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STUDY ON THE REFINEMENT OF THE SATELLITE BROADCAST CONCEPT

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FOREWORD

The Communications/Meteorology (COM/MET) Divisional Meeting held in Montreal in 1982 recommended that ICAO carry out an early study of the satellite broadcast concept and its implementation, upon which the world area forecast system configuration and telecommunications support function would be based. It would comprise:

a) two world area forecast centres, each generating global area forecast system products;

b) uplinks to an appropriate international satellite system and broadcast of area forecast system products; and

c) national reception, processing and distribution of area forecast system products.

The Air Navigation Commission (ANC) formed the Aeronautical Fixed Service Systems Planning for Data Interchange Panel (ASPP), which held its first meeting in Montreal in 1986. The ASPP's terms of reference included development of the world-wide plans for the evolutionary development of the aeronautical fixed service (AFS) to meet the operational requirements for data interchange of all AFS users including the world area forecast system (WAFS). This document presents a study on the refinement of the satellite broadcast concept.

GLOSSARY OF TERMS

ADF	Aviation digital forecast
AFI	Africa-Indian Ocean
AFP	Area Forecast Panel
AFS	Aeronautical fixed service
AFTN	Aeronautical fixed telecommunication network
ANC	Air Navigation Commission
APIRG	AFI Planning and Implementation Regional Group
ARINC	Aeronautical Radio, Inc.
ASIA/PAC	Asia and Pacific
ASPP	Aeronautical Fixed Service Systems Planning for Data Interchange Panel
BER	Bit error rate
CAR/SAM	Caribbean and South American
C-BAND	6/4 GHz
CCITT	International Consultative Committee for Telegraph and Telephone
CIDIN	Common ICAO Data Interchange Network
COM/MET	Communications/Meteorology
COMSAT	Communications Satellite Corporation
DIFAX	Digital facsimile
DIV	Divisional
EANPG	European Air Navigation Planning Group
EUMETSAT	Organization for the Exploitation of Meteorological Satellites
EUR	European
EUTELSAT	European Telecommunication Satellite Organization
FEC	Forward error correction
GMS	Geostationary Meteorological Satellite
GRACYAS	Caribbean and South American Aeronautical Fixed Service Regional Planning Group
GTS	Global Telecommunications System
HF	High frequency
IA	International Alphabet
ICAO	International Civil Aviation Organization
INMARSAT	International Maritime Satellite Organization
INTELSAT	International Telecommunications Satellite Organization
IOR	Indian Ocean INTELSAT
ITA	International Telegraph Alphabet
ITU	International Telecommunications Union
Ku-BAND	14/12 GHz
MDD	Meteorological data distribution
METAG	Meteorological Advisory Group
METEOSAT	Meteorological satellite
MID	Middle East
MTN	Main telecommunication network
NAM	North American
NAT	North Atlantic
NMTN	National meteorological telecommunication network
NOTAM	Notices to airmen
OPMET	Operational meteorological
PDN	Public data network
PTT	Postal telephone and telegraph administrations
RAFC	Regional area forecast centre
RAN	Regional air navigation
RMTN	Regional meteorological telecommunication network
RPG	Regional Planning Group
RPOA	Recognized private operating agency
RTH	Regional telecommunication hub
SIGWX	Significant weather
SITA	Societe Internationale de Telecommunications Aeronautiques
STO	Standard time of observation
UTC	Universal co-ordinated time
VSAT	Very small aperture terminals
WAFC	World area forecast centre
WAFS	World area forecast system
WMC	World meteorological centres
WMO	World Meteorological Organization
WWW	World Weather Watch

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Chapter 1
INTRODUCTION

GENERAL

1.1 The importance to the aeronautical community of accurate and timely meteorological information cannot be over-emphasized. The objective and means of provision of meteorological service are given in ICAO Annex 3 — *Meteorological Service for International Air Navigation:*

> "The objective of meteorological service for international air navigation shall be to contribute towards the safety, regularity and efficiency of international air navigation.
>
> This objective shall be achieved by supplying operators, flight crew members, air traffic service units, search and rescue service units, airport management and others concerned with the conduct or development of international air navigation with the meteorological information necessary for the performance of their respective functions."

1.2 One of the main reasons for the development of the WAFS was the urgent need to ensure the availability of standardized and high quality forecast data at all aerodromes serving international civil aviation operations.

1.3 Radio weather broadcast systems continued in use into the 1980s because of the inability of existing traditional networks to provide the necessary meteorological service in some areas of the world. However, radioteletypewriter and analogue facsimile high frequency (HF) broadcasts cannot satisfactorily meet operational requirements with respect to quantity, quality, timeliness and reliability. Thus, HF broadcasts are considered inappropriate for use in disseminating WAFS data.

1.4 Throughout this circular, the term "satellite broadcast" is used interchangeably with "point-to-multipoint telecommunications via satellite" as defined in International Consultative Committee for Telegraph and Telephone (CCITT) Recommendation F.140 (Appendix 1):

> "*Definition of service.*— International point-to-multipoint telecommunication service via satellite is defined as a service provided to a customer by Administrations for the transmission for example, of text, photographs or data via a satellite for the reception at a multiplicity of destinations by receive-only earth stations."

BACKGROUND

1.5 The concept of the area forecast system was outlined by the Meteorology and Operations Divisional Meeting (1964). Subsequent divisional meetings and air navigation conferences developed the framework of the system and regional area forecast systems were initiated, being completed in 1973. At the Eighth Air Navigation Conference in 1974, it was recommended that a two-part review of the area forecast system be undertaken in order to achieve, as far as practical, a unified world-wide system.

1.6 The first part of the review involved fact-finding and was undertaken by the Secretariat. It resulted in the publication in 1980 of ICAO Circular 159, *A Report on the Area Forecast System*. The second part involved the setting up of the Area Forecast Panel (AFP) to advise on the planning of a more efficient, uniform and economical area forecast system in respect to availability, coverage, reliability, timeliness and cost-effectiveness.

1.7 The AFP held two formal meetings, the first in January 1980 and the second in September 1981. The second meeting in particular addressed telecommunication arrangements for the dissemination of WAFS products and included a proposal for the use of a satellite broadcast system based on International Telecommunications Satellite Organization (INTELSAT) satellites. The panel also recognized that there were a number of prerequisite tasks which needed to be completed before any such system could be introduced. The ANC in reviewing the AFP/2 Report agreed to refer the recommendations to the 1982 Communications/Meteorology Divisional Meeting (COM/MET DIV 82) for consideration.

1.8 COM/MET DIV 82 agreed that a satellite system appeared to be capable of satisfying the operational requirement for the dissemination of area forecast products in the final phase of the WAFS implementation. The meeting recognized that although the telecommunication capability to implement the satellite concept was available, many jurisdictional, administrative, technical and procedural matters needed to be resolved, and recommended that a study be undertaken of "a concept and its implementation according to which the world area forecast system configuration would be based on satellite broadcast." This circular is directed at satisfying the need for that study.

1.9 COM/MET DIV 82 visualized an initial phase composed of two world area forecast centres (WAFCs), each to be a back-up for the other, and a number of regional area forecast centres (RAFCs), each to be associated with one WAFC.

1.10 Further, COM/MET DIV 82 visualized a final system to comprise the following:

a) two WAFCs, each generating global area forecast system products;

b) uplinks to an appropriate international satellite system and broadcast of area forecast system products; and

c) national reception, processing and distribution of area forecast system products.

RAFCs would no longer exist. A global satellite broadcast dissemination system was visualized as the cornerstone of the final phase of WAFS. Each WAFC would prepare global forecasts of upper winds, upper-air temperatures and significant weather (SIGWX).

1.11 The ANC, in reviewing the COM/MET DIV 82 report (Doc 9367) and subsequent Secretariat proposals, established the Aeronautical Fixed Service Systems Planning for Data Interchange Panel (ASPP) in June 1984. At its first meeting, the ASPP established Working Group 2, based on its terms of reference, a request from the ANC relative to high priority, and the referral to the panel by the ANC of applicable recommendations of COM/MET DIV 82. Working Group 2 assumed the associated work programme regarding the refinement of the satellite broadcast concept which was to be completed prior to the convening of, and to be considered by the second meeting of the ASPP.

ASPP TERMS OF REFERENCE

1.12 The ANC established the ASPP to undertake tasks approved by the ANC concerning:

a) development of world-wide plans for the evolutionary development of the AFS to meet the operational requirements for data interchange of all AFS users including the WAFS;

b) the study of alternatives available to ICAO for co-ordination of AFS data interchange implementation and planning; and

c) monitoring of AFS data interchange regional planning and implementation activities and development of solutions to problems arising with these aspects of the AFS.

ASPP WORK PROGRAMME REGARDING THE SATELLITE BROADCAST SYSTEM

1.13 Some of the items to be included in the study were:

a) agreement of provider States to implement WAFCs and associated support communications;

b) agreement of user States to implement complementary facilities;

c) generation of SIGWX forecasts in the format of grid point data in digital form;

d) analysis of traffic volume and resultant determination of modulation rate necessary to complete timely broadcast of area forecast products and the scheduling of periodic rebroadcast;

e) cost of a satellite broadcast and regulatory implications;

f) use of established telecommunications systems;

g) analysis of message format and refinement as necessary for satellite broadcast and selective reception;

h) selection of a protocol to be applied;

i) selection of forward error correction (FEC) coding techniques to be applied, as necessary;

j) amendment to Annexes 3 and 10 and other related ICAO and World Meteorological Organization (WMO) documents; and

k) transition from initial to final phase.

ASSUMPTIONS

1.14 During the course of this study, the following assumptions were made:

a) the automation of generating SIGWX forecasts in the format of grid point data in digital form will become operational;

b) States will regulate receive-only earth stations;

c) regulatory constraints will not prevent reception of the satellite broadcast in States desiring to receive the WAFS transmission;

d) provider States and user States will provide sufficient resources to support the satellite broadcast system;

e) WAFS products will be transmitted in the form of grid point data in digital form;

f) both WAFCs will transmit WAFS products in the same format and code; and

g) the volumes of data to be distributed are as listed in 5.2 of this circular.

CURRENT SYSTEMS FOR WAFS DISSEMINATION

1.15 The current systems used to disseminate WAFS products both nationally and internationally are identified in Table 1-1. While there are a wide variety of telecommunication means used, the WMO's Global Telecommunications System (GTS), as described below, is the main system used at present. However, this system is not set up to disseminate civil aviation weather products, that task being the responsibility of the aeronautical fixed service.

1.16 The WMO GTS has been designed as an integrated network for global collection, exchange and distribution of meteorological information in alphanumeric, binary and pictorial form (processed and unprocessed data). It is organized on a three-level basis, namely:

a) the national meteorological telecommunication networks (NMTN) for national collection and distribution within each State;

b) the regional meteorological telecommunication networks (RMTN) for collection, exchange and distribution within the six regions of WMO; and

c) the main telecommunication network (MTN) linking together the world meteorological centres (WMC) as well as designated regional telecommunication hubs (RTH) for interregional and global collection, exchange and distribution.

Thus, it is organized to accommodate the volume of basic (non-aviation) meteorological information to meet the requirements of world, regional and national meteorological centres and services.

1.17 For the MTN and the RMTNs, dedicated circuits employing data-signalling rates of up to 9 600 bits per second are in operation and NMTNs are developed to ensure an efficient flow of traffic over the GTS.

1.18 In consequence of the growing volume of processed data derived from increased computer utilization of data from meteorological satellites and its inclusion in the models for automated forecasting, some RTHs have recently implemented, or plan to implement, data-signalling rates up to 19 200 bits per second for the exchange between centres where required. Furthermore, upgrading to total telecommunication capacity of 64 000 bits per second between centres is under consideration in order to facilitate the early availability of the data.

1.19 Due to the fact that there are areas where the current GTS point-to-point circuits are not adequate, WMO has decided to integrate the GTS data collection and data distribution systems provided by geostationary meteorological satellites. Furthermore, WMO is studying the use of point-to- multipoint telecommunication services via satellite to complement the existing GTS point-to-point circuits, as well as the use of two-way multiple access service via satellite to meet the GTS requirements in some areas.

