: Alt. 5 plus Houston, Merida, Miami (Gulf) CTA/FIR Radar
Houston CTA/FIR	45	122	77	36	122	122	-
Merida UTA/UIR	30	108	60	27	108	108	-
Miami (Gulf) CTA/FIR	15	2	2	-	2	2	-
Habana CTA/FIR	30	330	234	126	330	-	-
Port-au-Prince FIR*	15	75*	38*	15*	75*	75*	75*
Santo Domingo CTA/FIR	30	102	60	18	102	102	102
Miami (East CAR) CTA/FIR†	60	810	810	354	-	-	-
Kingston CTA/FIR	30	96	75	48	96	96	96
San Juan (CAR) CTA/UTA/FIR†	30	231	231	129	-	-	-
Curacao CTA/FIR	30	18	9	9	18	18	18
Piarco UTA/FIR†	30	162	120	69	162	162	162
Maiquetia UTA/FIR	15	-	-	-	-	-	-
Total		2056	1716	831	1015	685	453
Diversion Duration Factor		1.0	.83	.40	.49	.33	.22

*The hypothetical divergence durations for the Port-au-Prince FIR assume provision of ATC service although ATC is not currently provided.

† Excludes Piarco Atlantic Ocean IFR, Miami NAT and San Juan NAT air traffic.

7.6 Improvement Implications

Table 11 indicates that the system improvements that are the basis for separation minima of 10 min and 5 min would reduce overall CAR diversion duration by 17 and 60 percent respectively (as shown by the Diversion Duration Factors in Table 10). Such improvements may include satellite or HF data link and voice communication, advanced navigation and airborne separation assurance device systems. However, expansion of radar services, especially by the planned radar implementations along the Miami-San Juan corridor, also could achieve gain. These sites would reduce diversion duration by 51 percent and, with the addition of radar services in the Habana CTA/FIR, would be the basis for a 77 percent reduction. Expansion of radar services in the Gulf of Mexico together with the above radar implementation would obtain a total CAR diversion duration reduction of 78 percent. The addition of radar services in the remaining areas would reduce diversion durations in proportion to their establishment assuming that the radar service implementation in each area is operationally, technologically, economically and institutionally feasible.

But, the practicality of expanding radar services in coordination with other ATS service improvements might be a question of concern in some areas of the CAR. The planned radar installations between Miami and San Juan would cover a gap between the existing radar service provided by a single ATS authority (i.e., the FAA) and should not be difficult to integrate with existing technical and operational facilities. Radar service implementations in other CAR areas may not be so readily accomplished, particularly if significant improvements to communications and navigation facilities are required. Radar service establishment would also be difficult where ATC service currently is not provided and where ATC facilities and expertise would need to be developed.

A sensitive area concerning improvement feasibility is the uncontrolled upper airspace of the Port-au-Prince FIR which is strategically located in the middle of the CAR. The above conflict and diversion analysis indicates that flights through this area are exposed to potential conflict situations. Therefore, ATS improvements aimed at reducing collision risk in this area would be desirable.

In regard to the Port-au-Prince FIR, there are no known current plans to establish a CTA in the upper airspace. Therefore, alleviation of the potential conflict situation in the Port-au-Prince FIR is not expected to occur unless special attention is given to this area. The Haiti ATS authority may establish en route ATC service in the future, but the fact that such plans do not exist indicate that extensive international coordination and support including funding may be necessary through ICAO. In lieu of CTA establishment, aircraft operators may wish to routinely follow precautionary collision avoidance procedures such as mutual self-announced, self-initiated VHF radio broadcast of position while flying through the FIR. The potential conflicts experienced in the Port-au-Prince FIR might be alleviated if some aircraft operators choose to divert their flight to the adjacent Santo Domingo CTA/FIR. The implementation of airborne separation assurance device systems would be one means of applying new technology to enhance the situation.

Another approach to providing ATC service in an uncontrolled FIR would be to assign responsibility for such service to another state. Apart from the international diplomatic complications of such an action, this approach leads to the more general question of ATS facility consolidation in the CAR. Given the restricted size of the current CTA/UTA/FIR/UIRs and their number, efficiencies might be gained by replacing the current ACCs and FICs by one or a few regional ACCs. For example, one may envision a single ACC which would provide ATS to the entire CAR or a network of two or three such units which could cover the Gulf of Mexico, Caribbean Ocean and Atlantic Ocean areas in the CAR. The arguments in favor of consolidation would be the possibility of reducing ATS provider costs because fewer facilities and operating personnel may be necessary; and a streamlined ATS provider oganization may better be able to coordinate system improvements including expanded radar service.

Consolidation would be subject to technical and operational considerations. For example, a consolidated ACC would need to be linked with the remote radar and radio transmitter and receiver sites and an extensive restructuring of the current communications network would be required. Although consolidation would alleviate the current problems experienced in the point-to-point ATS and AFTN communications between the numerous ACCs and FICs in existance, a consolidated ACC would need to be linked to the various terminal control facilities operating throughout the CAR. Because of the density of the communications linkages required and the complication associated with inter-island communications, a consolidated ATS operation might require establishment of an advanced (e.g., HF or satellite-based data link and voice) communication system. Such a system would require special equipment installations on aircraft and at the terminal ATS facilities and procurement and establishment (e.g., launch) costs.

7.7 Traffic Growth Implications

The preceding analyses address CAR operations under the 1979 traffic loadings and the following first-cut assessment of future operations is of interest. Traffic loadings in the CAR may be assumed to grow by a factor of 2 over the next 25 years for analysis purposes. Because the potential conflicts are caused by pairwise interactions between aircraft, the expected number of conflicts is expected to grow roughly at a rate which is the square of the traffic growth rate. Therefore, the potential conflict and diversion duration estimates presented in Tables 8 through 11 should be multiplied by 4 to roughly estimate long term impacts.

Such a calculation will find that the future daily potential conflict and diversion duration estimates are consistent with the discussions in the preceding paragraphs. That is, the expansion of radar services or the application of new technologies in the CAR will alleviate diversion and collision risk exposure, and special attention needs to be given to the provision of collision avoidance in the Port-au-Prince FIR. The traffic growth projections emphasize the importance of the planned radars in the Miami-San Juan corridor where diversion costs will grow to significant proportions if the radars are not established.

APPENDIX A

CAR ATS UNITS--AVAILABLE SUPPLEMENTAL DESCRIPTIVE DATA

A.1 Introduction

This appendix presents brief descriptions of the Houston, Miami, San Juan, Merida and Maiquetia ACCs and the Port-au-Prince FIC based on available data. These descriptions supplement the information given in the main text and provide data to support the cost estimates given in Appendix B.

A.2 Houston ACC

A.2.1 Information Source

The following information is based on an observational visit to the Houston ACC in June 1979 and subsequent consultations with Houston ACC personnel.

A.2.2 Airspace Structure

The Houston 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 FL25 and above. One non-radar control sector provides air traffic services for the oceanic area under the jurisdiction of the Houston Center. This sector, named "Ocean", is part of the Alexandria Area ofSpecialty which also includes five domestic en route radar sectors. Controllers who specialize only in the Alexandria area rotate their duty assignments through the Area's radar and manual sector positions and thereby maintain proficiency in domestic and oceanic control operations.

The airspace jurisdiction and ATS route structures of the Ocean sector are shown in Figure 3 of the main text. In addition to the ATS routes shown in Figure 3, certain routes are approved for use by specific carriers as listed in Table A-1.

With reference to Figure 3, the main routes in decreasing order of busyness are as follows:

- A4 and A49 (less used than A4) between New Orleans and Mexico City

- J177 (or overland) between Tampico and the Central United States including Houston

Table A-1

SPECIAL ROUTES, HOUSTON CTA/FIR

YA ROUTE* - MARCO TO BRAZOS SANTIAGO - FOR USE BY LUFTHANSA AIRLINES

MARCO REPORTING POINT	Non-compulsory reporting fix	25°55'N/82°04'W
CORK REPORTING POINT	Compulsory reporting fix	25°56'N/83°46'W
YA-1	Compulsory reporting fix	26°68'N/88°27'W
YA-2	Compulsory reporting fix	26°10'N/93°35'W
PIL NDB	Compulsory reporting fix	26°04'N/97°10'W

*The YA ROUTE is a segment of the approved route:
Nassau BR52V BSY MIA via MIA 290R to 2MC ORK YA PIL direct MAM J10 MTY

YB ROUTE - TAMPA TO MERIDA - FOR USE BY PAN AMERICAN AIRWAYS

PIE VORTAC	Compulsory reporting fix	
YB-1	Compulsory reporting fix	27°28'N/84°48'W
YB-2	Compulsory reporting fix	23°00'N/88°09'W
MERIDA		

YC ROUTE - TAMPA TO TUXPAN - FOR USE BY PAN AMERICAN AIRWAYS

PIE VORTAC	Compulsory reporting fix	
YB-1	Compulsory reporting fix	27°28'N/84°48'W
YC-1	Non-compulsory reporting fix	25°54'N/88°17'W
YC-2	Compulsory reporting fix	25°08'N/89°53'W
SALMON (YC-3)	Compulsory reporting fix	23°00'N/93°55'W
VELA	Compulsory reporting fix	21°57'N/95°43'W
TUXPAN		

- A6 and B3 between Houston and the Yucatan Peninsula
- A7 between New Orleans and Merida
- A39 between Miami and Mexico City.

An area of congestion exists at the BARTON and COLLINS reporting points where routes A4 and A49 intersect routes A6 and UB3. Another reporting point, ALARD, where numerous routes (i.e., A39, A6, and A7) intersect is not currently considered "hot spot" because of relatively low traffic volume.

Houston Center personnel report recent traffic increases on the A6 and B3 routes to and from the Yucatan Peninsula. Traffic movement is generally increasing on all routes except A7 where no recent traffic increases are noted.

A.2.3 General Accomodations

Figure A-1 shows the Houston ACCs control room layout including control positions. Each of the domestic radar sectors include a radio or radar (R) position, a handoff or data (D) position, and an assistant (A) position which may be shared between adjacent sectors. The Ocean sector operations provide for the manning of the D and A positions with the D controller in charge.

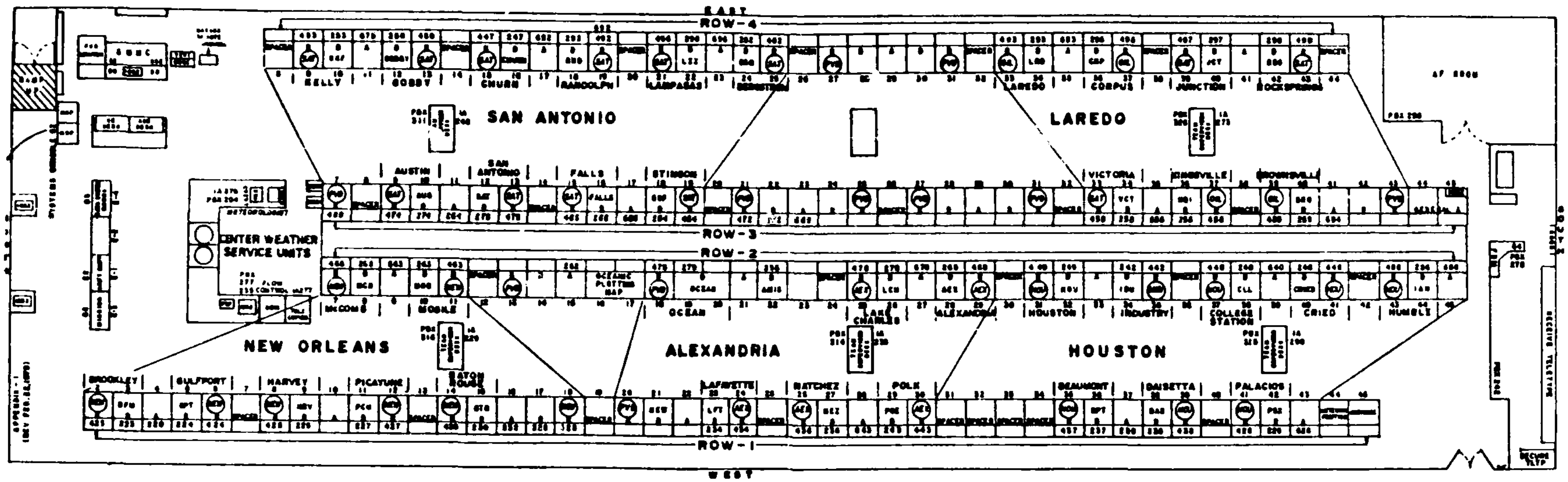
A.3 Miami ACC

A.3.1 Information Source

The following information is based on an observational visit to the Miami ACC in June 1979 and subsequent consultations with Miami ACC personnel.

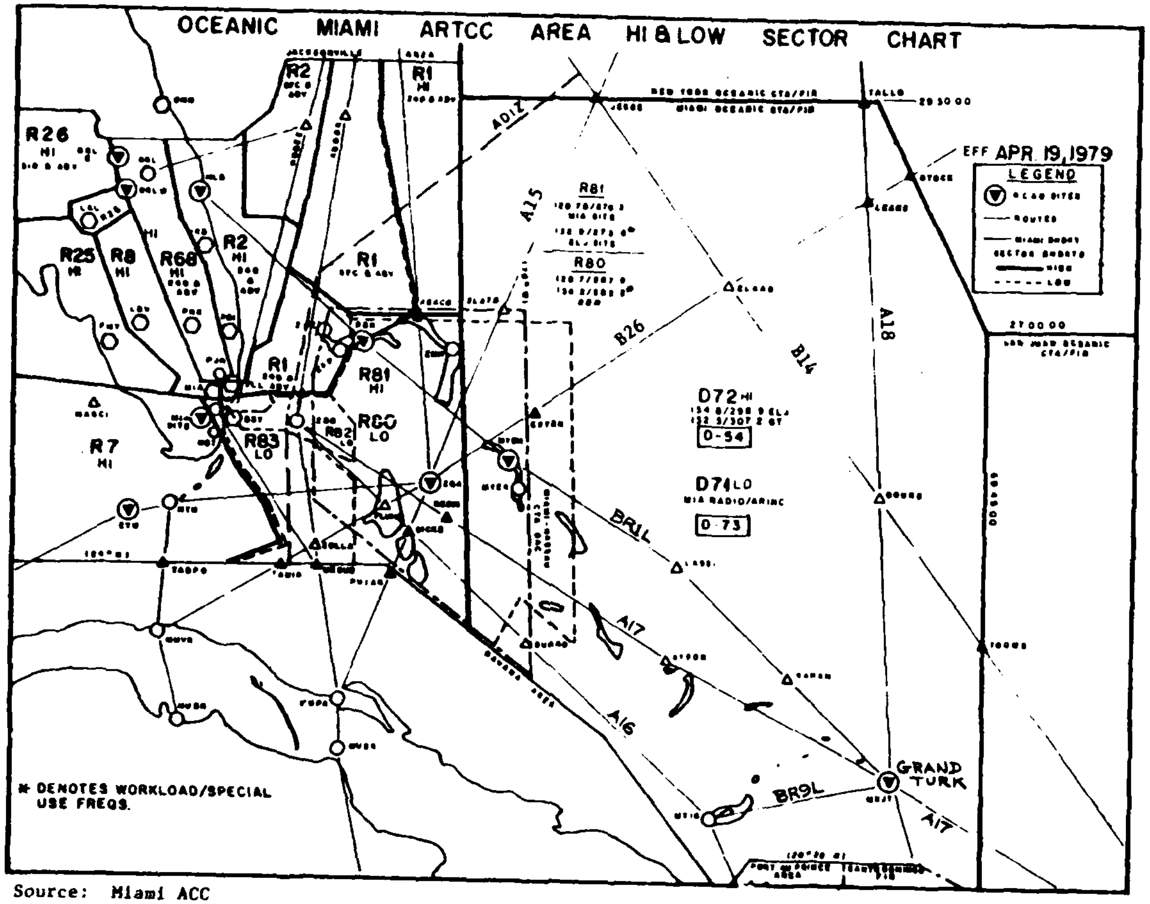
A.3.2 Airspace Structure

The Miami ACC is a US FAA en route NAS Stage A ARTCC providing domestic and oceanic ATS; oceanic area control service is provided from FL25 and above. The domestic and oceanic airspace sector and ATS route structures of the Miami ACC are shown in Figures A-2 and A-3. Figure A-2 shows that a part of high altitude Sector 72 and a part of low altitude Sector 71 covers the East CAR airspace between Florida and Puerto Rico. The ATS routes through the Miami (East CAR) CTA/FIR include BR1L (Bahama Route One Lima), A17, A16, and BR9L which are east-west in orientation with a major intersection point at Grand Turk. The north-south ATS route A/G also intersects Grand Turk, which is considered a key area of congestion. The routes in decreasing order of business are A17, A18, A16 and BR1L. The Sectors 71 and 72 airspace north of these routes is considered in this study to be part of the NAT region and is not considered part of the CAR.



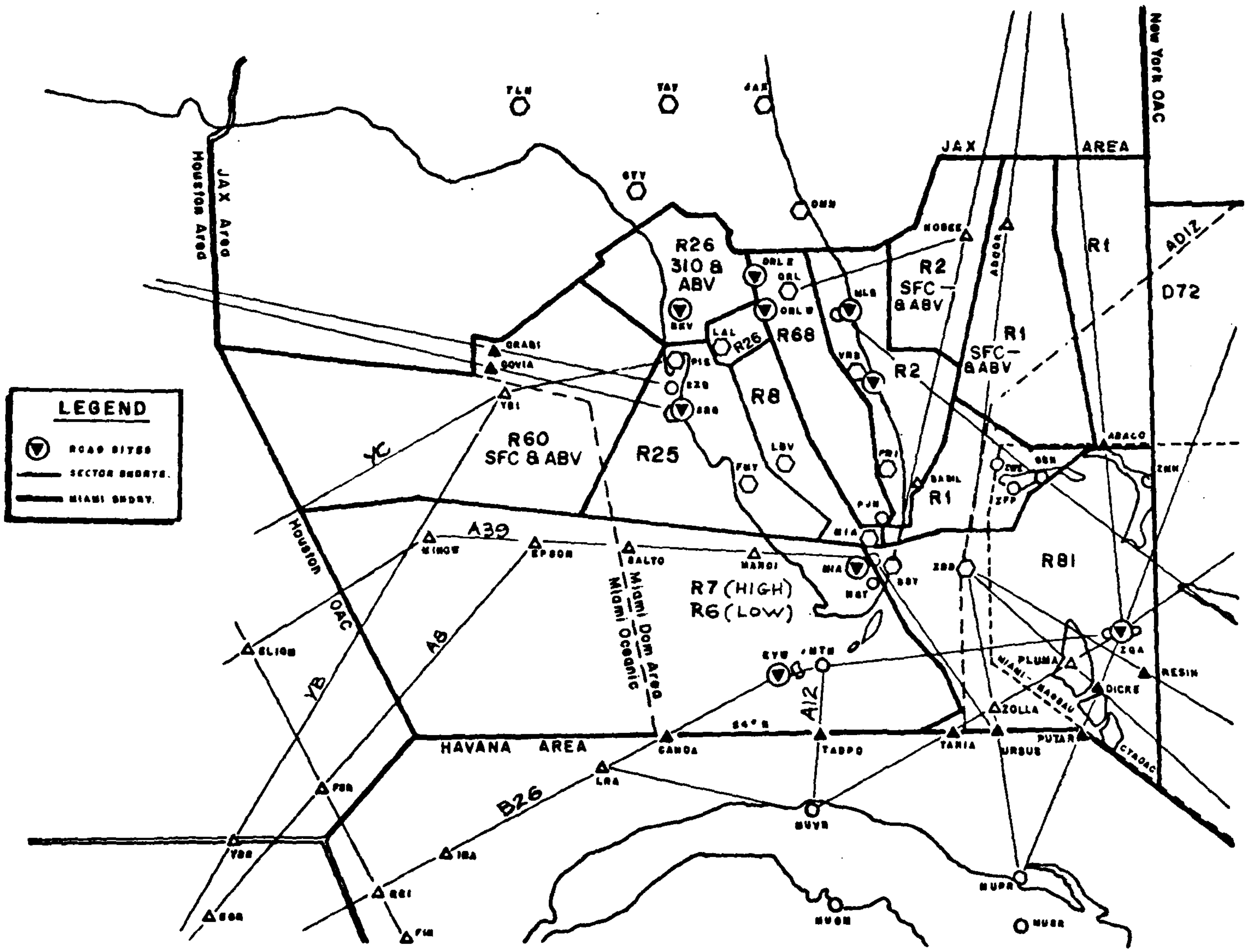
Source: Houston ACC

Figure A-1. HOUSTON CENTER CONTROL ROOM LAYOUT



Source: Miami ACC

Figure A-2 MIAMI ACC EAST CAR AIRSPACE



Source: Miami ACC

Figure A-3. MIAMI ACC GULF OF MEXICO AIRSPACE

Figure A-3 shows that a part of high altitude Sector 7, a part of low altitude Sector 6 and a part of high and low altitude Sector 60 covers the Miami (Gulf) CTA/FIR. The routes in decreasing order of business include A12, B26, A39, YB and YC, but A12 and B26 are in the Miami ACCs domestic airspace and not in the Miami (East CAR) CTA/FIR.

A.3.3 General Accomodations

Figure A-4 shows the control room layout for the Miami ACC. The D positions at each of the identified CAR sectors is responsible for oceanic operations and is supported by an A position.

A.4 San Juan ACC

A.4.1 Information Source

The following information is based on an observational visit to the San Juan ACC in June 1979 and subsequent consultations with San Juan ACC personnel.

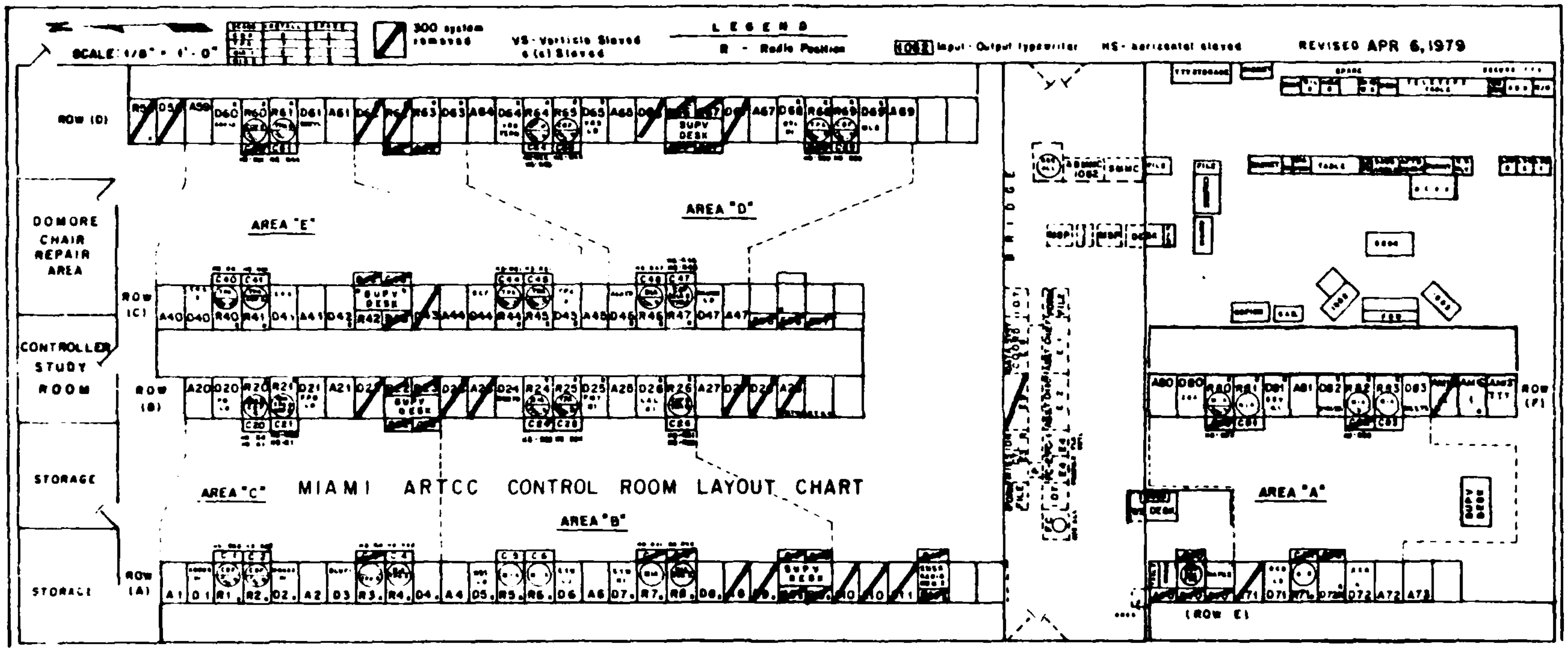
A.4.2 Airspace Structure

The San Juan ACC is a US FAA Combined En Route and Radar Approach and Departure (CERAP) control facility providing domestic and oceanic ATS; oceanic area control service is provided from FL25 and above and domestic service (except for terminal transition) is provided from FL20 and above. The airspace sector and ATS route structures of the San Juan ACC are shown in Figure A-4. Sectors 1 and 5 cover nonradar oceanic airspace and operate, respectively, in coordination with Sectors 2 and 4. Sectors 2 and 4 are provided with radar coverage but Sector 4 also includes significant nonradar oceanic airspace.

The part of the San Juan ACCs en route airspace relevant to the CAR oceanic and domestic operations consists of: the southwestern corner of Sector 1 including Route A17 (i.e., south of and exclusive of Route B14); all of Sector 2; and the part of Sector 4 under radar coverage. The remaining en route airspace is considered part of the NAT in this study. Route A17 serves the heavily used traffic corridor between Florida and Puerto Rico and is under non-radar procedures in Sector 1. The other ATS routes serving north-south traffic through Sector 4 are heavily used and are under radar coverage while in CAR airspace. North-south flights through Sector 2 also are under radar coverage but are dispersed over the routes shown in Figure A-5.