Table 1-1. Current systems for the dissemination of WAFS products

Product	*Telecommunication means*
Upper wind/temperature forecasts for grid points	GTS Bilateral circuits
Forecasts in chart form	GTS Radio broadcasts Bilateral circuits Satellite point-to-multipoint systems Public data networks
Forecasts in alphanumeric form	Aeronautical fixed telecommunication network (AFTN) Bilateral circuits

Note 1.— Forecasts in pictorial form are distributed by analogue and coded or non-coded digital facsimile techniques.

Note 2.— Satellite point-to-multipoint systems and public networks are used for national distribution.

Note 3.— Upper wind/temperature forecasts are distributed in these code forms:

a) character-oriented, GRID code;

b) bit-oriented, GRIB code; and

c) character-oriented, aviation digital forecast (ADF) code (to airlines for flight planning purposes).

1.20 Circuits of the GTS are efficiently used in a number of regions for regional and interregional distribution of WAFS products, while in other parts of the world, national meteorological services still rely on radio broadcasts (radioteletypewriter and analogue facsimile) and low-speed circuits (teletypewriter) or receive them in chart form only. In those areas where the GTS has been well developed to meet the requirements of world, regional and national meteorological services, the capacity exists to carry a limited degree of WAFS products, even though the GTS does not have a requirement to carry WAFS products.

1.21 Mainly coded data are exchanged on the GTS, with a negligible amount of traffic in plain language. Numerous codes are in use depending on the type of data (e.g. land, sea, upper-air, from satellite observations; forecasts for stations, surface, upper-air at various heights). These codes have been developed within WMO, which is responsible for the coding of meteorological information for the purposes of exchange and representation. For the distribution and representation of the upper-air forecasts for grid points (grid point data in digital form) produced by the WAFCs, the character-oriented GRID form and the binary GRIB form are currently in use.

Chapter 2
REQUIREMENTS

The WAFS is planned and implemented to meet the requirements of users regarding area forecasts needed for pre-flight planning and flight documentation. With regard to the distribution of area forecast products using different telecommunication means (terrestrial networks and/or satellite broadcast systems), it is essential to take into account the user requirements, the system requirements and the topology of the system.

USER REQUIREMENTS

2.1 The different types of products and services which are to be provided by the WAFS centres are described in detail in Chapters 3 and 11 of Annex 3, *Meteorological Service for International Air Navigation.* The objectives, components and recommendations contained in these chapters are the result of discussions and agreements between providers and users reflecting the user requirements and the methods of fulfilment. With respect to the distribution of the products, Chapter 11 of Annex 3 refers to telecommunication requirements in general terms only. Moreover, it is agreed that refinements could be brought into operation subject to regional agreements and/or agreements between the centres and users.

2.2 In addition to the primary tasks of producing and distributing WAFS products, there are a number of important timing considerations, including the following:

a) WAFS products must be available at the users' site nine hours prior to commencement of the valid time of the forecasts; and

b) centres require two distinct time frames: one for data collection and the production of the forecasts and another for their distribution.

Consequently, there is the necessity for high transmission rates to accommodate large volumes of data within acceptable transit times.

2.3 The dissemination has to be reliable to ensure that users will receive the products according to their requirements. This may involve repetitions of the dissemination to cover cases of equipment failure.

2.4 As long as there is the need to transmit parts of the WAFS products in chart form, they must be sufficiently legible when received to permit ready reproduction.

2.5 The following is a summary of required WAFS products:

a) Global forecasts of upper wind and temperatures per Annex 3, 3.3.2.4, at ten different flight levels and maximum wind speed and tropopause height for grid points (in the format of grid point data in digital form). The data are produced and issued in digital form twice a day by the two WAFCs.

b) SIGWX forecast charts. Until the automation of SIGWX forecasts in the format of grid point data in digital form is implemented, the RAFCs must continue to produce and supply the SIGWX charts four times a day according to four different validity times. Segments of SIGWX charts are produced and exchanged four times a day between the RAFCs as the basis for the preparation of the above SIGWX charts.

c) Upper wind and temperature charts for the different levels. The RAFCs, after receipt of the grid point data, convert them into chart form and distribute them four times a day for the four different validity times.

2.6 The number of wind, temperature and SIGWX charts, which at present have to be produced and supplied by an RAFC for each level and for each of the four validity times per day, depends on the service area allocated to the RAFC(s). The number varies from service area to service area and from RAFC to RAFC; however, there will be approximately twenty for each of the four validity times per RAFC.

2.7 The products and services described in Chapter 3 of Annex 3 and summarized above are based on the "initial phase" of the WAFS concept as developed by COM/MET DIV 82. The products and services are also applicable to the interim phase defined in this circular (see Chapter 3).

2.8 According to the COM/MET DIV 82 report, the "final phase" of the WAFS is due for implementation when the significant weather forecasts are produced objectively by computer in the format of grid point data in digital form by the two WAFCs (see 3.4 and 3.5). Then, there will no longer be a requirement for the services of the RAFCs (i.e. the production of the SIGWX charts and the conversion into upper wind and temperature charts as well as the distribution of these charts) because the WAFCs will issue all these forecasts in the format of grid point data in digital form.

2.9 The above concept for the final phase, however, will only be applicable when users are in the position to handle the grid point data for wind, temperature and SIGWX forecasts by converting the grid point data into chart form in accordance with the variety of required areas of coverage. Recognizing that the current situation indicated this capability may not be feasible in the near term, there will still be a continuing need for the supply of the forecasts in chart form. This could be accomplished either by the two WAFCs if their distribution capabilities ensure the timely availability of the variety of forecast charts, or by the RAFCs supplying their areas of responsibility.

2.10 The production of grid point data (the above global wind and temperature, tropopause, height and maximum wind forecasts) is based on the global meteorological observations made at 0000 UTC and 1200 UTC. These basic data are collected and transmitted to the two WAFCs via the WMO's GTS.

2.11 Users requiring the grid point data for computer flight planning and RAFCs as a prerequisite to preparation of the wind/temperature charts need the grid point data, at the latest, five hours after the above standard time of observation (STO, i.e. 0000 UTC and 1200 UTC). Thus, only five hours are available for the collection of the global basic data, the calculation of the grid point data and their distribution to RAFCs and users.

2.12 The grid point data are produced and disseminated twice a day. The data are valid for 12, 18, 24 and 30 hours after each STO.

2.13 For the period the RAFCs are in full operation, they are responsible for:

a) the supply selectively of grid point data to the user for preparation of forecast charts;

b) preparation of forecast charts from the grid point data;

c) preparation of SIGWX charts; and

d) the provision of these charts to user States (and end users) within their respective service areas.

2.14 The users need the forecast charts nine hours before the validity time. Thus, an RAFC has only four hours to prepare the segments of SIGWX charts, exchange them with the adjacent RAFCs, prepare as the result of this exchange the SIGWX charts and distribute these charts to the users. The number of SIGWX charts to be produced by an RAFC depends on regional agreements.

SYSTEM REQUIREMENTS

2.15 WAFS satellite broadcast system requirements should be based on the following:

a) a minimum number of uplinks;

b) no technical limit on the number of receivers;

c) forward error correction;

d) small receiving antenna;

e) service access control;

f) selective reception of products;

g) distribution of grid point data in digital form and graphical products in coded digital facsimile form in the interim phase;

h) global coverage; and

i) back-up capability (WAFC facilities and associated telecommunications).

TOPOLOGY

2.16 Topology may be defined as the structure of the system which provides a service to the users. There are a number of factors which need to be taken into account when determining the optimum topology of a system. These factors include:

a) the number of users and their geographical distribution;

b) data throughput requirements, in particular, peak load;

c) reliability and availability;

d) expandability;

e) cost;

f) regulatory constraints; and

g) joint use of the system with WMO.

2.17 For the purpose of this circular, the proposals for the topology of the satellite broadcast system are confined to the user requirements, i.e. the variations with respect to the means of receiving the data. In this respect, there are two options as follows:

a) reception of data at national earth station(s) for processing and onward transmission to users via national dissemination systems; and/or

b) reception of data by users via direct access to the broadcast.

2.18 It is proposed that planning for the topology of a satellite broadcast system should be based on the following:

a) the satellite broadcast system should be capable of providing service to all ICAO Contracting States from satellites in geostationary orbit;

b) no special consideration should be given to providing access to a State not covered by a) above;

c) the provision of a satellite broadcast system for the dissemination of WAFS products should not inhibit a State from making alternative arrangements to receive the data, as may be available; and

d) determination of implementation responsibilities and distribution arrangements should be organized at least initially at the regional level.

2.19 With respect to the foregoing topology considerations, there will be a need to determine the following:

a) uplink responsibility;

b) downlink responsibility;

c) the number and distribution of users intending to receive the satellite broadcast;

d) user requirements with respect to the whole range of WAFS products; and

e) policy or regulatory restrictions with respect to the installation and operation of small receive-only earth stations at user's premises.

Chapter 3

TELECOMMUNICATION SUPPORT FOR THE WAFS SYSTEM

The introduction of satellite broadcast technology for the dissemination of WAFS products has been considered in two phases: namely, when RAFCs as well as WAFCs are in operation and, at a later date, when only WAFCs are in use. These two situations are described below and are referred to as the telecommunication support for the interim and final phases of the WAFS system, respectively.

INTERIM PHASE

3.1 The requirements to be met in the interim phase are as follows:

a) supply of WAFC products to RAFCs, States and end users;

b) supply of wind and temperature charts to States and end users;

c) supply of SIGWX charts to States and end users; and

d) exchange of SIGWX charts and segments between RAFCs, as appropriate.

3.2 In order to meet the WAFS supply requirements in the interim phase, the concept is as follows:

a) WAFCs disseminate WAFS products in coded form through a suitable satellite broadcast system so that it shall be possible for RAFCs, States and end users to receive the products at small receive-only terminals. It shall also be possible, as an option, for States and end users to have access to WAFS products supplied by a RAFC through a suitable alternative satellite broadcast system.

b) WAFCs disseminate wind, temperature and SIGWX charts through a suitable satellite broadcast system so that it shall be possible for RAFCs, States and end users to receive the charts at small receive-only terminals. The WAFCs receive the charts from RAFCs via terrestrial or satellite links. It shall also be possible, as an option, for States and end users to have access to charts supplied by a RAFC through a suitable alternative satellite broadcast system.

c) SIGWX charts and segments should be exchanged between RAFCs, as agreed, using the WMO's GTS or other point-to-point communications links.

The concept for satellite broadcast of WAFS products in the interim phase is illustrated in Appendix 2.

3.3 The scenario and options for the distribution of WAFS products from the WAFC in the interim phase are as follows:

a) The interim phase of WAFS product distribution will use different telecommunication means to meet the requirements for the supply of WAFS products to RAFCs, States and end users. The telecommunication means will include global and regional satellite systems, AFTN (those elements of the AFTN employing Common ICAO Data Interchange Network (CIDIN) protocol), GTS and radio broadcast.

b) Prior to the production of SIGWX forecasts in the format of grid point data in digital form, there will be a continuing need for RAFCs to prepare the SIGWX charts for the area of coverage assigned to them. These SIGWX charts and the wind and temperature charts may, as appropriate, be uplinked to serve regional needs.

The scenario and options are shown in Appendix 3.

FINAL PHASE

3.4 In the final phase, the requirement is for WAFCs to supply WAFS grid point data in digital form, including wind, temperature and SIGWX forecasts, to States and end users.

3.5 In order to meet the WAFS transmission requirements in the final phase, WAFCs are to supply WAFS products in the format of grid point data in digital form through a suitable satellite broadcast system(s) so that it shall be possible for States and end users to receive the products at small receive-only terminals on a global basis.

The concept for satellite broadcast of WAFS products in the final phase is illustrated in Appendix 4.

Chapter 4
SYSTEM CONCEPT

GENERAL

4.1 In 1988 CCITT adopted Recommendations F.140 and D.185 for one-way point-to-multipoint telecommunication services via satellite (Appendices 1 and 4). A satellite broadcast system utilized for the dissemination of WAFS products should conform to these recommendations.

TECHNICAL DESCRIPTION

4.2 There are a number of system options that can be identified for the broadcast of WAFS data. These include:

a) 6/4 GHz (C-band) international system using INTELSAT satellites;

b) 14/12 GHz (Ku-band) international system using INTELSAT satellites;

c) 14/12 GHz (Ku-band) regional systems using national/regional satellites;

d) 6/4 GHz (C-band) national and 14/12 GHz (Ku-band) regional using national/regional satellites; and

e) 6/4 GHz (C-band) national and 14/12 GHz (Ku-band) international system using INTELSAT satellites.