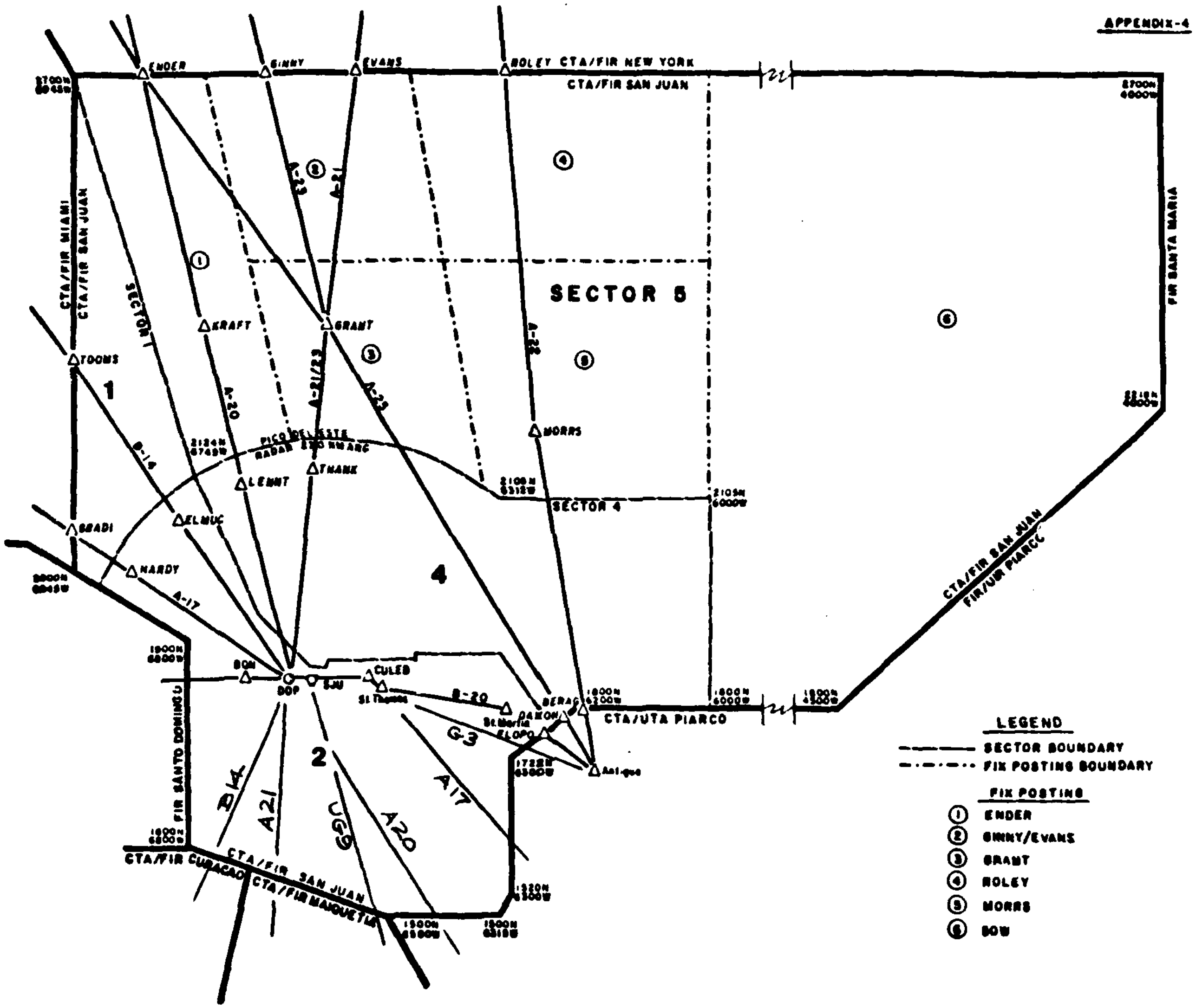
A.4.3 General Accommodations

Figure A-6 shows the current control room layout for the San Juan ACC. The R positions direct the CAR operations of Sectors 2 and 4. The D and A positions of Sector 2 provide the CAR oceanic non-radar ATS for Sector 1. The clearance delivery (CD) and flight data (FD) positions



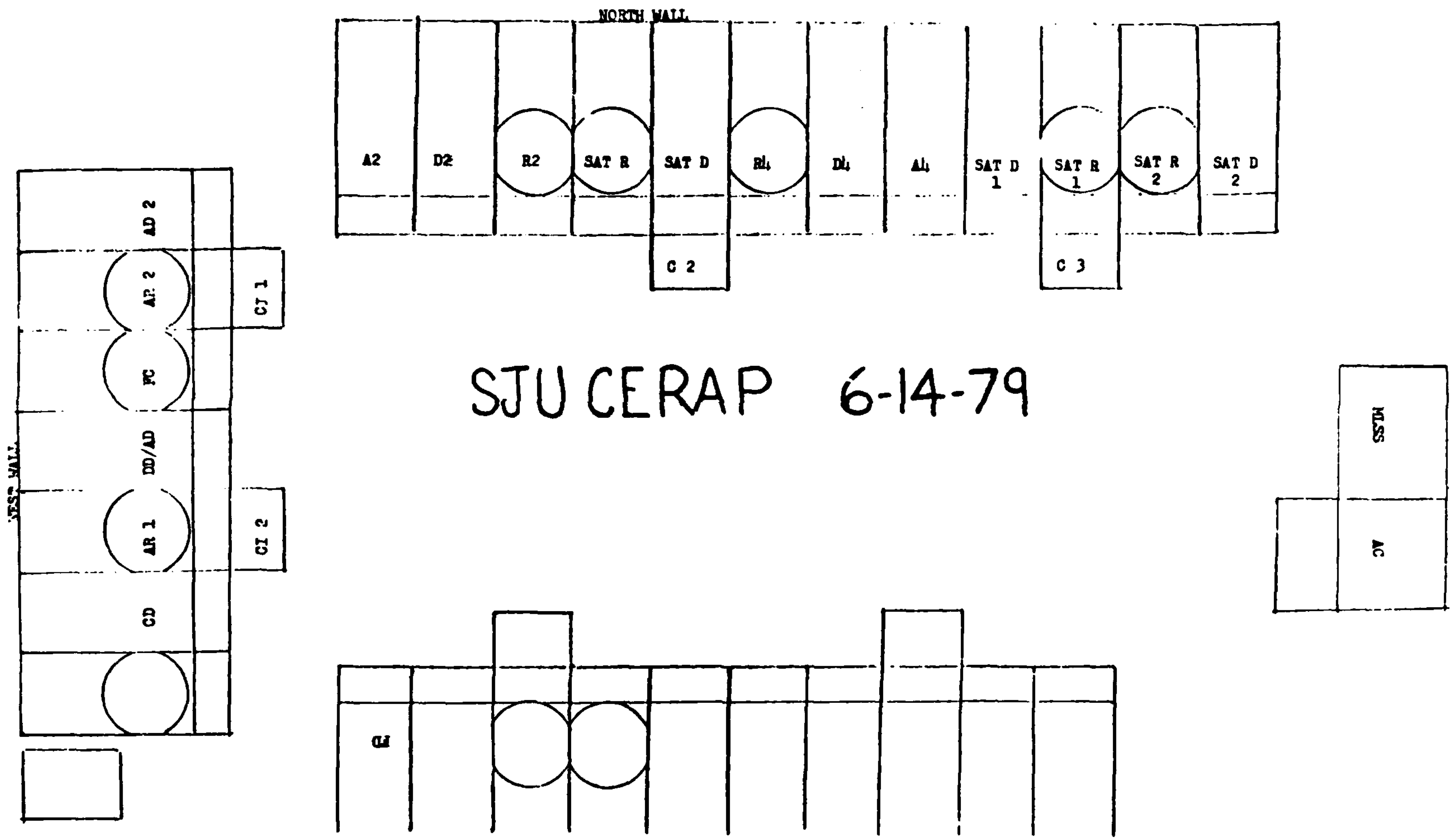
Source: Miami ACC

FIGURE A-4. MIAMI ACC CONTROL ROOM



Source: San Juan ACC

FIGURE A-5 SAN JUAN ACC AIRSPACE



Source: San Juan ACC

FIGURE A-6. SAN JUAN ACC CONTROL ROOM

support oceanic and domestic operations. The latter include the arrival (AR) and departure (DR) positions for local traffic (St. Thomas, St. Croix, Roosevelt Roads), and associated coordination and support positions.

A.5 Merida ACC

A.5.1 Information Source

The following information is excerpted directly from ref. 10 provided in Spanish by S.E.N.E.A.M., Mexico, and translated by the FAA.

A.5.2 Structural Organization

The Government of Mexico provides air transit services within the air space of the UTA/UIR and part of the FIR of Merida through a decentralized body dependent on the Office of the Secretary for Communication and Transport called Mexican Air Space Navigation Services (S.E.N.E.A.M.). This body's functions are to provide air traffic, navigation, meteorological and communication services in accordance with ICAO standards and the law on general communication channels, as well as to establish and develop said services.

The Merida Control Center and Radio Merida are located at the International Airport of the city of Merida.

The air traffic services provided are:

(1) Air traffic control above FL200.

(2) Flight information.

Some of these services are provided by the Merida Control Center in the Caribbean area. Due to the extent of space included as UTA/FIR under the jurisdiction of this control center, there is no need to establish oceanic control sectors; air traffic control services are provided by this facility, and the flight information services are provided by the Mérida radio station. Both facilities have the appropriate VHF and HF air/ground communication media for this purpose. The Control Center is included under a regional organization system which covers all ATS facilities, navigating aids, flight information services and meteorological services in the Merida region coincident with the air control limits. This Center has two staffs: administrative and operating personnel. Included in the latter are the air traffic control personnel responsible for providing air traffic control services. Technical personnel are responsible for equipment and systems as well as for their maintenance and radio beacons, who serve both in the Control Center and at Radio Merida, and in meteorology. Radio operating personnel are responsible for providing flight information services, and meteorological personnel are responsible for that service.

A.5.3 Sector Structure

The Merida Control Center is a facility providing en route and terminal control. En route control is exercised in the air space from FL200 upward, and terminal control within a radius of 50 NM of the airport and from FL200 downward. This facility has two en route control sectors and terminal control sectors. The en route sectors are the Caribbean sector to the east and Gulf sector to the west. The terminal control sectors are divided into departure and arrival sectors, and an approach sector.

A.5.4 Sector Personnel

Each of the three sectors includes a radar control position. A flight data position is shared by the three radar control positions.

The en route radar control position in both sectors is responsible for providing radar service and for providing nonradar control within its sector for domestic operations and operations over the Gulf.

The Gulf sector control position is responsible for coordinating with the Houston Oceanic Control Sector, with Sector 2 of the Mexico Center, and with the Havana Center. The Caribbean Control position is responsible for coordinating with the Havana Center, with the Tegucigalpa Center, and with the Belize Tower.

The terminal control position provides radar service.

The number of personnel per shift (4) and the number of sectors (3 manual radar controllers and one auxiliary FD controller) do not permit variations in the assignment of personnel to each position. It is planned to increase the personnel so that each en route sector will be covered with a radar controller and a manual controller; the flight data position will be covered with two assistants, and the Terminal Sector will be covered with two radar controllers.

A.5.5 Interphone Equipment

The interphone system equipment provides indirect communications with the Houston Center and with the Tegucigalpa Center, since to achieve communication it is necessary to ask the Mexico Center flight data position for a connection with Houston or Tegucigalpa. There is a long range plan to install Dialeo equipment in the ATS units to expand capacity and improve the quality of the interphone system.

The HF radio equipment provides direct oral communication with the Havana Center. Transmissions are made on SSB. This means of communication has proved unreliable, since at certain hours of the day it is virtually unreadable. An independent line is going to be used so that Merida does not have to share with Mexico the circuit to Houston; in this way there will be direct oral communication with Houston. In the immediate future we do not see any possibility of improving radio communication between the Merida and Havana Centers.

A.5.6 Oceanic Air-to-Ground Communications

The air-to-ground communication system of the Merida Center is VHF with COM stations in Merida and remote stations in Villahermosa and Cancun for direct pilot-controller communication.

A.5.7 Ocean Route Structure

Nondirectional radio beacons (NDB's), on which the structure of ocean lanes is based, are checked by the General Civil Aviation Board. The ocean lanes have been developed through regional accords and are part of the navigating plan for the Caribbean region. It is not planned to make changes in the lanes or in the radio beacons.

A.5.8 Traffic Loading

The main routes in order of decreasing traffic are: B-4 BLZ/CZM; B26 NAU/MID; R-14 VER/MID; A-7 GUA/MSY; R-2 NAU/MIA. Daily traffic volume in the area is from 200 to 250 operations.

A.5.9 Separation Minima

The UTA/MID has not been designated as an ocean area. That part of the UTA above the Gulf is some 600 miles long (E-W) and from 120 to 240 miles wide (N-2). The separation standards used in the Merida UTA/UIR between subsonic aircraft are as follows:

Longitudinal	15 minutes
Vertical	1000 under FL290; 2000 above FL290
Radar	10 nautical miles

The separation standards are based on radio beacons and on the established ATS lanes and on radar monitoring of the traffic.

A.5.10 Separation Maintenance Procedures

The air traffic movement is followed through the position reports and pilot estimates noted on the control strips placed on the flight progress panel, and within radar coverage, by means of radar images. The most widely used control technique for avoiding potential conflicts is that of change in altitude.

The proximity of the A-9 to the UTA/MID limit, running almost parallel to the limit within the CTA/HAV, causes separation problems between the traffic operating in this airway and the traffic leaving Merida by A-8 and B-26 and CZM by B-4 and B-20.

A.5.11 Distribution of Flight Plan Data

The flight plans appear in manuscript form in the Dispatch Offices. These offices orally notify the centers of the pertinent flight plan data. The center issues permits through the appropriate local ATS units. The flight data, including outgoing messages, are sent to and received from other installations by means of the ATS oral circuits. Within a Center, the "Flight Data" position prepares the control strips and distributes them to the appropriate sectors. The outgoing messages are sent to the concerned sector by the appropriate local ATS unit. This sector distributes these messages to the other concerned sectors in the zone by the local intercommunication system.

A.5.12 Coordination between Installations and Data Transfer Procedures

Merida Center coordinates control of international traffic operating over the Gulf with Houston oceanic control, Havana Center and Tegucigalpa Center. Merida Center sends FPL/CPL, estimates, and altitudes to the adjacent installations. This information is utilized to coordinate flight control. These data are transmitted by the ATS oral circuits and are recorded on the flight progress strips.

Coordination with other installations is achieved according to procedures agreed upon with each adjacent installation and specified in reconciliation charts, summarized below:

Procedures for Merida with Houston, Havana, Tegucigalpa (similar): The exchange of flight data (FPL, CPL, estimates, etc.) is carried out through oral circuits in accordance with the stipulated abbreviated messages. Aircraft are authorized up to the destination airport, and this constitutes authorization to fly in the authorized lane and altitude as far as the destination airport with no need for re-authorization by the adjacent center, unless traffic conditions require a change of altitude or, in exceptional cases, of lane. This type of revision of authorization is coordinated between centers. Minimum longitudinal separation between successive aircraft from one area to another is 15 minutes, vertical 1,000 or 2,000 whichever is applicable.

Cruising altitudes are assigned according to the Hemisphere Cruising Levels in Annex 2 of the ICAO.

In the case of oral circuit failure between Merida and Havana, control procedures have been developed in order not to suspend traffic under these conditions. This procedure consists basically of having each center authorize flights in such a way that they are levelled off before crossing the boundary between the two UTA's, and they are instructed to communicate with the adjacent center for further instructions.

Each center is allocated an altitude block, levels for assignment of cruising levels; and above these blocks are the areas reserved for the A-9 in case of communications failure.

A.5.13 Search and Rescue Service

The local Coordination Center is the Merida Airport Command, located at the airport. The Search and Rescue Service is the responsibility of the General Civil Aviation Board.

A.6 Port-au-Prince FIC

A.6.1 Information Source

The following information is excerpted directly from ref. 11 provided by the Service de L'Aviation Civile, Republic of Haiti.

A.6.2 Organizational Structure

Haiti, as a contracting State to ICAO provides Flight Information Service within the Port-au-Prince Flight Information Region shown in Figure 1.

The "Secretaire d'Etat des Travaux Publics Transports et Communications has designed by contract for a period of 5 years,: "L'Administration de l'Aeroport International Francois Duvalier" as the Government authority responsible to provide in accordance with ICAO provisions.:

(1) Flight Information Service from the surface upwards.

(2) Alerting Service from the surface upwards.

The "Secretaire d'Etat T.P.T.C." has also designated the "Direction Generale de l'Aviation Civile" to provide Aerodrome Flight Information Service on all other aerodromes of the Country.

Flight Information Service and Alerting Service are provided by the Flight Information Center which is located in the Terminal Building of the Francois Duvalier International Airport.

Aerodrome Flight Information Service is provided locally by the following aerodromes in Haiti:

(1) Port-au-Prince Tower at Francois Duvalier International Airport

(2) Cap Haitien Tower at the Cap Haitien International Airport

(3) Jeremie Tower at the Jeremie Airport

(4) Les Cayes Tower at the Cayes Airport

(5) Port-de-Paix at the Port-de-Paix Airport

(6) Jacmel Tower at the Jacmel Airport.

Flight Information Service is provided by the Flight Information Center Alerting Service at the Flight Information Center and Towers. Aerodrome Flight Information Services are provided by each Control Tower.

The Flight Information Center is operated by Communications' operators and maintenance technicians, of the "Administration del'Aeroport". The Operators are responsible for providing operational services to the usersand coordination with other air traffic Units.

The maintenance technicians are responsible for the provision and maintenance of equipment installed in the Center, the Towers on the airport or its environment. Some equipment has been leased from private company and is maintained by the company's technicians. Both operators and technicians are co-located and fall within the same administrative, operational and support personnel.

As for the Provincial tower operators and HF/SSB terminal operators at Port-au-Prince they come under the authority of the "Director General de l'Aviation Civile". They are located at each airport or at Port-au-Prince.

The maintenance of equipment assigned to these Provincial airports is provided by a mobile team of technicians based at Port-au-Prince and which travels as required for the maintenance of equipment.

It is anticipated that in the Fall of 1979, the Port-au-Prince Approach Control Area will be defined and implemented within a forty nautical mile radius, extending upwards from 700 feet above the surface of the earth or the sea to 10.000 feet ASL; as well as the Port-au-Prince Control Zone within an eight nautical mile radius extending upwards from the surface of the earth or the sea to 6,000 feet ASL, within which air traffic control services will be provided to IFR traffic in the CTA and to all traffic within the Control Zone.

It is anticipated that in the Fall of 1979, Approach Control Service will be provided to IFR traffic operating within the Port-au-Prince Approach Control Area. The Approach Control Sector will include one data position and one radio position manned by the same controller.

A.6.3 Route Structure

ATS routes based on NDB and VOR radionavigation aids are flight checked by FAA aircraft as required and by the established contract.

A.6.4 Traffic Loading

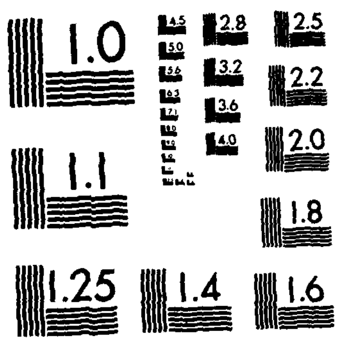
The most active routes, in decreasing order of business, are A16, G3 and A57, with congestion on A16 (MTPP to MDRO).

A.6.5 Flight Data Distribution

Flight plan data are forwarded to and from other ATS facilities via AFTN. Departure messages are forwarded by AFTN to other facilities except Santo Domingo which is via direct speech circuit.

AD-A123 828 OCEANIC AREA SYSTEM IMPROVEMENT STUDY (OASIS) VOLUME IV 2/2
CARIBBEAN REGION..(U) SRI INTERNATIONAL MENLO PARK CA
G J COULURIS SEP 81 OASIS-CAR-ATS FAA-EM-81-17-4

UNCLASSIFIED DOT-FA79WA-4265 F/G 17/7 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AFTN distribution of flight plan data experiences slow processing. There are no plans to change the AFTN and direct speech circuits.

A.7 Maiquetia ACC

A.7.1 Information Source

The following descriptions are excerpted directly from ref. 12 provided in Spanish by the Director General of the Air Transport and Air Traffic Section, Ministry of Transportation and Communication, Republic of Venezuela, and recently translated by the FAA.

A.7.2 Structural Organization

The Republic of Venezuela, a member state of ICAO, has designated the Chief of the Air Traffic Department (Jefe del Departamento de Transito Aereo) of the National Airways Division (Division de Aerovias Nacionales) as the authority responsible for the general administration of the Air Traffic Services. This Division is attached to the Directorate of Civil Aviation (Direccion de Aeronautica Civil) of the General Directorate of Air Transport and Traffic (Direccion General Sectorial de Transporte y Transito Aereo - DGTTA), which in turn falls under the authority of the Ministry of Transportation and Communications.

Air traffic control is provided within the airways from 1500 feet above the ground up to FL 200; within the entire upper air space from FL 200 inclusive. Flight and alert information is provided within the entire Maiquetia FIR and UIR regions.

The Maiquetia Control Center is operated by a unit of the same name, attached to the Air Traffic Department, which provides ATS services, and by the Northern Coastal Region of the Directorate of Engineering and Systems (Direccion de Ingenieria y Sistemas), which is responsible for maintenance of the equipment installed at the Control Center and of the radio aids that support the system.

These administrative units are separate entities, but both are attached to the General Directorate of Air Transport and Traffic (Direccion General Sectorial de Transporte y Transito Aereo - DGTTA). Plans are now being drafted to provide Flight Information from specialized positions within the Control Center. Both short-term and long-term plans are being prepared to remodel the installations at the Center.

The plans call for a data bank, automatic data processing, and for outfitting Sector 6 with a screen for secondary radar information from the Margarita TMA.

A.7.3 Sector Structure

The Control Center operates four (4) sectors as shown in Figure A-7. Of these, Sectors 3, 5, and 6 provide ATS services to aircraft over the ocean area at low and high levels. No specific sector for the ocean area has been established. Sectors 3 and 5 provide for control at the low level from the Maiquetia TMA. Radar control for VFR flights is provided frm the Maiquetia TMA. Sector 6 is a manual control position only. Short-term remodelling plans call for the establishment of two new sectors as shown in Figure A-8, in addition to two specialized Flight Information sectors. The Barcelona and Margarita TMAs are under the jurisdiction of Sector 6.

A.7.4 Sector Personnel

As shown in Figure A-9, Sectors 3 and 5 have two positions: Radar position and Assistant position. Sectors 2 and 6 have two positions: Manual Control position (no radar) and Assistant position. The Radar Controller for Sectors 3 and 5 and the Manual Controller for Sector 6 are responsible for providing air traffic services to aircraft operating within their sector, whether over the land or the ocean area, for placing progress strips on the board, computing the estimated hours at the fixes, updating the information on the progress strips, breaking down and storing the used progress strips, receiving and transmitting data regarding flight data as well as coordinating data with the adjacent sectors, TMA, ACC, and Control Tower by means of the intercom system. If position A is activated, the Assistant Controller is responsible for coordinating, receiving, and transmitting flight data and for breaking down and storing the used progress strips.

The sectors are usually operated by just one Controller. If, however, the traffic load so requires, the Assistant to the Supervisor, or the Supervisor himself, will work in the position of Assistant in the sector experiencing the heavy traffic load.