4.3 The following factors were considered in the selection of the satellite system to be used for the WAFS satellite broadcast system:

— coverage area
— reliability
— availability
— back-up facilities
— ease of implementation
— regulatory approval
— expandability
— cost of satellite broadcast system
— cost of receiving equipment

4.4 Although all parameters were not evaluated in detail because of the various carrier systems and services offered, it would appear from a preliminary review that a 6/4 GHz (C-band) international system using INTELSAT satellites is a viable option. It meets the critical requirements for global coverage and is cost-effective for domestic ownership and distribution requirements. The 14/12 GHz (Ku-band) system is not considered feasible at this time due to signal attenuation in rain and the antenna size required to serve fringe areas.

Sub-system design

4.5 The technical parameters of the uplink, receive-only earth station and operating environment should include the following:

a) uplink design parameters:

1) uplink location: to be determined;
2) frequency: 6 GHz (C-band);
3) capacity: aggregate 9 600 bits per second channel;
4) bit error rate: 1 in 10^7 for 99.95 per cent availability;
5) modulation: spread spectrum;
6) redundancy: satellite earth station, inclusive of high power amplifier and power supply; satellite;
7) error correction: forward error correction techniques; and
8) availability: 99.95 per cent, exclusive of sun transit outage, or 4 hours per year;

b) receive-only earth station design parameters:

1) frequency: 4 GHz (C-band);
2) capacity: aggregate 9 600 bits per second channel;
3) modulation: spread spectrum;
4) gain/temperature: 20 db/°K;
5) error correction: forward error correction techniques;
6) dish diameter: 0.6 to 2.5 m;
7) redundancy: user option; and
8) electrical interface: RS232-DCE/U28; and

c) operating environment:

1) steady wind: 100 km/h;
2) maximum wind: 185 km/h;
3) temperature: −40 to +55° C;
4) radial ice build-up: 0.5 cm.

RESPONSIBILITIES

4.6 Elements of service (Appendix 1) for a point-to-multipoint telecommunication service for the dissemination of WAFS products via satellite will be as follows:

a) the providers of information;

b) the link between the providers and the control management centre;

c) the control management centre which uses various transmission means in order to collect, address and multiplex the information from the providers;

d) the transmit earth station;

e) the transponder of a satellite;

f) one or several receive earth station(s); and

g) the links from the receive earth stations to the users' equipment.

The WAFC provider States will be responsible for ensuring the proper operation of elements of service a) through e). The user States will be responsible for ensuring the proper operation of elements of service f) and g).

4.7 Further, in any satellite broadcast system used for the dissemination of WAFS products one additional element of service would be appropriate, i.e. end user telecommunication equipment. The responsibility for this equipment rests with the user States, but may be delegated to the end user.

4.8 The conditions for use of transmit and receive earth stations and links conveying the information flow as well as the distribution of the WAFS products to the end user remain national matters to be determined by the competent authority in each State.

Chapter 5
SATELLITE SYSTEM DESCRIPTION

REQUIREMENTS

5.1 The following are the technical requirements that would be satisfied by a satellite broadcast system.

Data volumes

5.2 The following paragraphs contain estimates of data volumes involved in distributing WAFS products. The figures are based on the assumption that the system will need to broadcast global products and as such represent the maximum requirements according to Annex 3, through Amendment 68.

5.3 Forecasts for grid points in digital form

a) Parameters (3)	wind U-component wind V-component temperature
b) Flight levels (10)	50, 100, 180, 240, 300, 340, 390, 450, 530, 600 tropopause height speed and height of maximum wind
c) Forecast periods (4)	12, 18, 24, 30 hours after the times of synoptic data (0000 UTC and 1200 UTC) on which the forecasts are based
d) Coverage	4 global sectors
e) Number of bulletins	1 056 per day
f) Bulletin length	1 417 bytes/bulletin
g) Byte length	8 bits/byte
h) Data volumes	approximately 12 megabits per day (6 megabits twice per day)

5.4 SIGWX charts

a) Areas of coverage (9)	6 mercator projection 3 polar sterographic projection

b) Validity times (4) ---------- 0000 UTC, 0600 UTC, 1200 UTC, 1800 UTC

c) Number of charts ---------- 36 per day

d) Data volumes ---------- uncompressed 144 megabits per day
---------- T4 encoded 29 megabits per day

5.5 Wind/temperature charts

a) Areas of coverage (9) ---------- 6 mercator projection
---------- 3 polar sterographic projection

b) Validity times (4) ---------- 0000 UTC, 0600 UTC, 1200 UTC, 1800 UTC

c) Flight levels (10) ---------- 50, 100, 180, 240, 300, 340, 390, 450, 530, 600

d) Number of charts ---------- 360/day

e) Data volumes ---------- uncompressed 1 440 megabits per day
---------- T4 encoded 290 megabits per day

5.6 Table 5-1 clearly relates the data volumes to time using a 9 600 bits per second channel.

Table 5-1. WAFS volume-time chart

WAFS product	*Volume megabits/day*	*Time units/day*
Grid points	12	21 minutes
SIGWX		
Uncompressed	144	4 hours, 12 minutes
T4 encoded	29	50 minutes
Wind and temperature		
Uncompressed	1 440	41 hours, 40 minutes
T4 encoded	290	8 hours, 20 minutes

5.7 *Future changes.* The second meeting of the WAFS Study Group considered changes to the WAFS requirements indicated below which, if adopted, will affect the data volumes per production run of the forecasts for grid points in digital form accordingly.

a) New requirements.

1) Spatial density (doubling horizontal resolution)
Multiplication factor = 4.0

2) Number of flight levels (increase from 10 to 15)
Multiplication factor = 1.5

b) Future requirements under study.

1) Number of validity times (increase from 4 to 6)
Multiplication factor = 1.5
2) Production run frequency (increase from 2 to 4)
Multiplication factor = 2.0

For example, if all the WAFS Study Group's proposals were adopted, this would mean a nine-fold increase to the data volumes of the forecasts for grid points in digital form.

c) SIGWX automation.

The automatic forecasting of SIGWX in the format of grid point data in digital form will result in an additional data volume increase per production run of 16 megabits.

The meeting recognized that there may be further future changes.

Performance

5.8 The system shall have sufficient capacity to handle the data volumes identified in 5.3 through 5.5 above in a timely manner, e.g. grid point data in digital form to be transmitted at intervals of not more than thirty minutes.

5.9 Since user sites throughout the world must be able to reliably receive data during all weather conditions, it is imperative that the performance of the system not be adversely affected by commonly encountered weather environments. The C-band (6/4 GHz) frequencies are recommended because of the performance advantage they provide in heavy rain environments (common in many parts of the world) compared to Ku-band (14/12 GHz) frequencies.

5.10 In order to minimize the possible adverse effect of radio frequency interference on earth station receiving antennas, a robust technology such as spread spectrum encoding/decoding is recommended. An additional advantage of this technology is the availability of very small, low cost receiving earth stations. The spread spectrum technology also affords resistance to interference from conventional microwave transmitters found in many urban environments.

Data integrity

5.11 Satellite transmissions are highly reliable. A corrected bit error rate (BER) of 1 in 10^7 using FEC is considered adequate for the exchange of alphanumeric data or binary data in coded form.

Throughput and channels

5.12 When weather graphics (i.e. charts) are to be transmitted via the satellite broadcast, a data rate of 4 800 bits per second will be adequate using T4 compression techniques, based on the data volume requirements of Annex 3 through Amendment 68.

5.13 A data rate of 4 800 bits per second will be adequate for the twice daily transmission of grid point data in digital form, based on the data volume requirements of Annex 3 through Amendment 68.

Reliability and availability

5.14 Because the meteorological data to be distributed via the WAFS global satellite broadcast system are essential to flight planning operations, and therefore to flight safety, it is imperative that the system consist of high reliability elements leading to a high over-all system availability. Hence, it is considered essential that a full-time, non-pre-emptible protected satellite service in accordance with CCITT Recommendation F.140 and D.185 (Appendices 1 and 8) be provided.

Back-up arrangements

5.15 Washington and Bracknell WAFCs currently have the capability to back up each other from the standpoint of generating grid point data forecasts of winds and temperatures which are the meteorological data products of importance to aviation. Recognizing the need for assurance that the WAFS data will always be available, alternate means of feeding data from either of the WAFCs to all satellite uplink sites should be provided.

Product scheduling

5.16 A priority scheduling system will be utilized based on user requirements for the transmission of WAFS products and for the clearing of WAFS products after an outage.

5.17 Grid point data will be routinely retransmitted at the completion of the normal transmission cycle and after a defined break period, provided time is available.

5.18 As soon as WAFS products become available, they will be uplinked by the WAFCs. Hence, users must be ready to receive data at all times.

Data formats and addressing

5.19 Because the inherent characteristic of the satellite broadcast system is a data stream which will be received by all user receiver sites, explicit addressing of data is neither required nor appropriate. All data will be transmitted utilizing standard WMO data codes, formats and identifiers. User receiver terminals will have the capability of decoding the message headers contained in the incoming data stream and, hence, of selectively extracting the information of interest to local users.

User access

5.20 Control of user access to the satellite broadcast data stream is through the use of appropriate control signals sent from the control management centre of the satellite broadcast system.

NETWORK MANAGEMENT

Monitoring

5.21 Each WAFC provider State is responsible for the monitoring of the satellite broadcast system.

5.22 Responsibilities will include the monitoring of facilities, user access, data integrity and problem resolution in order to provide a high degree of service reliability. In keeping with CCITT recommendations, the telecommunication agencies providing the satellite service are expected to provide management services in order to meet published service levels. These services are normally detailed in contractual arrangements between the service provider and the service subscriber.

5.23 In addition to these contracted services, each WAFC provider State should have a receiving earth station monitoring the uplink transmission to ensure integrity of the WAFS data. This end-to-end monitoring will confirm that all elements of the satellite broadcast system are operating satisfactorily.

5.24 Each WAFC provider State should maintain statistics on data volumes, queues, service availability, user access and other operational aspects in order to support the users of the satellite broadcast system.

Administration

5.25 WAFS products to be distributed by satellite broadcast should follow a published schedule based on the times of availability of the products and the requirements of the users with respect to validity time of the products.

5.26 Changes to the content or scheduling of the broadcast programme will need to be co-ordinated and introduced after due notification. The most appropriate means of notification will be to use the satellite broadcast facility.

5.27 To ensure that the satellite broadcast system will be responsive to the changing needs of Contracting States and others concerned with the meteorological service it provides, ICAO should co-ordinate, with the appropriate organizations, aspects of the satellite broadcast system, including requirement changes, product priorities and scheduling.

Maintenance and repair

5.28 The WAFC provider States shall be responsible for maintaining maximum availability of the satellite distribution systems. Each WAFC provider State will be responsible for working closely with the satellite service providers to ensure that any system anomalies are quickly corrected and that over-all system performance is maintained at high levels.

5.29 Procedures should be available and agreed by WAFC provider States for alternate routing of WAFS products in the event of production computer outages in excess of three hours. These procedures should be tested by the WAFC provider States at least twice annually.

5.30 Maintenance activities on either the uplink earth station or the production computer system should be scheduled during quiet periods between production runs. Users should be notified in advance of any

scheduled maintenance outages and of expected time of restoration. Notification should be by systems message on the satellite broadcast system and by notices to airmen (NOTAM). Scheduled maintenance should be co-ordinated between the WAFC provider States to ensure that both systems are not taken down at the same time.

5.31 WAFC provider States should provide information on unscheduled outages by message on the satellite broadcast system upon restoration of the service.

5.32 Users are responsible for monitoring receiving terminal equipment and for reporting problems directly to the vendor or agency responsible. The WAFC provider States are not responsible for user equipment. The decision on leasing versus purchasing as well as spares, redundancy and maintenance is a user responsibility.

Chapter 6
IMPLEMENTATION AND OPERATIONAL ASPECTS

SATELLITE SERVICES

6.1 Satellite-based telecommunication services which are available and operational include the International Telecommunications Satellite Organization (INTELSAT), the International Maritime Satellite Organization (INMARSAT) and a number of domestic and regional telecommunication satellites. Meteorological satellites also provide for meteorological data collection and distribution systems within the framework of the WMO World Weather Watch (WWW) System.