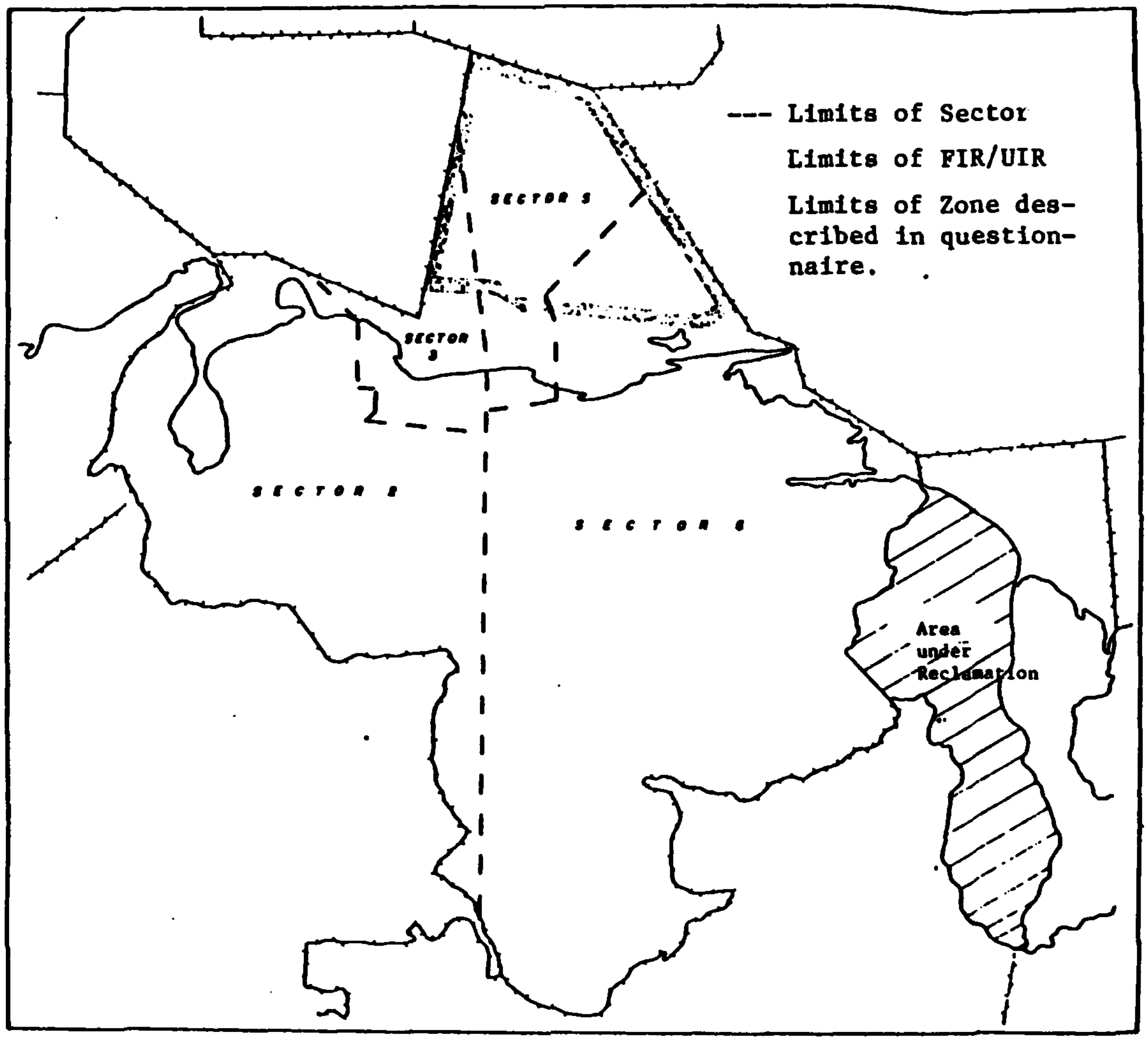


Figure A-7 MAIQUETIA ACC SECTORS

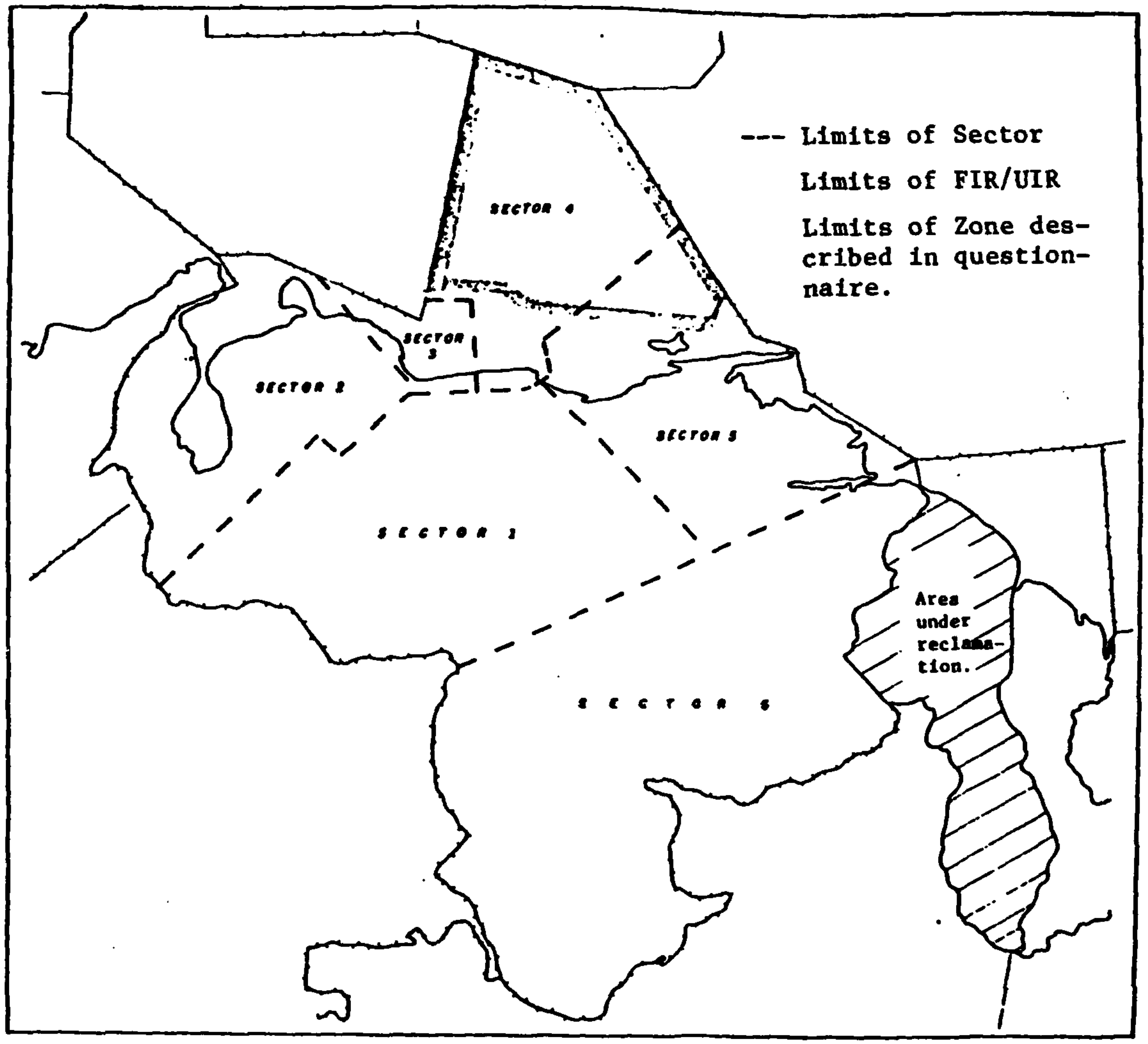
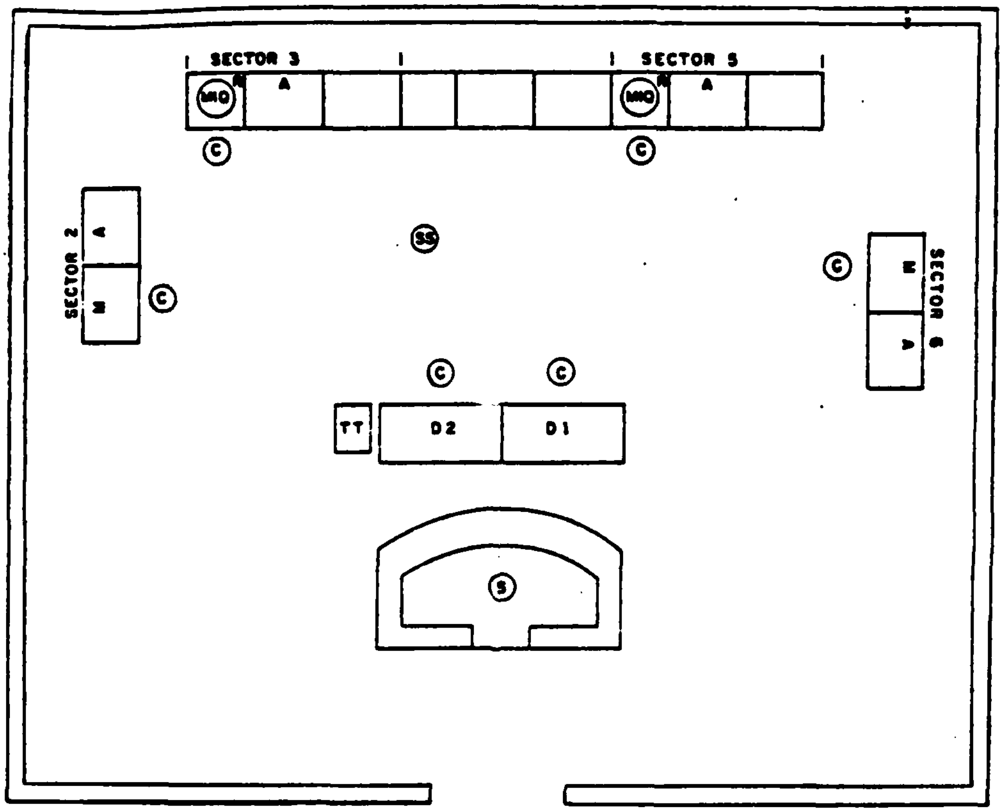


Figure A-8 MAIQUETIA ACC FUTURE SECTOR PLAN



R Radar Control Position
M Manual Control Position
A Assistant Position
D1,D2 Flight Data Position
S Supervisor
SS Assistant to the Supervisor
C Controller

Figure A-9 MAIQUETIA CONTROL CENTER, PERSONNEL PER SECTOR DIVISION

A.7.5 Sector Equipment

The consoles used in Sectors 3 and 5 are equipped with "hot" lines, intercom systems, radar screen, sector map and flight progress board. The consoles used in Sectors 2 and 6 have the same equipment as Sectors 3 and 5, except for the "hot" line and radar screen. The "hot" lines permit communication between sectors 3 and 5 as well as with the Maiquetia Approach Control Center.

The intercom systems permit communication among the Approach Control Centers of Maiquetia, of Barcelona, and of Margarita, as well as with the Control Centers of Curacao, San Juan, and Piarco. Telephones provide communication with ATS offices at the Maiquetia Airport, as well as with the offices of equipment maintenance, communications station, meteorology, airport administration, surveillance, airlines, and the Rescue Coordinating Center.

The radar screens display on a permanent basis primary radar information with a range of 80 NM and on an experimental basis secondary radar with a range of 200 NM.

The flight progress board is outfitted with the flight progress strips prepared manually by two flight data positions that serve all sectors of the center. A flight progress strip is placed on the board for each reporting point in the sector. The controllers are responsible for placing the strips at the corresponding reporting point designator, for updating, retrieving, and storing the data.

A teletype receiver has been installed in the Control Center room at the flight data position, through which all AFTN messages are received. The Controller who works in the flight data position must bring the progress strips and AFTN messages to the corresponding sector. The AFTN messages originated by the Center must be brought by hand to the Communications Station that operates in the same building.

A.7.6 Oceanic Route Structure

The ATS routes over the ocean area use the NDB, except for routes R5/UR5 between BELLO and TOTO and A21/UA21 between SILVA and GRAN ROQUE, which use the GRAN ROQUE VOR/DME and Route SP2 which use autonomous navigation.

The ATS route network at the low and high level and the radio aids that support the network are described in Figures A-10 and A-11.