International Telecommunications Satellite Organization (INTELSAT)

6.2 INTELSAT was established in 1964 when eleven countries agreed to form a single global commercial telecommunication satellite system. INTELSAT is responsible for the design, development, construction, establishment, operation and maintenance of the space segment of its global system. Earth stations are owned and operated by postal telephone and telegraph administrations (PTT) or recognized private operating agencies (RPOA) in the countries where they are located.

6.3 The INTELSAT system consists of high capacity telecommunication satellites stationed in geostationary synchronous orbit over the Equator, 35 584 km above the Atlantic, Pacific and Indian Oceans. From these positions, each of the satellites serves an area larger than one-third of the earth's surface, thereby providing global coverage. The satellites in the global system and the 760 earth stations operating with them provide some 1 800 pathways, or direct telecommunication links, between more than 170 countries, territories and possessions. A growing number of countries are also building earth stations within their boundaries and are using INTELSAT satellites to improve their domestic telecommunication systems.

6.4 In 1984, the INTELSAT Board of Governors approved new service offerings, INTELNET I (one-way) and INTELNET II (two-way), which utilize a small amount of space segment on satellites of the INTELSAT global system for data transmission. For the purposes of this circular, only the INTELNET I service will be discussed. INTELNET I provides a global interconnexion using very small aperture terminals (VSAT), creating a point-to-multipoint satellite telecommunication system. The INTELNET service has been in operation since 1984.

6.5 The INTELNET service uses spread spectrum technology with BERs typically less than 1 in 10^7. The spread spectrum technique minimizes interference from other satellite or terrestrial sources by utilizing more bandwidth than conventional signals transmitting comparable data rates. This technique permits the use of receive-only VSATs, antennas as small as 0.6 m in diameter, and low power requirements and has the ability to achieve a high degree of noise rejection. The spread spectrum technique permits reliable data transmission in the presence of strong interfering signals. The problems inherent in using a small receiving antenna are in large measure overcome by using the spread spectrum technique.

6.6 The INTELNET service is available on a full-time, part-time, occasional, pre-emptible or non-pre-emptible basis and utilizes C-band frequencies (earth-to-satellite, 6 GHz; satellite-to-earth, 4 GHz), Ku-band frequencies (earth-to-satellite, 14 GHz; satellite-to-earth, 12 GHz) and a combination of C-band (6/4 GHz) and Ku-band (14/12 GHz) frequencies. Available bandwidths include 1, 5, 9, 18, 36 and 72 MHz. A 5 MHz bandwidth provides a service having an effective nominal bit rate of not less than 9 600 bits per second. This service may be provided for periods of 1, 4 and 7 years for non-pre-emptible service and 2, 5 and 7 years for pre-emptible service.

6.7 National telecommunication agencies make use of the INTELNET service of INTELSAT to provide an international point-to-multipoint telecommunication service via satellite to its customers. On the basis that INTELSAT is a consortium of PTTs and RPOAs, use of the INTELSAT INTELNET service should, in principle, simplify obtaining local approval for licensing of receiving earth stations in those States which are INTELSAT signatories.

6.8 A micro-earth station is required to receive the INTELSAT INTELNET I service and consists of three elements:

a) a feed horn antenna;

b) a low-noise converter/amplifier; and

c) a digital receiver/controller.

6.9 Global footprints of the INTELSAT service are found in the INTELSAT/Communications Satellite Corporation (COMSAT) Satellite Beam Coverage Maps Handbook, May 1988. Typical footprints can be found in Appendices 5 to 7. These maps show the beam coverage contours superimposed on earth as seen from the geosynchronous orbit. The shaded areas represent the east and west hemi-beams while the outer rings represent the C-band (6/4 GHz) and Ku-band (14/12 GHz) global beam coverage at elevation angle contours of 0° and 5°. The 0° elevation angle contour is the theoretical extent of coverage, while the 5° elevation angle is considered to be the practical extent of coverage according to nominal design criteria.

6.10 Point-to-multipoint telecommunication service based on the INTELSAT INTELNET I service appears to provide an appropriate satellite broadcast service for the dissemination of WAFS data products which would facilitate its acceptability to State telecommunication authorities.

International Maritime Satellite Organization (INMARSAT)

6.11 INMARSAT, an international organization established in 1979, is responsible for providing satellite capability and encouraging over-all system integrity in order to provide ships with commercial and safety telecommunications linking them with the international public telecommunication network. When the amendment to their Convention is ratified, their service will be extended to include aeronautical and land mobile services.

6.12 INMARSAT has 52 Member States (parties) with an international staff in the directorate in London, England. Parties nominate telecommunication agencies (signatories) to represent their interests in INMARSAT, to provide funds to meet the capital requirements of the organization and to vote in relation to their financial shares. INMARSAT does not provide mobile service directly to end users since this is the responsibility of the PTT and RPOA signatories.

6.13 Considering that INMARSAT is concerned with provision of mobile services, it cannot be considered as a supplier of the fixed telecommunication services required for distribution of WAFS data products.

Domestic and regional telecommunication satellite systems

6.14 There are a number of commercial domestic and regional satellite systems all over the world which are in operation or are planned for operation. Regional and domestic satellite systems could possibly be used to complement or supplement an international satellite broadcast system for the dissemination of WAFS data products.

Meteorological satellites

6.15 Geostationary meteorological satellites, which are components of the space-based observing network of the WMO WWW, perform the following three primary functions:

a) imaging of the earth in a variety of resolutions and spectral bands;

b) distribution of images and image-derived data; and

c) data collection of environmental measurements from fixed or mobile data collection platforms.

6.16 In addition to these primary functions, some geostationary meteorological satellites provide meteorological data distribution systems, which are integrated in the GTS of the WWW to complement point-to-point circuits. Such systems are currently being developed for two satellites, of the meteorological satellite (METEOSAT) system.

6.17 METEOSAT, operated by the Organization for the Exploitation of Meteorological Satellites (EUMETSAT), became operational in 1989 and provides a meteorological data distribution (MDD) system. The geostationary meteorological satellite is located at 0° longitude. The METEOSAT operational programme series includes a MDD mission, consisting of four digital channels operated at 2 400 bits per second. The first satellite of this series was launched in March 1989. The first phase of implementation of the MDD mission consists of two channels, one for distribution of meteorological observational data and processed information in alphanumeric and binary form, and the other for distribution of graphical products in coded digital form (CCITT Group 3 code). The uplink stations will be operated by the RTH Rome and RTH Bracknell. An MDD receiving station includes a dish of about 2.5 m (which can be the same used for reception of satellite images), a receiver, a microcomputer and appropriate display and hard copy units. The receiving station provides for selection of the required data and can be interfaced to the telecommunication equipment of the national meteorological centre. An in-orbit back-up satellite will be launched in 1991. METEOSAT will be capable of WAFS dissemination in some regions of the world.

6.18 The Geostationary Meteorological Satellite (GMS), operated by Japan, will provide the dissemination of WWW-processed information in grid point form and graphic form. The GMS is located at 140°E. The Japanese Meteorological Agency plans to implement a data distribution service for the distribution of WWW products in grid point form and coded digital facsimile form, elaborated by the WWW Regional Specialized Meteorological Centre Tokyo. The data signalling rate will be 4 800 bits per second, and the channel will be multiplexed with weather facsimile transmission. The receiving station will consist of a standard weather facsimile receiving station, complemented with appropriate demodulator, microcomputer

and terminals. Back-up facilities (ground, space) are not available. Due to the operational time required to perform the primary function of the GMS, time will not be available to transmit WAFS products. Consequently, the GMS will not be capable of WAFS dissemination.

ORGANIZATION

6.19 The satellite broadcast distribution system is so closely tied to the two WAFC provider States that implementation and operations should be directly under their control. The WAFC provider States should administer the technical aspects of the satellite broadcast system. This circular does not consider what, if any, additional resources or change in organization the WAFC provider States may require to allow them to undertake these responsibilities.

6.20 User States are expected to arrange for reception of the WAFS service. While footprints of the INTELSAT INTELNET I service provide global coverage, some States within a given footprint may elect not to support this service through national regulatory constraints. In such limited cases, alternative arrangements will be necessary; this subject is not addressed in this circular.

REGULATORY IMPLICATIONS

6.21 The concept of satellite broadcast distribution will be directly influenced by international regulations from the International Telecommunications Union (ITU) and by national policies on implementation of these regulations. This impact has not been considered in detail and it is incumbent on States concerned to determine if the satellite broadcast system for the distribution of WAFS products can be accommodated by national practices.

TRANSITION ASPECTS

6.22 ICAO should co-ordinate, with appropriate organizations, the transition from the present means of WAFS dissemination to the satellite broadcast system. This transition period will involve an evolutionary progression from the present systems to the final phase.

6.23 Advance information on the implementation of the satellite broadcast system is needed so that user States can take action to receive the WAFS information. It will be necessary to provide user States with sufficient information to allow them to procure the WAFS service from their PTTs and/or arrange for the end users within their State to receive the service. If it is not possible for whatever reason to provide a WAFS reception service within a State from the satellite broadcast system, special arrangements may then have to be made by such States to receive the WAFS products.

DEMONSTRATIONS OF SATELLITE BROADCAST TECHNOLOGY

6.24 Three demonstrations of satellite broadcast technology have been given at ICAO meetings. In each demonstration, a different satellite was utilized. A description of these demonstrations follows.

Lima, Peru

6.25 At the fourth meeting of the Caribbean and South American Aeronautical Fixed Service Regional Planning Group (GRACYAS/4) held in Lima in 1985, a demonstration was given of satellite broadcast technology via the INTELNET service offering of INTELSAT.

6.26 The weather data was transmitted simultaneously on three channels by multiplexing a terrestrial voice-grade link to a COMSAT standard A earth station where the signal was uplinked to the INTELSAT V Atlantic Ocean region satellite located in geosynchronous orbit at 53° W longitude. The downlink was broadcast via the global beam covering the Caribbean and South American Regions as well as eastern North America, Central America, western Europe and western Africa.

6.27 The signal was received by a receive-only micro-terminal equipped with a 1.2 m diameter antenna installed at the ICAO South American Regional Office at Jorge Chavez International Airport in Lima, Peru. The broadcast channel was multiplexed so as to derive three channels as follows:

a) 4 800 bits per second data channel — digital facsimile;

b) 1 200 bits per second data channel — grid point data using International Alphabet Number 5 (IA-5); and

c) 75 baud telegraph channel — alphanumeric data using International Telegraph Alphabet Number 2 (ITA-2).

Reception of the WAFS products was excellent on all channels.

Washington, D.C., United States

6.28 A demonstration of technology which could be used in the WAFS satellite broadcast system was given at the ASPP Working Group 2 Meeting held in Washington, D.C., in 1987. This demonstration was held in conjunction with the discussion of the experiences of the United States in disseminating weather graphics via satellite to low cost receiver earth stations.

6.29 This demonstration used a 1.5 m diameter receiving antenna on the roof of the Federal Aviation Administration building located in downtown Washington, D.C. The broadcast of weather graphic data (DIFAX — Digital Facsimile) made routinely by the United States National Weather Service was received. While a domestic satellite system provided the broadcast, the satellite technology used was identical to that used with the INTELNET I service offered by INTELSAT.

6.30 For the purpose of the demonstration, the weather charts were printed on a thermal recorder. The members of the working group were impressed with the quality of the received weather charts and the simplicity and compactness of the receiving earth station system.

Lomé, Togo

6.31 A demonstration of satellite broadcast technology for the distribution of meteorological charts was given at the Limited Africa-Indian Ocean (Communications/Meteorology/Rules of the Air and Air Traffic Services) Regional Air Navigation (RAN) Meeting which took place in Lomé in 1988.

6.32 Using an Equatorial master station, the signal was uplinked in Hong Kong to the Indian Ocean INTELSAT (IOR) satellite. The signal was received using an Equatorial C-144 micro-earth station with a 1.2 m offset receive antenna and an Alden Electronics 9315 TRT digital recorder. The resulting upper wind charts were received sharp and clear.

OPERATIONAL SATELLITE BROADCAST (POINT-TO-MULTIPOINT) SYSTEMS

6.33 Working papers describing three national satellite broadcast systems were received during the study of the refinement of the satellite broadcast concept. Those operational systems were the United States' National Weather Service's Satellite Broadcast System, France's Reseau de Transmission des Information Meteorologique and Canada's Meteorological Information Dissemination System.