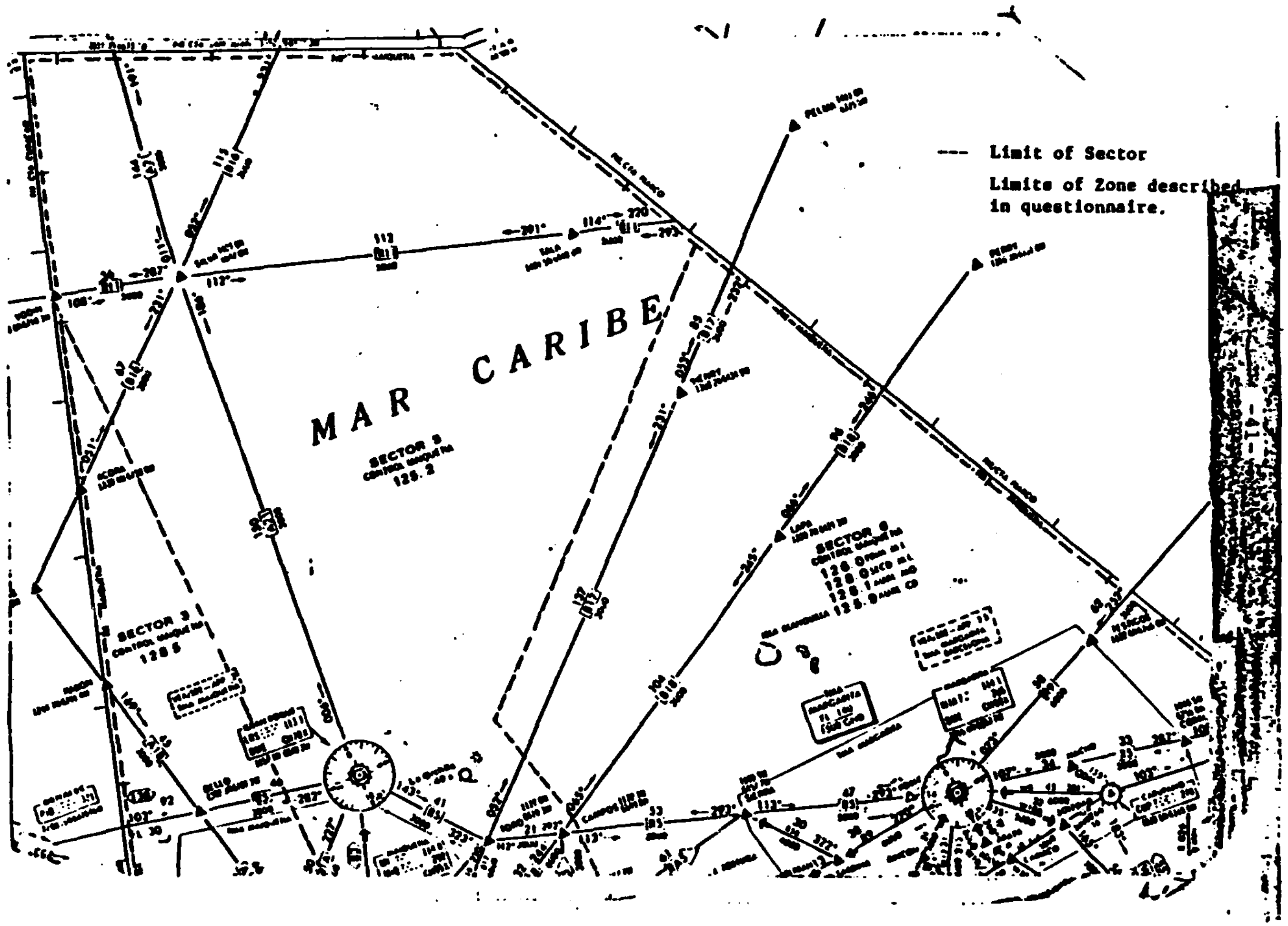


Figure A-10 MAIQUETIA ACC LOW LEVEL OCEANIC ROUTES

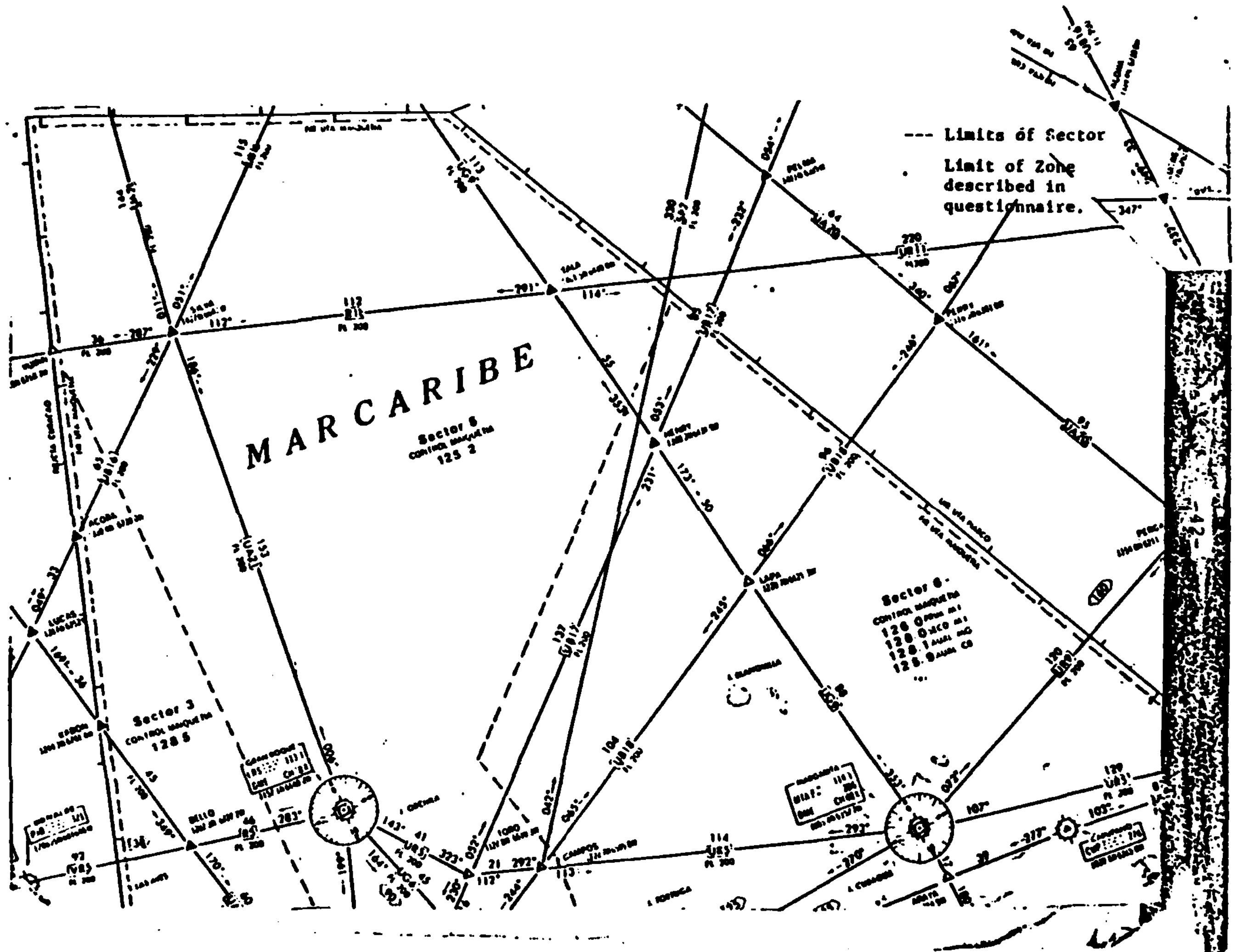


Figure A-11 MAIQUETIA ACC HIGH LEVEL OCEANIC ROUTES

The radio aids are tested in flight by the Directorate of Civil Aviation (Direccion de Aeronautica Civil) with its own equipment or with equipment contracted from FAA. The routes over the high seas are not tested.

The feasibility of realigning Routes B17 and UB17 to the GRAN ROQUE VOR/DME and the direct R5 and UR5 routes between the GRAN ROQUE and MARGARITA VORs is being studied. Table A-2 lists the ATS routes.

A.7.7 Traffic Loading

The traffic loading on the ATS routes within the ocean area on a peak day (Friday) is:

ATS Route	Daily Flights
A21/UA21	24
A18/UA18	16
B16/UB16	11
B17/UB17	11
B18/UB18	9
R11	5
R9	2
UG9	2
SP2	2 (See Note)

Note: Air France makes two (2) flights per week.

The most congested points are TORO, CAMPOS, and SILVA, which constitute the intersections of various routes. The traffic load on a peak day per hour in each sector is described in table A-3. The number of aircraft operating daily in the ocean area may be approximatrely 80.

A.7.8 Separation Minimua

The following separations are used in the ATS routes over the ocean area:

Vertical: 1,000 feet at FL 290 or below 2,000 feet above FL 290.

Longitudinal: Fifteen (15) minutes between aircraft flying in the same track. Ten minutes if navigational aids give the position and velocity of the aircraft. Five minutes if the aircraft that leads has a difference of velocity of 20 knots or more; and 3 minutes if the difference is more than 40 knots or more.

Table A-2

ATS ROUTES IN THE AREA OVER THE OCEAN

IDENTIFICATION	SECTION	LONGITUDE	SECTION
A18/UA18	BELLO/KABOn	45	NM
A21/UA21	GRAN ROQUE/ BRY FIR SAN JUAN	219	NM
B16/UB16	ACORA/BRY FIR SAN JUAN	135	NM
B17/UB17	BEACON/BRY FIR PIARCO	190	NM
B18/UB18	MARLIN/BRY FIR PIARCO	188	NM
R9/UR9	MARGARITA/BRY FIR PIARCO	75	NM
R11	VODIN/BRY FIR PIARCO	179	NM
UG9	MARGARITA/BRY FIR SAN JUAN	256	NM
SP2	CAMPOS/BRY FIR PIARCO	172	NM

Table A-3

MAIQUETIA ACC
TRAFFIC LOAD ON A PEAK DAY IN THE OCEAN AREA
HOUR: GMT

HOUR	00	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
SECTOR 3	2	2	2	0	2	0	0	0	0	0	0	0	0	1	5	0	1	1	2	2	2	2	0	3	27
SECTOR 5	5	2	3	4	4	0	2	2	3	0	0	1	2	2	7	1	1	2	2	3	5	0	3	6	60
SECTOR 6	1	2	1	1	1	0	0	0	1	0	0	1	2	0	3	1	1	1	0	1	2	0	2	3	24
TOTAL	8	6	6	5	7	0	2	2	4	0	0	2	4	3	15	2	3	4	4	6	9	2	5	12	111

Separations are applied on the basis of the flight plan, its subsequent updating, reports from aircraft at the fixes of the routes and the manual computation of the controller based on the true air velocity of the flight plan or as reported by the aircraft and the winds affecting said aircraft. If the aircraft is capable of using the VOR/DME, this informaiton is employed to reduce the separations.

The feasibility of applying specific separation standards for the ocean area is being studied.

A.7.9 Separation Maintenance Procedures

Transfer from the land to the ocean area is made within the same sector. Therefore, no special procedure is required. The most frequent conflicts that occur in the ocean routes are caused by aircrafts that plan to cross the Atlantic by the same route and at the same level. Generally speaking, for reasons of the technical performance, the aircraft in question refuses to accept a change in the level, which forces the controller to provide for a longitudinal separation by controlling the hour of take-off.

Monitoring of traffic over the ocean area is carried out by radio position reports via radio and the flight progress board. Potential problems are resolved by changing altitudes if the aircraft are in flight and by applying a delay in the take-off if an aircraft is on the ground. Furthermore, radar is used to provide for separation in the transition areas of the Maiquetia TMA.

Problems in providing separation over the ocean areas generally arise in cases of traffic coming from Europe via different routes. Radar has been used to check for a modification of the flight paths from the proposed routes; if horizontal separation has been applied alone by itself, it would have been found to be ineffective. Consequently, vertical separation is usually employed as quickly as possible.

A.7.10 Distribution of Flight Plan Data

The ARO (Air Traffic Services Reporting Office) receives the flight plan in written form. Through the intercom system, the plan is transmitted to the Control Center's flight data position. The Controller in charge of the position prepares the progress strips by hand and distributes them to the sectors involved in the flight plan.

The flight plan is simultaneously transmitted from the ARO via the TTO to the Air Communications Station, where it is distributed automatically to all interested centers by computer via the AFTN.

The Control Center transmits the flight authorizations through the Control Tower before take-off. The Center transmits the take-off message to the Communications Station via telephone for distribution via the AFTN. The flight plan is up-dated by means of direct speech with the Control Center.

A.7.11 Coordination Between Installations and Data Transfer Procedures

Sectors 3, 5, and 6 of the Maiquetia ACC are interfaced with the following adjacent ATS installations:

Sector 3: with CURACAO ACC, Sector 5 MAIQUETIA ACC and MAIQUETIA APP

Sector 5: with CURACAO ACC, SAN JUAN ACC, PIARCO ACC, Sector 3 and 6 MAIQUETIA ACC and MAIQUETIA APP

Sector 6: with PAIRCO ACC, Sector 5 MAIQUETIA ACC MARGARITA APP and BARCELONA APP

The agreements for special procedures signed with adjacent services are aimed at establishing in detail the routing of the IFR traffic, the transfer points for responsibility of control, and the coordination procedures. See Summary of Agreements in Table A-4.

Due to the absence of a special sector for the ocean area, except for Sectors 3, 5, and 6, which cover part of the ocean as well as of the land area, there is no specific transfer procedure for land/ocean areas, since the transition is made within the same sector. Therefore, to transfer control, it is necessary only to establish coordination with the controls of the terminal areas or with the adjacent sectors.

Radar is preferred at the Maiquetia Terminal Area for separating aircraft. If it is not possible to use radar, the technique of vertical separation and of the holding pattern are used.

TABLE A-4

MAIQUETIA ACC

SUMMARY OF AGREEMENTS WITH ATS INSTALLATIONS ADJACENT TO SECTORS 3, 5, AND 6

	ASSIGNMENT OF LEVELS	SEPARATIONS IN TRANSFERS	MODE OF COMMUNICATIONS		TRANSFER OF CONTROL
		LONGITUDINAL	NORMAL	ALTERNATIVE	
CURACAO ACC	CURACAO TO MAIQUETIA FIRST SEMI-CIRCLE. CURACAO TO MAIQUETIA. SECOND SEMI-CIRCLE	R5/UR5 ROUTE 10 MINUTES	STEP TO STEP	a) VIA ORAL SAN JUAN ATS b) AFTN	a) FLIGHT PLAN MESSAGE b) CHANGES c) COORDINATION (NO ACCEPTANCE MESSAGES)
SAN JUAN ACC	SAN JUAN TO MAIQUETIA A-21 - B-16 2° SEMI-CIRCLE. UG9 FIRST SEMI-CIRCLE. MAIQUETIA-SAN JUAN A-21 AND B-16 FIRST SEMI-CIRCLE. UG9 2° SEMI-CIRCLE	OTHER ATS ROUTES 15 MINUTES A/O OVER FL 200 AND 20 MINUTES A/O BELOW F1-190 AT THE TIME OF TRANSFER	AND	a) VIA ORAL CURACAO ATS b) AFTN	BY COORDINATION. THE ACCEPTING ACC WILL NOT GIVE NOTIFICATION WHEN IT ESTABLISHES COMMUNICATION WITH THE TRANSFERRED AIRCRAFT.
PIARCO ACC	PIARCO A MAIQUETIA SECOND SEMI-CIRCLE. MAIQUETIA TO PIARCO FIRST SEMI-CIRCLE	10 MINUTES AT THE TIME OF TRANSFER	SIMULTANTEOUS	a) VIA ORAL ATS b) AFTN	a) BY FLIGHT PLAN MESSAGES b) CHANGES c) COORDINATION (NO ACCEPTANCE MESSAGES)
MARGARITA APP	THE MAIQUETIA ACC ASSIGNS THE LEVELS.	10 MINUTES AT THE TIME OF TRANSFER	STEP TO STEP	a) ORALLY VIA BARCELONA ATS/APP b) AFTN	BY MEANS OF COORDINATION VIA ATS ORAL CIRCUIT.
BARCELONA APP				a) ORALLY VIA MARGARITA ATS/APP b) AFTN	

A.7.12 ATS Charges

The costs of providing the ATS service are paid for by the State of Venezuela, which applies charges and fees for the use of airports, for the transport of passengers and cargo, for the issuance of licenses, for registration, use of radio navigation aids, fines, etc.

A.7.13 Search and Rescue Service

The SAR region assigned to Venezuela maintains a Search and Rescue Department. This department is attached to the Division of Air Safety (Division de Seguridad Aerea) which forms a part of the organizational structure of the Directorate of Civil Aviation of the Ministry of transportation and Communications.

The Department maintains a Rescue Coordination Centre (RCC), which operates out of the Maiquetia "Simon Bolivar" Airport, twenty-four (24) hours a day, 365 days a year, with liaison offices located at the Air Traffic Control Services, at the F.F.A.A. communications centers. In addition, there are several private and public organizations with primary and secondary resources available to render assistance during air emergencies that occur in Venezuela. Nevertheless, it should be pointed out that currently there are certain factors that seem to impede due performance of the rescue mission, such as the following: (1) The current organization of SAR presents a series of limitations in view of the high operating costs that a Search and Rescue Service operation requires; (2) The current organization of the service presents a series of limitations as to the feasibility and self-sufficiency required for the successful performance of the mission; (3) Purchase of air, ground, and sea equipment is required in order to establish the basic structure that the SAR needs to operate on a permanent basis (24 hours) as an integral part of the State of Venezuela; (4) Currently, the Central Personnel Office (in Spanish: Oficina Central de Personal - O.C.P.) has no plans to set up the SAR as a special unit. As a result of key problems in this area, there is the need for an in-depth analysis of the SAR mission in order to be able to set up an organization structure that will be adaptable, practical, and acceptable costwise to the State of Venezuela.

In connection to Item (4) above, a project, consisting of eight (8) stages, has been drawn up to operate as follows: First Stage, the RCC (Rescue Coordination Centre) is in the process of implementing a twenty-four (24) hour operation, with a communication capacity to processing emergency calls at the National and International Aeronautical level with TELEX, AFTN, HF, VHF, Telephone, etc.; Second Stage, establishment of SAR sub-regions; Third Stage, establishment of the State SAR Board; Fourth Stage, use of computer as a Data Storage Bank; Fifth Stage, purchase of equipment (for the Air, Sea, and Land fleet); Sixth Stage, preparation of the Search and Rescue Handbook; Seventh Stage, staffing with operational personnel and on-the-job training; Eighth Stage, dissemination of SAR communications (bulletins, press releases, radio, films, etc.).

In conclusion, it is felt that with the implementation of this project it will be possible to carry out effective peace-time missions with respect to the civil aviation incidents set forth in Article No. 59 of the Civil Aviation Law.

APPENDIX B

ATS ANNUAL COST CALCULATIONS

B.1 Introduction

This appendix describes the calculation of ATS provider annual costs for the CAR. The estimates include staff cost, other direct operating cost and indirect operating cost. Cost estimates are developed for the Houston, Miami and San Juan ACCs based on informal data provided by the US FAA. A cost estimate for the Port-au-Prince FIC is based on reported data. Cost estimates for the remaining CAR ATS units are judgementally derived because of the lack of additional cost information.

B.2 Houston, Miami and San Juan ACC Annual Costs

B.2.1 Annual Staff Cost Estimates

At the Houston ACC, one sector (Ocean) handles CAR oceanic traffic while the other sectors are part of the US domestic operation. Informal preliminary estimates of the Houston ACCs oceanic controller staff were made by the FAA and resulted in 65 persons. However, this staff is active in CAR oceanic and US domestic operations. Because these personnel spend part of their time in CAR and part in domestic operations, an allocation of a portion of this staff to CAR operations is appropriate as follows. The ocean sector is one of six control sectors in a single Area of Specialty and consequently accounts for about 17 percent of the area's control requirements. Therefore, 17 percent of the 65 persons result in 11 equivalent full time persons allocated to CAR oceanic operations on an annual basis.

At the Miami ACC, five sectors are involved in CAR oceanic operations: two sectors (Sectors 71 and 72) handle CAR and NAT traffic, and three sectors (Sectors 6, 7 and 60) handle strictly CAR traffic. About 70 percent of the traffic through Sectors 71 and 72 account for the CAR services provided in these sectors, with the remaining 30 percent being NAT traffic. Given that 100 percent of Sectors 6, 7 and 60 are involved in CAR operations, 88 percent of Miami ACCs oceanic controller staff consists of 65 persons. These personnel operate domestic control positions in addition to oceanic control positions, and an allocation of a part of this staff to CAR oceanic operations would appear appropriate (as was done in the case of the Houston ACC). However, 65 persons is roughly the annual staff size expected to be required by 5 sectors; recall that 11 persons are allocated to the one oceanic sector in the Houston ACC. Therefore, subject to subsequent FAA reevaluations of the oceanic staffing estimates and calculation procedures, 88 percent of the 65 persons are taken to represent a preliminary estimate of the Miami ACCs CAR oceanic staff requirements. This calculation results in a CAR staff allocation of 57 equivalent full time persons on an annual basis.

At the San Juan ACC, three of four sectors are involved in CAR Oceanic and domestic operations: two sectors (Sector 1 and 4) handle CAR and NAT traffic; one sector (Sector 2) handles CAR traffic, and one sector (Sector 5) handles NAT traffic. Sectors 2 and 4 are radar equipped. About 80 percent of Sector 1's traffic accounts for the CAR services provided in this sector, and, for allocation purposes, all of Sector 4's services are assumed to be involved in CAR operations. Given that 100 percent of Sector 2's services are for CAR operations and none of Sector 5's services are CAR, 70 percent of the San Juan ACCs personnel are allocated to CAR operations. The FAA informally estimated on a preliminary basis that the oceanic controller staff consists of 33 persons. Assuming that the oceanic operation accounts for half the total CAR domestic and oceanic en route operation at the San Juan ACC, 70 percent of 66 persons results in a CAR staff allocation of 46 equivalent full time persons on an annual basis.

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

Unit	CAR Controller Staff (persons)	Controller Annual Staff Cost 1979 US$ (000)
Houston ACC	11	330
Miami ACC	57	1710
San Juan ACC	46	1380
Total	114	3420

In addition to the controller staff, the staff of the FAA units include ATC support (including administrative) and maintenance personnel. Detailed descriptions of the complete CAR staff at each facility are not available, and staff allocations to NAT operations are made as follows. 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 6.7 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 CAR 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; a first-cut estimate of 7 noncontroller persons per sector is assumed to apply to CAR radar sectors of the FAA.

Based on the discussions above, the Houston ACC has 1 CAR oceanic sector, the Miami ACC has the equivalent of 4.4 CAR oceanic nonradar sectors, and the San Juan ACC has the equivalent of 0.8 oceanic nonradar sectors and 2 CAR domestic radar sectors. The Houston ACC's oceanic sector is equipped with a PVD simulation of aircraft position and, for cost estimation purposes, is treated as a radar sector. Assuming 2 persons per non-radar sector, 7 persons per radar sector and an average annual wage per person of 30 thousand 1979 US $, the estimated non-controller staffing costs are:

Unit	Number of CAR Equivalent Sectors	NAT Noncontroller Staff (persons)	Noncontroller Annual Staff Cost 1979 US$ (000)
Houston ACC	1.0 radar	7.0	210
Miami ACC	4.4 nonradar	8.8	264
San Juan ACC	0.8 nonradar	1.6	48
	2.0 radar	14.0	420
Total	8.2	31.4	942

B.1.2 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 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 are:

ATS Unit	Number of CAR Equivalent Sectors	Other Annual Direct Operating Costs 1979 US$ (000)
Houston ACC	1.0 radar	30
Miami ACC	4.4 nonradar	110
San Juan ACC	0.8 nonradar	20
	2.0 radar	60
Total	8.2	220

B.1.3 Indirect Annual Operating Costs

Based on informal discussions with FAA, the annual procurement and installation cost is assumed to be 100 thousand 1979 US$ for an oceanic sector (which excludes radar and A/G communications) and 250 thousand 1979 US$ for a domestic radar sector (including A/G communications). Assuming a 10 percent 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 Unit	Number of CAR Equivalent Sectors	Annual Indirect Operating Cost 1979 US$ (000)
Houston ACC	1.0 radar	35
Miami ACC	4.4 nonradar	66
San Juan ACC	0.8 nonradar	12
	2.0 radar	70
Total	8.2	183

B.1.4 Total Cost

The total annual cost for the FAA facilities, based on the above calculations and adjusted for overhead, 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, region and logistics support.

Annual Cost (1979 US $ Thousand)

Cost Item	Houston ACC	Miami ACC	San Juan ACC	All
Controller Staff	330	1710	1380	3420
Noncontroller Staff	210	264	468	942
Total Staff	540	1974	1848	4362
Other Direct Operating	30	110	80	220
Indirect Operating	35	66	82	183
Subtotal	605	2150	2010	4765
Overhead	270	987	924	2181
Total	875	3137	2934	6946

B.3 Port-au-Prince FIC Annual Cost

The Service de L'Aviation Civile, Republic of Haiti, estimated that their 1979 annual facility and equipment operating and maintenance costs for providing ATS is $262,736 (ref. 11). Since full ATS is not provided in the Port-au-Prince FIR, the indicated cost estimate is assumed to include terminal control services which are outside the scope of this study. Lacking further information, the cost allocation to en route services in this FIR is assumed to be about half of the total ATS cost and equal to 130 thousand 1979 US$.

Note that annual staff wages reported in ref. 11 are $4230 per controller, $5184 per maintenance person and $1200 per administrative person. These wages are considerably less than US FAA personnel costs and, according to informal discussions with various ATS personnel, are indicative of a general relative wage trend in the CAR. That is, non-US ATS wages are assumed to be less than those of the FAA.

B.4 Other CAR ATS Unit Annual Costs

No ATS cost estimate data was provided for the ATS units other than the Houston ACC, Miami ACC, San Juan ACCs and Port-au-Prince FIC. The following first-cut cost estimates are made for the other units.

The Merida ACC has two en route radar sectors and one terminal radar sector with a 5-person staff per shift (ref. 10). The Merida ACC en route operation has more sectors than the Houston ACC (which has one sector supported by a radar simulated display) and serves domestic and oceanic CAR airspace (the Houston ACC serves Oceanic CAR airspace). Taking into account the likely controller wage differentials between the Houston and Merida ACCs, the Merida ACCs annual en route ATS cost is assumed to be about the same as that of the Houston ACC and equal to 875 thousand 1979 US$.

The Habana, Kingston, Curacao, and Piarco ACCs are not known to provide en route radar services and are assumed to be nonradar operations in the CAR. The level of sophistication of the ATS operation at each of these facilities has not been reported. Lacking further information (and allowing for the likely wage differential relative to FAA staff costs) the annual ATS provider cost for each such unit is assumed to be roughly half that of the Houston ACC and equal to 500 thousand 1979 US$.

The Maiquetia ACC reportedly has radar capabilities, but the operational status and mode (i.e., terminal versus en route) of the radar services has not been reported. Allowing for some additional costs due to the radar operation, the Maiquetia ACC's annual ATS cost is assumed to be slightly greater than the neighboring nonradar ATS units and equal to 600 thousand 1979 US$.

The annual ATS cost of the Santo Domingo FIC is assumed to be comparable to that of the Port-au-Prince FIC and equal to 130 thousand 1979 US$.

APPENDIX C

CAR TRAFFIC PATTERN ANALYSIS

Note: This Appendix is excerpted from Draft Working Note CAR-1, "A First-Cut Analysis of Scheduled Air Traffic Patterns in the Caribbean Region", R. Lieberman, SRI Project 8066 (April, 1980).

The scheduled air carrier flights in the CAR on July 6, 1979 were grouped by regional origin-destination flow pattern and tabulated by hour of departure as shown in Table C-1. These data were used to develop twenty-four "snapshot" diagrams of each flight's projected trajectory through the CAR. Each diagram displayed the possible positions of the flights at a different hour of the day, assuming ground speed of 480 knots and use of a single ATS route between origin and destination. The possible position of each flight covers one hour of flight time based on the hourly departure periods shown in Table C-1. The model day assumes continual repetition of a single day's flight patterns.