Chapter 7
ALTERNATIVE MEANS OF PROVIDING SERVICE

7.1 It appears that in the final phase of WAFS there may be a mixed telecommunication environment and that the WAFS products may be made available to users by a number of different means. The alternative means could include satellite broadcast systems, AFTN (CIDIN), GTS, bilateral circuits, public data networks (PDN) and airline telecommunication systems.

7.2 Based on present requirements in Annex 3 through Amendment 68, the costs of providing service by alternative means have not been quantified because of difficulties in defining the requirements, but in a number of cases only marginal costs would be involved because the systems would be used to support other applications.

7.3 It is believed that States may wish to compare the alternative means of provision of WAFS service both from cost and performance aspects before deciding on the approach that they will adopt. Hence, it is believed that service will be initiated using various means of telecommunications and that the associated costs will then become available for comparison with satellite broadcast offerings before final decisions are made by the majority of users.

7.4 A brief description of the alternative means of providing service is as follows:

a) *AFTN (CIDIN).* Planning is in progress in some regions to upgrade the AFTN by application of CIDIN protocols as described in Annex 10, *Aeronautical Telecommunications,* Volume I. CIDIN will use packet switching techniques and protocols. In addition to providing code and byte transparency and error control, it will also include priority, multiple dissemination and end-to-end acknowledgement features. A number of States in the ICAO European, North American and North Atlantic Regions have placed contracts for CIDIN systems and initial trials commenced early in 1989. This system will be capable of supporting multiple applications including WAFS product dissemination.

b) *GTS.* The GTS of WMO, which presently supports limited WAFS product dissemination, is being upgraded to include CCITT X.25 procedures. It will, however, continue to support only limited dissemination of WAFS products in the future, since that task is the responsibility of the aeronautical fixed service (AFS).

c) *Bilateral circuits.* There are direct leased telecommunication services between RAFCs and a number of States and airlines for the delivery of WAFS products. It is expected that such connexions will continue to be used for the foreseeable future.

d) *PDNs.* PDNs are currently being used to distribute some WAFS products. It is unlikely that this mechanism would be used for chart delivery due to the cost involved.

e) *Airline telecommunication systems.* A number of airlines presently receive grid point data via the Societe Internationale de Telecommunications Aeronautiques (SITA) and the Aeronautical Radio,

Incorporated (ARINC) data networks and their own telecommunication networks. The SITA and ARINC data networks are airline-provided networks which are presently being converted to support CCITT X.25 or X.25-based procedures. It is anticipated that the SITA and ARINC networks are likely to continue to be available for this purpose, although it is believed that dissemination of charts will not be supported.

Chapter 8
IMPACT ON THE AFTN, WAFCs RAFCs AND GTS

The implementation of the satellite broadcast system for the dissemination of WAFS data products will have varying degrees of impact on the AFTN, WAFCs, RAFCs and the GTS.

AFTN

8.1 Introduction of a satellite broadcast system will provide a major improvement in the services provided for international civil aviation. However, it is expected to have minimum impact on the existing AFS since the required WAFS products are handled in abbreviated form via the AFTN or via other non-AFS facilities. Where the satellite broadcast system is not used, the improved AFTN should carry the data and be engineered to accept this significant increase in traffic.

WAFCs

8.2 The impact to the WAFC provider States with respect to the telecommunication responsibilities will be in accordance with their implementation of the interim and final phases as described in this circular.

8.3 In the final phase of the WAFS, the WAFCs will assume the functions of the RAFCs and be responsible for the production of SIGWX forecasts as part of the grid point data. The RAFCs will no longer be part of the system. The responsibilities of the WAFCs will then include making information available to States and not to RAFCs which previously had this responsibility.

8.4 Each WAFC should be able to disseminate WAFS products to all of its service area (to be defined) and be capable of providing a back-up service for the other WAFC.

8.5 The present telecommunication means to RAFCs, States and other users will be replaced by a mixed telecommunication environment including satellite broadcast systems, AFTN (CIDIN), GTS and other international means. These telecommunications means may be used to make data directly available to States and users.

RAFCs

8.6 The impact to the RAFC provider States with respect to the telecommunication responsibilities will be in accordance with their implementation of the interim and final phases as described in this circular.

8.7 In the final phase of the WAFS, the operational function of the RAFCs will be taken over by the WAFC. It is possible that when functions of the RAFCs are phased out, the RAFC provider States may retain a telecommunication role in the final phase of the WAFS in that they may provide regional distribution points for WAFS data.

GTS

8.8 The implementation of the satellite broadcast system for the dissemination of WAFS data products could have a positive impact on the GTS by providing an alternative means of telecommunications in regions where the GTS is having problems in the dissemination of meteorological information. On the other hand, in regions where the GTS has the capacity and capability to disseminate the WAFS information, the satellite broadcast system will have little impact on the GTS and could result in some duplications of telecommunication facilities for the reception of meteorological information.

Chapter 9
ICAO REGIONAL WAFS PLANNING

AFRICA-INDIAN OCEAN (AFI) REGION

9.1 The 1988 Limited AFI (Communications/Meteorology/Rules of the Air and Air Traffic Services) RAN Meeting recommended the use of a satellite broadcast system for the dissemination of WAFS products in the AFI Region. The meeting also recommended that the AFI Planning and Implementation Regional Group (APIRG), as a matter of urgency, carry out the necessary planning for the dissemination of WAFS products in the AFI Region using a satellite broadcast system. The ANC noted the recommendation for the use of a satellite broadcast system in the AFI Region and approved the recommendation that the APIRG, as a matter of urgency, plan for such a system.

CARIBBEAN AND SOUTH AMERICAN (CAR/SAM) REGION

9.2 In 1985 the fourth GRACYAS Meeting recommended that a satellite broadcast system be endorsed in principle as the means of dissemination of WAFS data in the CAR/SAM Region. This recommendation was approved by the ANC.

9.3 In 1988 the fifth GRACYAS Meeting reaffirmed its endorsement of the satellite broadcast system for the dissemination of WAFS data in the CAR/SAM Region. The group indicated that the high quality altitude data (upper wind and temperature) transmission should not be sacrificed because of the lack of availability of SIGWX forecasts. The group also requested ICAO to conduct a survey to ascertain the willingness of States in the CAR/SAM Region to receive WAFS data via a satellite broadcast system. The ANC agreed to conduct such a survey. All other actions were deferred to the CAR/SAM/2 RAN Meeting.

9.4 In 1989 the CAR/SAM/2 RAN Meeting reviewed the results of a survey of the States in the regions which was conducted pursuant to Conclusion 5/1 of the fifth GRACYAS Meeting to determine the willingness of States to implement a receive capability for the satellite broadcast of WAFS products. Responses received by the convening date of the meeting indicated full support for the concept. The United States announced at the meeting its plans to implement satellite broadcast for the dissemination of WAFS products in the CAR/SAM Region in the 1990-1991 time period. The meeting unanimously agreed that the satellite broadcast method would be used for dissemination of WAFS data in the CAR/SAM Region and developed recommendations accordingly. Concerning the format of the data, the CAR/SAM/2 RAN Meeting recommended that the authorities responsible for the operation of the Washington WAFC be requested to uplink, in digital facsimile chart format, the WAFS products since the grid point data in digital form was not considered a pressing or immediate requirement in the CAR/SAM Region. Those recommendations are still to be acted upon by the Council or the ANC under delegated authority.

ASIA AND PACIFIC (ASIA/PAC) REGION

9.5 The second ASIA/PAC AFS Regional Planning Group (RPG) Meeting in 1986 recommended that a satellite broadcast system be endorsed in principle as the means of distributing WAFS data in the ASIA/PAC Region. This recommendation was approved by the ANC.

9.6 In 1988 the third ASIA/PAC AFS RPG Meeting proposed for the interim period that a demonstration plan be carried out whereby the RAFC Tokyo would disseminate upper-air wind and temperature and SIGWX data in chart form in the ASIA/PAC Region by satellite broadcast and that a trial broadcast of such be started at the earliest possible date. This recommendation was approved by the ANC. The Japanese Government has since advised they will not be able to provide WAFS data via the GMS satellite.

EUROPEAN (EUR) REGION

9.7 The seventh EUR RAN Meeting held in 1985 recommended that the European Air Navigation Planning Group (EANPG) study all aspects of the evolutionary development of the WAFS in service area 7. This recommendation was approved by Council. The task has been assigned to the Meteorological Advisory Group (METAG) of the EANPG.

9.8 The 16th METAG Meeting in 1989 endorsed in principle the concept of a satellite broadcast as one of the means for the dissemination of WAFS products in service area 7. The METAG formed a sub-group for planning the implementation of a satellite broadcast system in service area 7 and agreed to continue use of available terrestrial telecommunication means and plan the use of the CIDIN when operational. The METAG had also proposed that its terms of reference should be extended to cover the western part of service area 1 (Eastern Europe) to ensure consistency in telecommunication provisions in the EUR Region.

MIDDLE EAST (MID) REGION

9.9 The third MID RAN Meeting in 1984 noted that satellite broadcast was the preferred longer-term dissemination method and recommended that a suitable ICAO body study the most cost-effective method of meeting the telecommunication requirements of the WAFS to serve the MID Region. The recommendation was approved by Council and is being undertaken by the EANPG (see 9.8 above).

NORTH AMERICAN AND NORTH ATLANTIC (NAM/NAT) REGION

9.10 There are no formal ICAO regional plans to study the possible use of satellite dissemination in the NAM/NAT Region. However, the NAM Region requirements are already satisfied by way of domestic (regional) satellite systems. Regarding the NAT Region, by virtue of the United States' commitment to provide satellite broadcast of WAFS data products to the CAR/SAM Region, that data will inherently be available for reception to ICAO Contracting States and territories in the NAT Region.

Chapter 10
FINANCIAL ASPECTS

10.1 The charges for the use of the space segment may be either borne by the provider State or shared between the provider State and the user State, as provided for in CCITT Recommendation D.185 (refer to Appendix 8).

10.2 The United States had indicated at the CAR/SAM 2 RAN Meeting that, as a WAFC provider State, it would fund the entire space segment for the dissemination of WAFS products via a satellite broadcast system to the CAR/SAM Region. It was also reported that the United States would fund a similar service to the ASIA/PAC Region. The United Kingdom, as the second WAFC provider State, had indicated that before it would undertake the responsibility for providing a satellite broadcast service for the dissemination of WAFS products, an equitable means of cost recovery would need to be agreed upon.

10.3 No definitive information was available with respect to the following as these costs will vary from State to State:

a) hardware costs;

b) leasing costs and fees; and

c) maintenance costs.

It was therefore not possible to determine the likely communication costs of a satellite broadcast system nor to demonstrate conclusively its cost-effectiveness compared with alternative means.

Chapter 11
UNRESOLVED ISSUES

During the course of the study on the refinement of the satellite broadcast system concept, some unresolved issues were identified. These issues, which should be resolved with all urgency by an appropriate ICAO body, are as follows.

ICAO-WMO STUDY

11.1 The ICAO-WMO study of the feasibility of the joint use of satellite dissemination in a system which would constitute a sub-system of the ICAO AFS and a sub-system of the WMO GTS is under way but has not been completed (ASPP/1 Recommendation 3/1). This study considers the possible joint utilization of satellite-based distribution systems to meet GTS and WAFS data distribution requirements, with a view to enabling States to avoid unnecessary duplications of effort, telecommunication facilities and expenses in the reception of meteorological processed information.

WAFS STUDY GROUP

11.2 The Secretariat WAFS Study Group has not completed its tasks and its results could have an impact on ICAO's satellite broadcast system. The WAFS Study Group reviewed the aeronautical requirements for SIGWX, the functions and procedures of RAFCs and WAFCs and the detailed aeronautical requirements for WAFS forecasts. As a result of the second meeting of the WAFS Study Group, a proposal to amend Annex 3 to take into account the data volume increase and changes in functions of WAFCs and RAFCs, enabling the transition to the final phase, was presented to the COM/MET/OPS Divisional Meeting (1990). The meeting, however, was not in a position to establish a final requirement regarding the resolution of WAFS data in space and time. It was understood that following the completion of studies which were currently in progress at the world area forecast centres, an appropriate amendment to Annex 3 would be developed.

WAFC RESPONSIBILITIES IN THE FINAL PHASE

11.3 The responsibilities of the WAFCs in the final phase have not yet been defined. This is one of the next tasks of the Secretariat WAFS Study Group.

REGULATORY IMPLICATIONS

11.4 The information in Appendix 2 describes the situation concerning individual States' regulatory environment applicable to operation of receive-only earth stations. States receiving the satellite broadcast will need to determine what, if any, regulatory limitations may be imposed.

SOFTWARE DEVELOPMENT

11.5 As the final phase of the WAFS will require the receiver of the digital grid point data to process and to convert it into chart form (i.e. wind, temperature and SIGWX), there is a software requirement for this task. This could result in considerable software development cost to civil aviation unless a means is found to minimize this cost. A number of national meteorological organizations already have software for the task, but this is implemented on different hardware and uses different operating systems. To minimize costs, a standard software package would have to be chosen and implemented on common hardware. As a result, agreement on this type of approach would be very difficult to reach.

Chapter 12
CONCLUSIONS

Subject to the assumptions made in this circular, the following conclusions are made:

a) the concept of a satellite broadcast system is valid for the dissemination of WAFS data;

b) the INTELSAT INTELNET I satellite broadcast service is capable of providing global coverage for the dissemination of WAFS data products;

c) the implementation of the satellite broadcast system should not be dependent upon the availability of SIGWX forecasts in the form of grid point data in digital form; and

d) in some regions, a mixed telecommunication environment for the dissemination of WAFS products will exist for some time.

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Appendix 1

CCITT RECOMMENDATION F.140 — POINT-TO-MULTIPOINT TELECOMMUNICATION SERVICE VIA SATELLITE

The CCITT,

considering

— the need for a point-to-multipoint telecommunication service;

— the loss of HF multi-destinational Press broadcast service for this purpose;

— the availability of satellites for point-to-multipoint telecommunications services on a regional and world-wide basis;

— the availability of a multiplicity of earth station sizes;

— the need for a clarification in terms of the functional elements of this service;

— the need for the flexibility of their implementation in order to adapt to the needs of all Administrations,

recommends

the following operational guidelines and quality of service requirements for an international point-to-multipoint telecommunication service via satellite.

1. Scope[1]

This Recommendation provides operational guidelines and quality of service requirements for an international one-way point-to-multipoint telecommunication service via satellite. See draft Recommendation D.1xx for the general tariff and accounting principles for international point-to-multipoint telecommunication service via satellite.

1.1 *Definition of service*

International point-to-multipoint telecommunication service via satellite is defined as a service provided to a customer by Administrations for the transmission for example, of text, photographs or data via a satellite for the reception at a multiplicity of destinations by receive-only earth stations.

2. Service description

2.1 *Functional elements of service*

A point-to-multipoint telecommunication service via satellite includes the seven following elements (see Figure 1):

1) the provider(s) of information;

2) the link between the provider(s) and the control management centre;

3) the control management centre which uses various transmission means in order to collect, address, multiplex the information from the provider(s);

4) the transmit earth station(s);

5) the transponder of a satellite(s);

6) one or several receive earth stations;

7) the link(s) from the receive earth station(s) to the user(s) equipment.

2.2 *Service provision*

The service may be provided on either a full time 24-hour basis, a scheduled part-time basis (e.g. five hours per day), or occasional use basis (e.g. a special event), subject to such terms as may be agreed between Administrations.

2.3 *Types of service*

The service may be provided:

a) in the form of one or more analogue channels the bandwidth of which may lie anywhere within the maximum available bandwidth of one transponder, or

b) in the form of one or more digital channels operating at any speed within the maximum available digital capacity of one transponder.

2.4 *Areas of service coverage*

The service may be provided on a regional or global basis depending on customer requirements and satellite capability.

2.5 *Service configurations*

As illustrated in Figure 1, there are seven (7) functional elements in the provision of a point-to-multipoint telecommunication service via satellite. Owing to the need for flexibility, the systems may be adapted to a diversity of needs and the regulations of each Administration involved.

The conditions of use of the transmit (4) and receive (6) earth stations and the links (2) conveying the information flow remains a national matter to be determined by the competent authority in each country.

The condition of use of the space segment (5) are defined by the organizations (INTELSAT, EUTELSAT, etc.) in charge of their provision and the necessary actions of the coordination carried out by the competent international organizations.

The control management centre (3) for the service may be located and/or operated with the transmit earth station, the provider of the information or independently of these two entities.

3. Quality of Service

The efficiency of operation and therefore the quality of service provided to the users are linked to the relationship of all parties which contribute to the provision of the service, i.e. the technical equipment and the entities in charge of their operation. Quality of service parameters and values are for further study based on operational experience.

3.1 *Service availability*

Service availability is the ratio of aggregate time during which satisfactory or tolerable service is or could be provided to the total observation period (CCITT Recommendation X.140 definition).

As this availability of service depends on the class of space segment, the earth station configurations, the propagation and interference effects and the bit error rate required, it is not possible to specify a service availability requirement for all point-to-multipoint telecommunication services via satellite. The service availability for each customer will have to be calculated on an individual case basis considering all the points mentioned above.

4. Access

4.1 *Transmit*

The point of interconnection to the service may be located at the providers' location or on the Administrations' premises. When the point of interconnection to the service is located on the Administrations' premises, the providers' access may be via a lease circuit or a public switched network.

4.2 *Receive*

The receive earth station(s) may be located on the user(s) premises or at Administrations' premises. Where the receive earth station(s) is located at the Administrations' premises access to the user should be via direct connection. The user of a public switched network is for further study.

5. Classes of space segment

5.1 Services offered may take account of classes of space segment available from the space segment provider(s). The following classes of space segment may be utilized to provide service:

a) NON-PRE-EMPTIBLE -- a service which may not be interrupted or terminated for the provision of a service to another customer. There are two types of non-pre-emptible service:

1) Protected -- a service for which restoration is guaranteed, and

2) Unprotected -- a service for which restoration is not guaranteed and which may only be restored subject to availability of an alternate facility.

b) PRE-EMPTIBLE -- a service which may be interrupted to provide a service of higher priority.

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[1] Multipoint-to-point and two-way multiple access services are not addressed in this Recommendation, and are subject to further study.

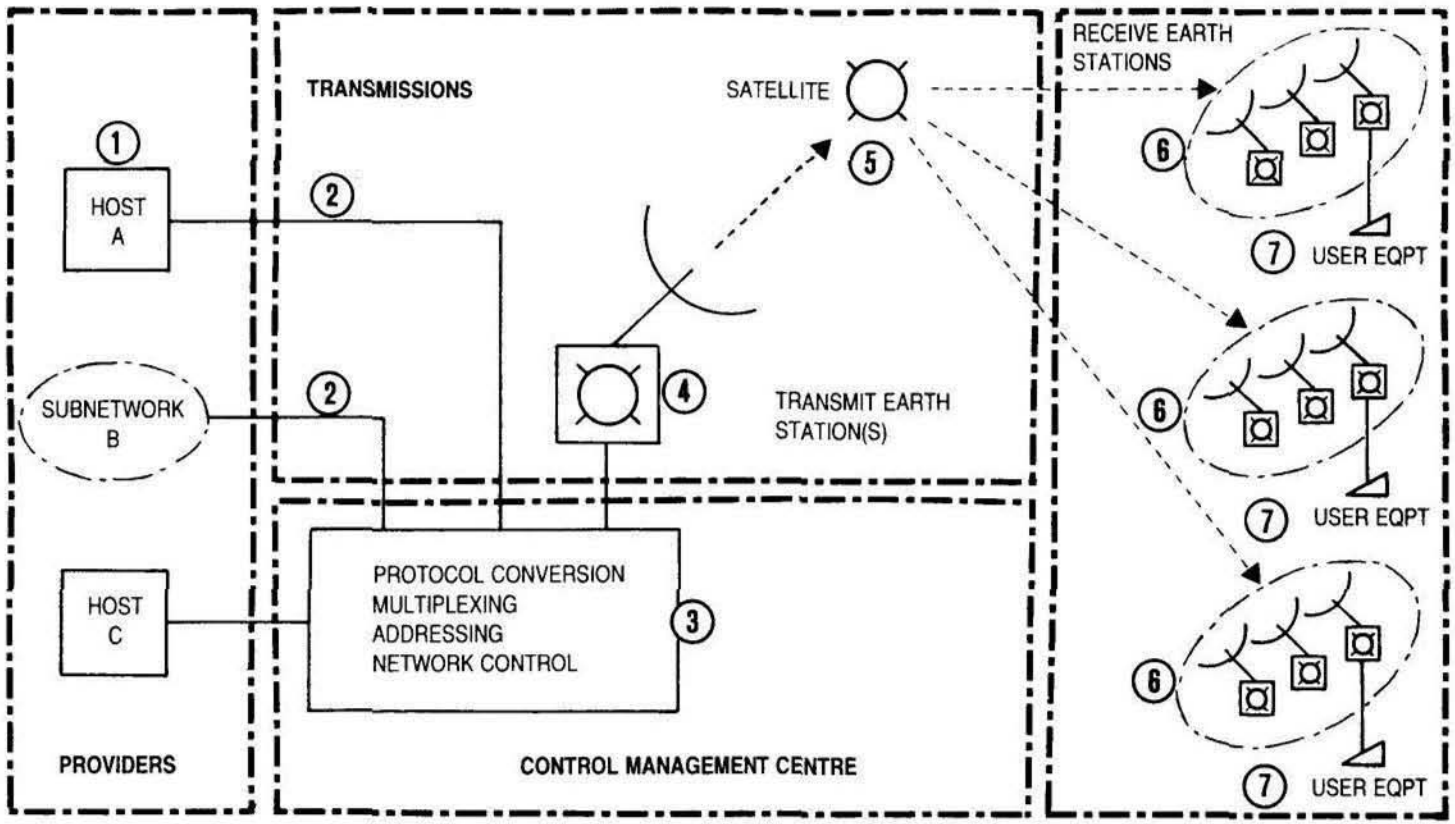
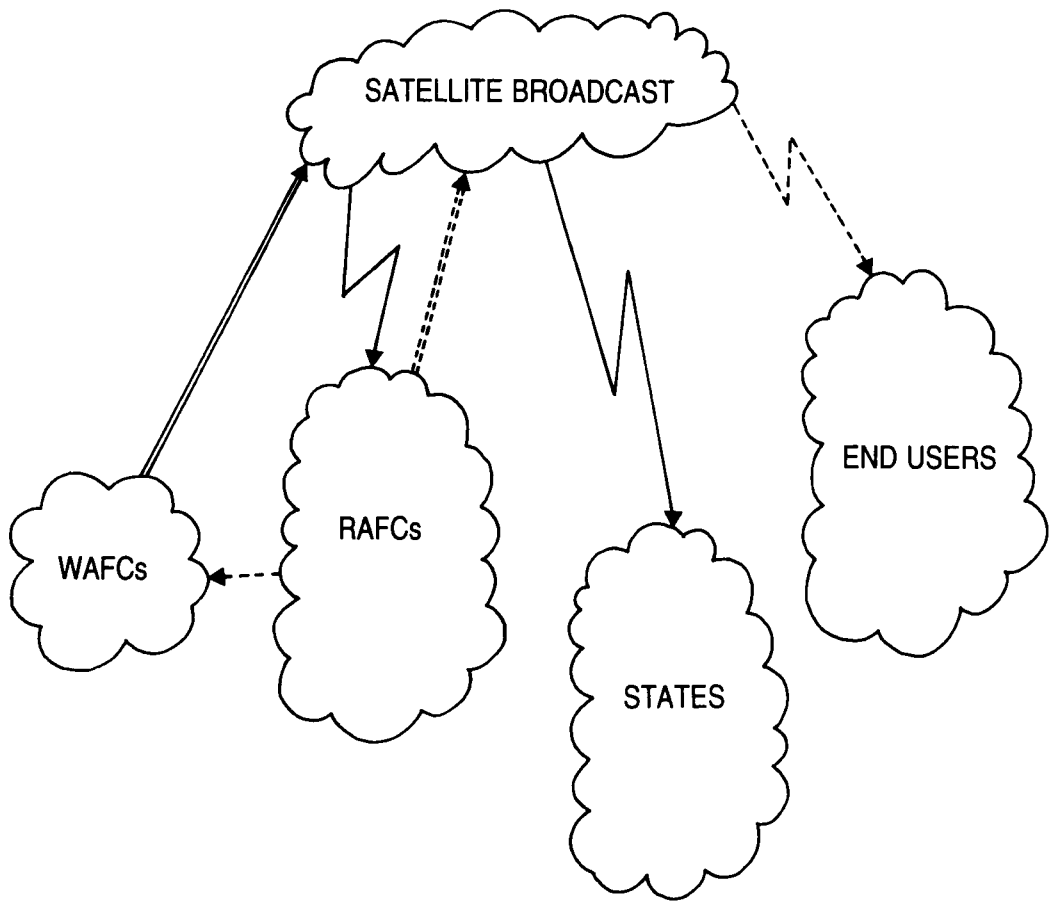
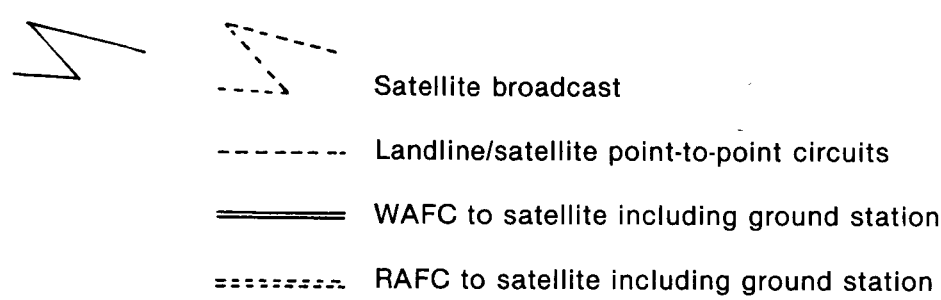