A graphical "eyeball" analysis of each of the snapshots was used to estimate instantaneous aircraft count, travel time, potential crossing conflicts and potential overtaking conflicts in each CTA/UTA/FIR/UIR. Tables C-2 and C-3 summarize the potential conflict data and supplement the analysis data presented in the main text of this report. Flights in the NAT region were not analyzed because such flights are not an integral part of the basic CAR. Flights in the Piarco Atlantic Ocean FIR also were not analyzed because the random tracks could not be projected.

For the purposes of the analysis, no eastbound flight was assumed to conflict with a westbound flight and vice-versa because of hemispheric separation rules. However, the ameliorating effect of altitude separation between eastbound (or westbound) flights was not included nor was the effect of a choice between alternative tracks (i.e., all flights in a single origin-destination flow were assumed to be at the same flight level on the same track).

Note that only scheduled flights are included in this rough analysis and that the inclusion of non-scheduled flights (i.e., charter, military and general aviation traffic) would increase the aircraft and potential conflict counts shown in Tables C-2 and C-3. However, the impact on potential conflict estimation of the inclusion of non-scheduled traffic would be more than offset by taking into account the fact that aircraft actually do not fly at the same altitude and that aircraft with the same regional origin and destination pattern do not necessarily fly the same track. The data shown in Tables C-2 and C-3 likely are conservative, high estimates of potential conflicts and, because of the preliminary nature of the analysis methodology, are not considered statistically precise.

Table C-1

NUMBER OF SCHEDULED FLIGHTS PER HOUR IN THE CARIBBEAN BY FLOW PATTERN: JULY 6, 1979, UPPER AIRSPACE

Airport	Time of Departure (In Greenwich Mean Time)																								
Pair	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Total
SOUTHEAST CARIBBEAN																									
SJU-POS	1	1	0	1	0	0	0	0	0	0	0	0	3	1	1	1	1	0	1	3	0	1	2	2	19
POS-SJU	1	1	0	0	0	0	0	0	0	0	0	1	3	5	1	0	0	0	0	1	2	1	2	1	19
MIA-SJU	1	0	1	0	1	0	0	0	0	0	0	0	1	1	1	1	3	6	1	3	0	2	0	0	22
SJU-MIA	0	0	1	0	0	0	0	0	0	0	0	1	0	2	1	2	0	2	1	2	2	0	1	0	15
MBJ-SJU	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	2	2	1	2	0	13
SJU-MBJ	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	2	1	2	1	2	0	0	0	1	14
MIA-MBJ	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	3	1	1	1	12
MBJ-MIA	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	2	1	2	0	2	0	12
MIA-CCS	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	7
CCS-MIA	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	2	0	0	1	0	0	0	0	9
NORTH ATLANTIC/ CARIBBEAN																									
JFK-SJU	2	2	1	3	0	0	0	0	1	0	0	3	5	5	5	1	2	0	0	2	0	2	1	1	36
SJU-JFK	1	2	4	2	2	0	1	0	1	0	0	1	1	2	0	0	3	0	3	4	2	5	0	1	35
JFK-MBJ	0	0	0	0	0	0	0	0	0	0	0	1	0	1	5	0	0	1	0	0	1	0	0	0	9
MBJ-JFK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	0	7
ORD-SJU	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	5
SJU-ORD	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	5
JFK-CCS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	4
CCS-JFK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	3
GULF OF MEXICO																									
MSY-MEX	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	1	0	0	0	0	1	7
MEX-MSY	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	5
MSY-MID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	2	0	0	0	0	7
MID-MSY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	1	0	0	0	5
MIA-MEX	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	1	6
MEX-MIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	1	0	0	1	0	0	6
MIA-MID	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	4
MID-MIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	3
IAH-MID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2
MID-IAH	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	4
SOUTHWEST CARIBBEAN																									
MIA-PTY	1	2	0	3	1	1	0	1	0	1	0	1	0	0	1	0	0	2	2	0	2	1	0	1	20
PTY-MIA	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	3	1	1	1	1	15
MIA-GUA	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	4	3	0	0	0	0	11
GUA-MIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	0	0	1	0	2	1	0	10
EUROPE/CARIBBEAN																									
POS-EUR	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	3	2	8
EUR-POS	0	1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	4
HAV-EUR	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	2	7
EUR-HAV	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PTP-EUR	0	0	2	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	8
EUR-PTP	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
SJU-EUR	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	1	4
EUR-SJU	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
PTM-EUR	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	3
EUR-PTM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	16	13	13	13	7	1	2	2	2	6	1	13	20	28	27	20	28	27	29	35	21	30	23	16	393

Table C-2

EXPECTED DAILY NUMBER OF POTENTIAL CROSSING CONFLICTS, JULY 1979 UPPER AIRSPACE

Hour (GMT)

	CTA/UTA/FIR	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
15-Minute Separation	Houston	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-	-	-	-
	Merida	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	.3	.8	-	.3	-	-
	Habana	-	-	-	-	-	-	-	-	-	-	-	-	.5	-	-	-	-	-	-	-	-	.5	.8	.5
	Port Au-Prince & Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	.3	.5	1.0	1.3	.5	1.5	1.0	-	-	-
	Port-Au-Prince	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	.3	.5	.8	1.3	.5	.5	-	-	-	-
	Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-	1.0	1.0	-	-	-
	Miami-CAR	-	-	.5	-	-	-	-	-	-	-	-	-	.3	-	-	1.3	3.8	-	-	1.5	1.5	2.0	.8	-
	All Others									N		O		N	E										
10-Minute Separation	Houston	.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	-	-
	Merida	.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.3	-	.1	-	-
	Habana	-	-	-	-	-	-	-	-	-	-	-	-	.2	-	-	-	-	-	-	-	-	.2	.3	.2
	Port-Au-Prince & Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.2	.4	.6	.2	.7	.4	-	-	-
	Port-Au-Prince	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.2	.3	.6	.2	.2	-	-	-	-
	Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	.4	.4	-	-	-
	Miami-CAR	-	-	.2	-	-	-	-	-	-	-	-	-	.1	-	-	.6	1.7	-	-	.7	.7	.9	.3	-
	All Others									N		O		N	E										
5-Minute Separation	Merida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	-
	Habana	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	-	-	-	-	-	.1	.1	.1
	Port-Au-Prince & Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.2	.1	-	-	-
	Port-Au-Prince	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.1	-	-	-	-
	Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	-	-	-
	Miami-CAR	-	-	.1	-	-	-	-	-	-	-	-	-	-	-	-	.1	.4	-	-	.2	.2	.2	.1	-
	All Others									N		O		N	E										

Table C-3

EXPECTED DAILY NUMBER OF POTENTIAL OVERTAKING CONFLICTS, JULY 1979 UPPER AIRSPACE

Hour (GMT)

Separation	CTA/UTA/FIR	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
15-Minute Separation	Houston	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.9	.3	.6	-	-	.3	-	-	-	-
	Merida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.2	.2	.4	-	-	.5	.2	.1	-	-
	Miami-Gulf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	-	-	-	-	-
	Habana	.1	.2	-	.4	-	-	-	-	-	-	-	-	.1	-	.1	.1	2.1	.8	1.6	.6	1.6	.3	.6	.1
	Port-Au-Prince & Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.2	.1	.2	.1	.3	.4	-	.4	-
	Port-Au-Prince	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.1	.1	-	.2	-
	Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.2	.3	-	.2	-
	Miami-CAR	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.3	.1	1.8	4.9	1.2	1.1	1.1	.8	.1	-
	Kingston	-	.1	.1	.2	.2	-	-	-	-	-	-	-	-	-	-	-	.8	-	.3	.3	.8	.1	.3	-
	San Juan-CAR	-	-	-	-	-	-	-	-	-	-	-	-	1.1	2.2	-	.2	-	.8	2.8	.9	1.4	.3	.6	.4
	Curacao	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.2	-	-	-	.2	.2	-	-
	Piarco-UTA	-	-	.2	.2	-	-	-	-	-	-	-	-	1.1	1.9	-	-	-	-	-	.6	.2	-	.8	.4
	Maiquetia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Minute Separation	Houston	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.7	.2	.4	-	-	.2	-	-	-	-
	Merida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.2	.3	-	-	.4	.2	.1	-	-
	Miami-Gulf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1		-	-	-	-	-	-	-
	Habana	.1	.1	-	.4	-	-	-	-	-	-	-	-	.1	-	.1	.1	1.5	.6	1.3	.5	1.3	.2	.5	.1
	Port-Au-Prince & Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.2	.1	.2	.1	.3	.4	-	.3	-
	Port-Au-Prince	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.1	.1	-	.2	-
	Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.2	.3	-	.2	-
	Miami-CAR	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	1.4	3.5	1.0	.8	.8	.4	.1	-
	Kingston	-	.1	.1	.2	.2	-	-	-	-	-	-	-	-	-	-	-	.7	-	.2	.3	.4	.1	.2	-
	San Juan-CAR	-	-	-	-	-	-	-	-	-	-	-	-	.8	1.6	-	.1	-	.6	2.1	.6	1.0	.2	.4	.3
	Curacao	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	.1	.1	-	-
	Piarco-UTA	-	-	.1	.1	-	-	-	-	-	-	-	-	.8	1.4	-	-	-	-	-	.4	.1	-	.8	.3
	Maiquetia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Minute Separation	Houston	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.4	.1	.2	-	-	.1	-	-	-	-
	Merida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.2	-	-	.3	.1	-	-	-
	Miami-Gulf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Habana	.1	-	.2	-	-	-	-	-	-	-	-	-	-	-	-	-	.8	.4	.7	.3	.8	.1	.3	.1
	Port-Au-Prince & Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	.1	.1	.2	.2	-	.2	-
	Port-Au-Prince	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	.1	-	.1	.1	-	.1	-
	Santo Domingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.2	-	.1	-
	Miami-CAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	.8	1.9	.6	.4	.5	.2	.1	-
	Kingston	-	-	.1	.1	-	-	-	-	-	-	-	-	-	-	-	-	.4	-	.2	.2	.5	-	.1	-
	San Juan-CAR	-	-	-	-	-	-	-	-	-	-	-	-	.5	.9	-	.1	-	.3	1.1	.4	.5	.1	.2	.2
	Curacao	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	.1	.1	-	-
	Piarco-UTA	-	-	-	-	-	-	-	-	-	-	-	-	.5	.8	-	-	-	-	-	.2	.1	-	.5	.2
	Maiquetia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

REFERENCES

1. International Civil Aviation Organization, "International Standards and Recommended Practices, Air Traffic Services," Annex 11 to the Convention on International Civil Aviation, Seventh Edition (April 1978).

2. International Civil Aviation Organization, "International Standards, Rules of the Air," Annex 2 to the Convention on International Civil Aviation, Sixth Edition (September 1970 with ammendments through June 1977).

3. International Civil Aviation Organization, "Procedures for Air Navigation Services, Rules of the Air and Air Traffic Services," Doc. 4444-RAC/501/11, Eleventh Edition (1978).

4. International Civil Aviation Organization, "Regional Supplementary Procedures," Doc. 7030/2, Second Edition (1971 with ammendments through August 1978).

5. International Civil Aviation Organization, "Air Navigation Plan--Caribbean and South American Regions" (ANP-CAR/SAM), Doc. 8733/10, Tenth Edition (June 1977). Superseded by July 1979 Eleventh Edition.

6. International Civil Aviation Organization, "Air Nabigation Plan--North Atlantic, North American and Pacific Regions" (ANP-NAT/NAM/PAC), Doc. 8775/10, Tenth Edition (September 1977.

7. International Civil Aviation Organization, "Air Navigation Plan--Africa-Indian Ocean Region" (ANP-AFl), Doc. 7474/21, A Twenty-First Edition (December 1977).

8. International Civil Aviation Organization, "Air Navigation Plan--European Region" (ANP-EUR), Doc. 7754/21, Twenty-First Edition (February 1977).

9. International Civil Aviation Organization, "Air Navigation Plan--Middle East and South East Asia Regions" (ANP-MID/SEA), Doc. 8700/12 Twelfth Edition (August 1978).

10. Mexican Air Space Navigaion Services (S.E.N.E.A.M.), Office of the Secretary for Communication and Transpot, Replies to Data Needs Questionnaire, Draft Letter Manuscript (Autumn, 1979).

11. Service de L'Aviation Civile, Republic of Haiti, Replies to Data Needs Questionnaire, Draft Letter Manuscript (September 19, 1979).

12. Director General of the Air Transport and Air Traffic Section, Department of the Office of the Secretary of the Aeronautical Technical Council and of the Liaison Office with ICAO Ministry of Transportation and Communications, Republic of Venezuela, Replies to Data Needs Questionnaire, Draft Letter Manuscript (June, 1980).

13. Federal Aviation Administration, "Air Traffic Control", Document 7110.65B, Air Traffic Service, FAA, DOT, US (January 1, 1980).