Figure 1/F.140

Appendix 2

CONCEPT FOR SATELLITE BROADCAST OF WAFS PRODUCTS — INTERIM PHASE

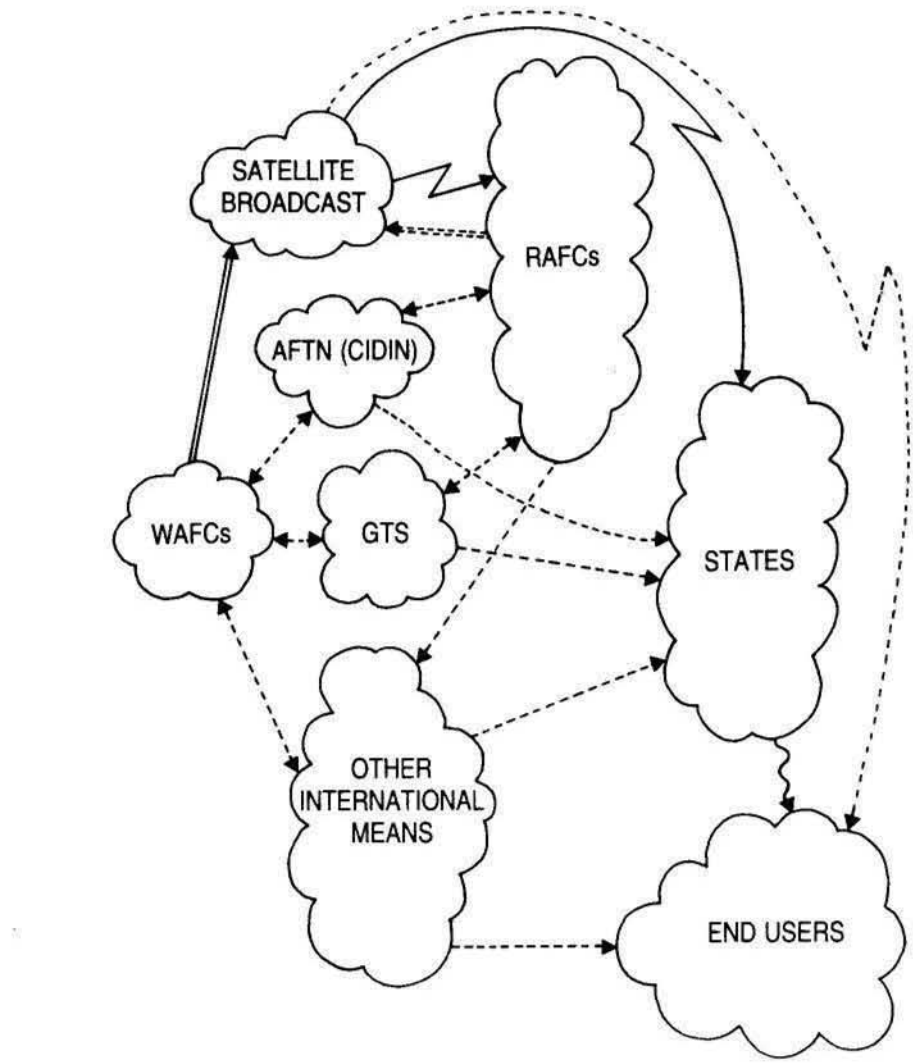




Note.— Dotted lines indicate optional elements

Appendix 3

SCENARIO AND OPTIONS FOR DISTRIBUTION OF WAFS PRODUCTS — INTERIM PHASE



Satellite broadcast

Landline/satellite point-to-point circuits

WAFC to satellite including ground station

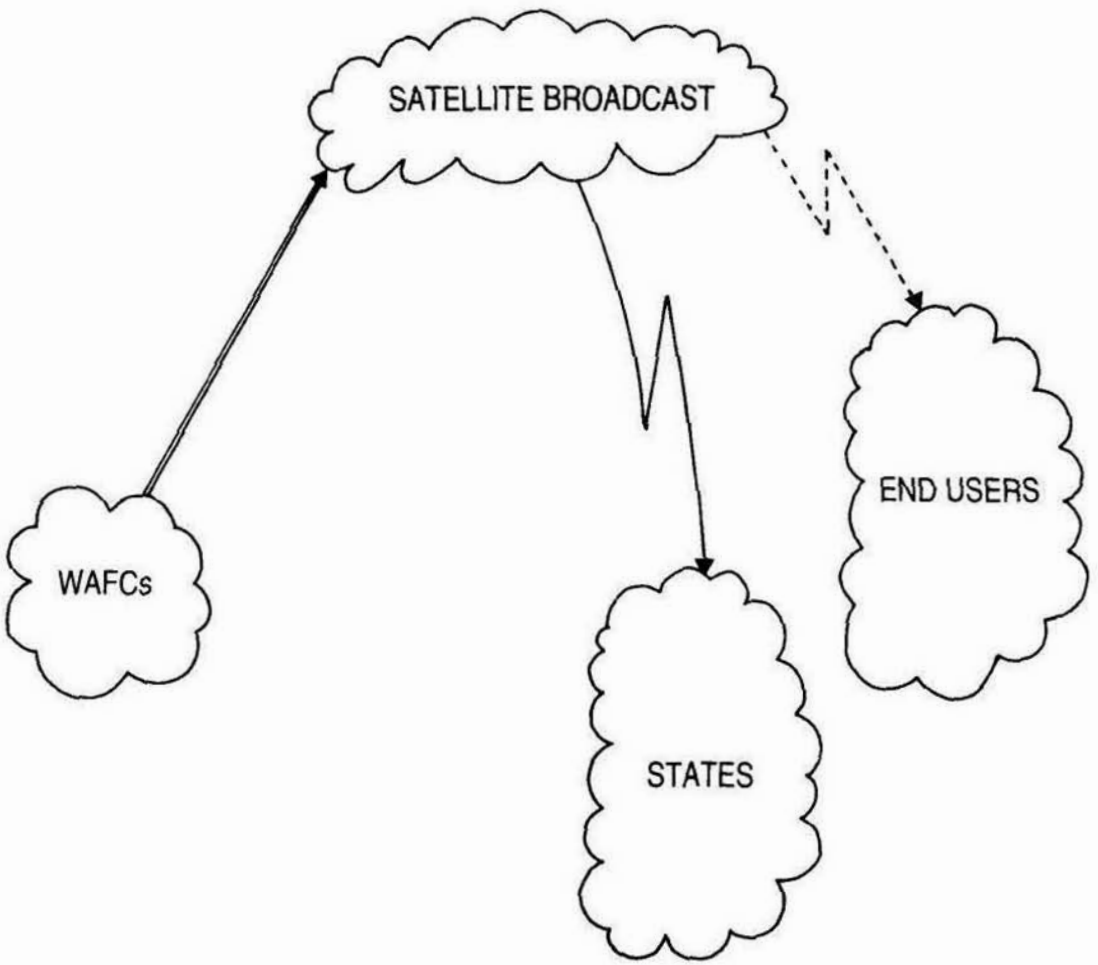
RAFC to satellite including ground station

National distribution

Note.— Dotted lines indicate optional elements

Appendix 4

CONCEPT FOR SATELLITE BROADCAST OF WAFS PRODUCTS — FINAL PHASE



Note.— Dotted lines indicate optional elements

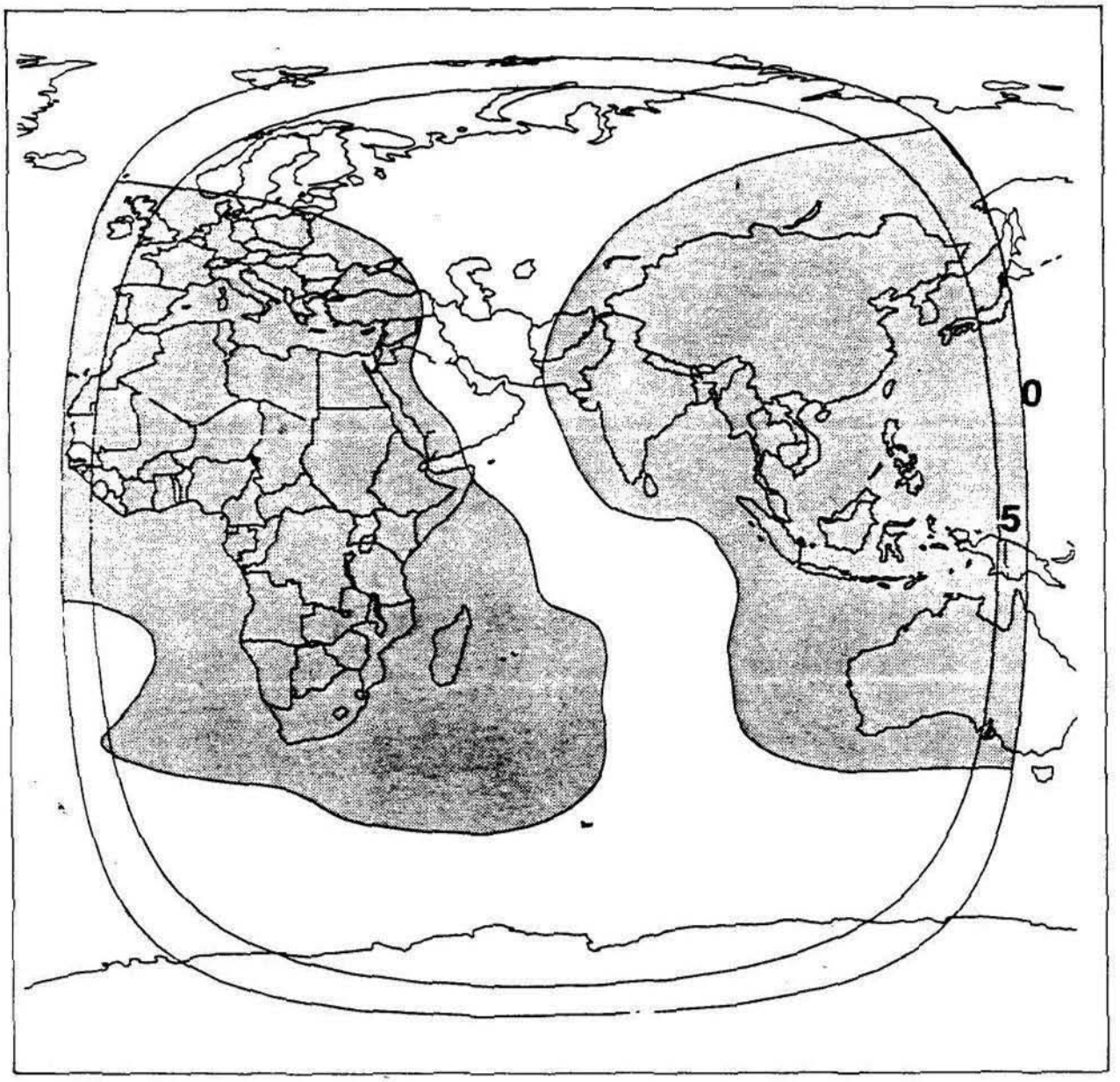
Appendix 5

FOOTPRINT — INTELSAT V/VA EAST AND WEST HEMI-BEAMS FROM 332.5°E

Note.— The shaded areas represent the east and west hemi-beams, while the outer rings represent the C-band (6/4 GHz) and Ku-band (14/12 GHz) global beam coverage at elevation angle contours of 0° and 5°. The 0° elevation angle contour is the theoretical extent of coverage, while the 5° elevation angle is considered to be the practical extent of coverage according to nominal design criteria.

Appendix 6

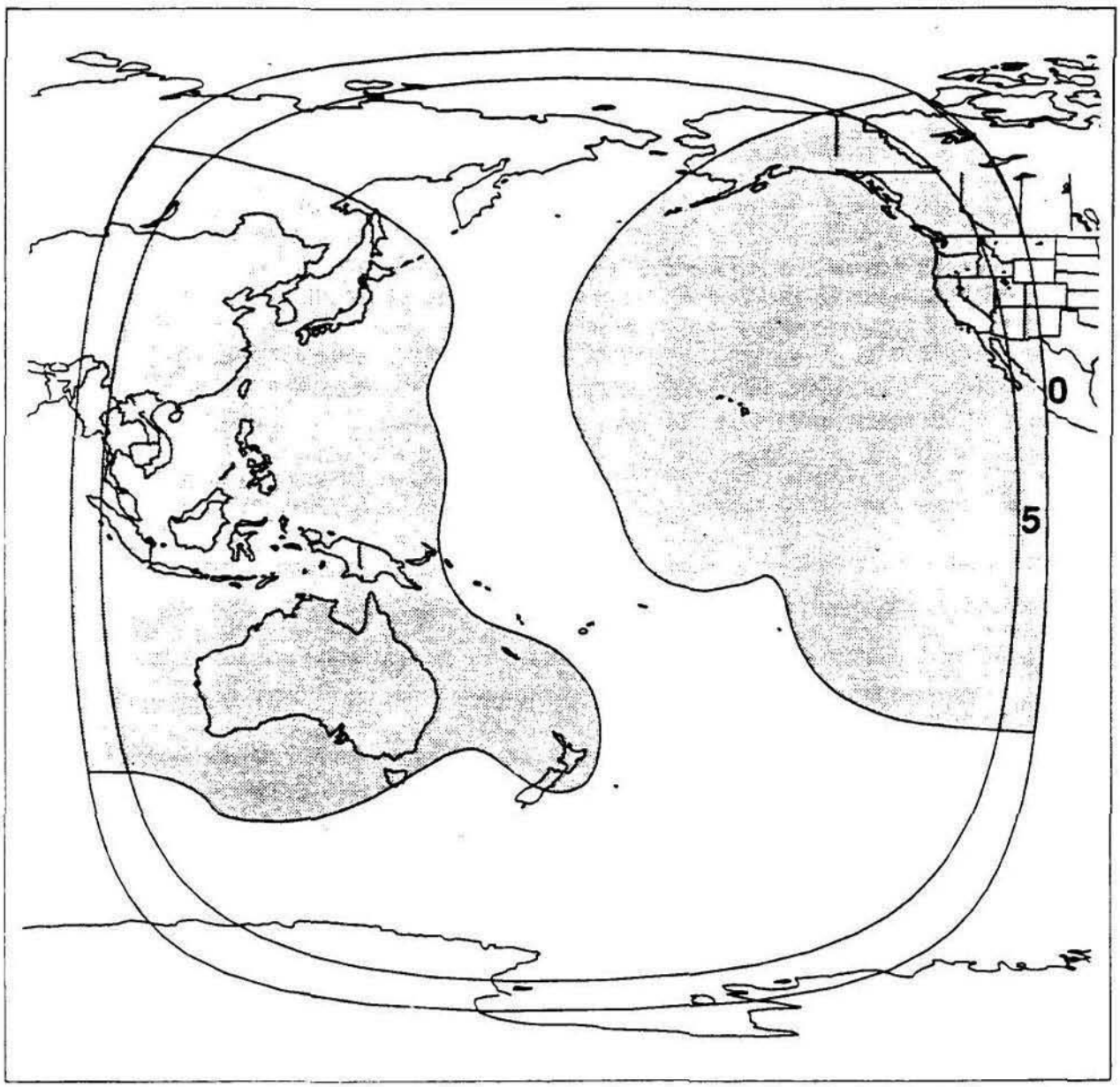
FOOTPRINT — INTELSAT VI EAST AND WEST HEMI-BEAMS FROM 63.0°E



Note.— The shaded areas represent the east and west hemi-beams, while the outer rings represent the C-band (6/4 GHz) and Ku-band (14/12 GHz) global beam coverage at elevation angle contours of 0° and 5°. The 0° elevation angle contour is the theoretical extent of coverage, while the 5° elevation angle is considered to be the practical extent of coverage according to nominal design criteria.

Appendix 7

FOOTPRINT — INTELSAT V/VA EAST AND WEST HEMI-BEAMS FROM 174.0°E



Note.— The shaded areas represent the east and west hemi-beams, while the outer rings represent the C-band (6/4 GHz) and Ku-band (14/12 GHz) global beam coverage at elevation angle contours of 0° and 5°. The 0° elevation angle contour is the theoretical extent of coverage, while the 5° elevation angle is considered to be the practical extent of coverage according to nominal design criteria.

Appendix 8

CCITT RECOMMENDATION D.185 — GENERAL TARIFF AND ACCOUNTING PRINCIPLES FOR INTERNATIONAL ONE-WAY POINT-TO-MULTIPOINT SATELLITE SERVICES

The CCITT,

considering

a) the development at world and regional levels of satellite systems permitting the provision of international multi-destination services; (b) the need to meet customers' requirements by offering a wide range of services, in particular, a service to find a replacement for the HF Press Broadcast Service;

c) the capital invested by the Administrations in satellite systems on which they expect an acceptable return, but which should not hinder the development of these multi-destination telecommunication services;

d) the provisions of CCITT Recommendation F.140 regarding the definition and provision of these services and their characteristics;

e) the interest to achieve as far as possible a certain degree of harmonization in general tariff and accounting principles for the provision of such services;

f) finally, the need to adopt principles which are flexible enough to take into account the different technical possibilities in the provision of these services as well as the national legislations governing the status of earth stations,

recommends

to the Administrations to apply the following tariff and accounting principles for international multi-destination satellite services.

1. **Preamble**

1.1 The present Recommendation contains general tariff and accounting principles applicable to one-way point-to-multipoint satellite services[1,2].

1.2 In the provision of those services a distinction may be drawn if necessary between tariff and accounting principles applying respectively to:

— the space segment,

— the transmitting earth station (including associated equipments which may include the control management centre),

— the receiving earth stations (including associated equipments),

— and, when appropriate, the extensions between earth stations and customers' premises.

1.3 When applying the present Recommendation the Administrations should also take into account the general provisions of CCITT Recommendation D.1.

1.4 This Recommendation does not apply to sound and television transmission services as may be provided under CCITT Recommendations D.4 and D.180.

2. Definitions

2.1 The **international point-to-multipoint telecommunications service via satellite** consists of making one or more analogue or digital international telecommunication links available to a customer[3] exclusively dedicated to the use for which they have been authorized on the terms and conditions set out in a lease agreement between the customer and the Administrations of the countries at each end of the link. The Administrations are in no way responsible for transmission content or enforcement of copyright laws.

2.2 This service may be provided in the following basic categories, subject to the agreement of the Administrations concerned:

a) point-to-multipoint;

b) full-time, part-time, occasional;

c) non-pre-emptible protected, non-pre-emptible unprotected, and pre-emptible, taking into account the availability of the space segment to the Administrations.

2.2.1 *Full-time use*

The links are established 24 hours per day, seven days per week for a specified contract period. In determining such a period, Administrations may take into account the conditions established by the organizations managing the satellite system.

2.2.2 *Part-time*

The links are made available according to a pre-arranged schedule of discrete transmission intervals reserved over a period of one or more months or years.

2.2.3 *Occasional*

The links are established on an ad hoc basis with prior reservation for a minimum period agreed upon between the Administrations concerned.

2.2.4 *Non-pre-emptible*

A service which may not be interrupted or terminated for the provision of a service to another customer.

There are two types of non-pre-emptible services:

a) protected — a service for which restoration is guaranteed, and,

b) unprotected — a service for which restoration is not guaranteed and which may only be restored subject to availability of an alternate facility.

2.2.5 *Pre-emptible*

A service which may be interrupted to provide a service of higher priority.

3. Charging principles

3.1 *Tariff components*

In determining their collection charges, the Administrations should take the following principles into account.

3.1.1 *Space segment*

The utilization charge for the space segment is determined by a number of factors such as the cost, the power, the bandwidth, the bit rate made available and the number of participating countries, whether use is full time, part time or occasional, and the pre-emptibility/protection status afforded the service.

3.1.2 *Earth stations (including associated equipment)*

3.1.2.1 *Use of earth stations owned and operated by the Administrations*

The provision of service through earth stations owned and operated by the Administrations entails the payment of a rental. The level of that charge applied by each Administration concerned is established according to the service rendered.

3.1.3 *Service extensions*

When the earth stations are located in the Administrations premises, the charging in the terminal countries of the extensions from/to these earth stations is subject to the principles adopted by the Administrations of the countries concerned.

3.1.4 *Service reservation*

For the reservation of facilities by customers, prior to service initiation, Administrations may establish and notify, as appropriate, reservation fees and their conditions of application.

3.1.5 *Service cancellation*

At the ordering of the service the Administrations notify to customers, when appropriate, the level and the conditions of application of cancellation charges.

3.2 *Collection charges*

The establishment of collection charges is a national matter.

3.3 *Methods of collection of charges*

3.3.1 Charges for the use of the space segment may be collected according to either of the following procedures.

3.3.1.1 Each Administration involved in the provision of the service collects its charges for the service provided to the customer(s) situated in its own country.

3.3.1.2 The Administration of the transmitting country collects the total charges for the service provided to the customer.

3.3.2 Charges for fees relating to the earth stations (including associated equipment and extensions where applicable) may be collected as follows:

3.3.2.1 The Administrations providing and operating the earth stations collect their charges for the provision of the service required by the customer(s).

3.3.2.2 When the earth stations are installed and operated by the customer(s), their use does not usually entail the application of charges. However the Administrations may levy a fee for the granting of the license covering the installation and operation of the station.

3.3.3 The Administration of the transmitting country may collect the total charges for the service (space segment, earth station(s) and extensions) in one or more country(ies), subject to the agreement of the Administrations concerned.

3.3.4 When charging the customer, the Administrations may combine the relevant components in one sum or may charge them separately.

4. Accounting

4.1.1 Charges levied under the provisions mentioned in paragraph 3.3.1.1 above do not entail the establishment of international accounts. Each Administration pays its share of remuneration due to the organization managing the satellite system.

4.1.2 When the Administration of the transmitting country collects the total charges for the space segment, as mentioned in paragraph 3.3.1.2 above, the Administrations involved in the provision of the service may agree:

a) either that the Administration of the transmitting country credits the organization managing the satellite system used with the full remuneration due for the space segment; or

b) that they establish accounts between themselves, every Administration paying its share due for the space segment utilization to the organization managing the satellite system used.

4.2.1 The charges and fees which may be levied as indicated in paragraph 3.3.2 above do not involve international accounts.

4.2.2 When the Administration of the transmitting country collects charges as indicated in paragraph 3.3.3 above, the collecting Administration credits the concerned Administration(s) through the international accounts.

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[1] Multipoint-to-point and two-way multiple access services are not yet addressed in this Recommendation, and are for further study.

[2] The application of the provision of this Recommendation to one-way point-to-multipoint services involving communications with mobiles is for further study.

[3] For the purposes of this Recommendation the customer is the individual or entity that leases one or more international links from an Administration and is responsible for payment of all charges or rentals due to that Administration.

— END —

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO Circulars make available specialized information of interest to Contracting States. This includes studies on technical subjects.

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