SYM-IP/1

SYMPOSIUM ON FUTURE GLOBAL COMMUNICATIONS, NAVIGATION AND SURVEILLANCE (CNS) SYSTEMS

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COMPILATION OF PRESENTATIONS

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SESSION 2.3 AERONAUTICAL MOBILE SATELLITE SERVICE (AMSS)

(Presented by D. Diez)

1. FANS conclusion

1.1 From its study of new concepts and new technologies, the FANS Committee concluded that the exploitation of satellite technology is the only now viable solution that will enable one to overcome the shortcomings of the present communications, navigation, and surveillance (CNS) system and to fulfil the needs and requirements of the foreseeable future on a global basis (page 3, executive summary, FANS/4 Report, Doc 9524).

2. Present communications shortcomings

2.1 The major shortcomings of the present communications system are:

a) the line-of-sight propagation limitation of very high frequency (VHF) and/or the accuracy and reliability limitations imposed by the variability of propagation characteristics of high frequency (HF) (see Figure 1);

b) the difficulty, caused by a variety of reasons, to implement present communications systems and operate them in a consistent manner in large parts of the world; and

c) the limitations of voice communications and the lack of digital air-ground data interchange systems to support modern automated systems in the air and on the ground.

3. AMSS major benefits

3.1 The aeronautical mobile satellite service (AMSS) will overcome those limitations and will provide:

a) global communications coverage from very low to very high altitudes, embracing remote, off-shore and oceanic areas, with the exception of extreme polar regions (see Figure 2 and Figure 3); and

b) digital data interchange between the air-ground systems to fully exploit the automated capabilities of both; one application, the automatic dependent surveillance (ADS), in which aircraft automatically transmit, via the data link, positional data derived from on-board navigation systems, will also provide global surveillance coverage in the areas specified under a) (see Figure 4).

3.2 The AMSS will provide four service types, two safety and two non-safety services. Air traffic control (ATC) and aeronautical operational control (AOC) are the safety services, and aeronautical administrative communication (AAC) and aeronautical passenger communication (APC) are the non-safety ones.

4. AMSSP

4.1 The progress toward using satellite communications for aeronautical safety is being realized through the preparation of Standards and Recommended Practices (SARPs) and guidance material by the ICAO Aeronautical Mobile-Satellite Service (AMSS) Panel.

4.2 The AMSS Panel has adopted the system defined in the INMARSAT System Definition Manual (SDM) and the Aeronautical Radio, Inc. (ARINC) Characteristic 741. Both, the SDM and the ARINC 741 will be continuously amended as SARPs develop.

4.3 The AMSS Panel was also tasked to prepare a summary document on the system architecture, design characteristics, benefits and applications of AMSS, to be recommended for promulgation by ICAO in the form of an advisory circular, which soon will be available.

5. AMSS major elements

5.1 The major elements of the AMSS are the space segment (satellites), ground earth stations (GESs), and aircraft earth stations (AESs) (see Figure 5).

5.2 Space segment

5.2.1 AMSS satellites operate at 36 000 km altitude above the Equator in a geostationary orbit. More than one-third of the earth's surface is visible from this altitude, and three satellites approximately equally spaced in longitude can provide global coverage. No line-of-sight radio coverage is available from geostationary satellites at the polar regions where, at latitudes greater than approximately 80 degrees, the path to the satellite approaches the horizon (see Figure 3).

5.2.2 INMARSAT-2 F1, first satellite to meet ICAO AMSS Standards was launched successfully on 31 October 1990, and placed on station at 64.5 degrees east over the Indian Ocean.

5.2.3 A number of organizations are planning to launch satellites in inclined (non-geostationary) orbits that will also provide coverage of polar regions. The first of these should be operational in the late 1990s, providing coverage of the North Polar region. It is not anticipated that continuous satellite coverage of the extreme South Polar region will be available in the timeframe covered by FANS.

5.3 Ground earth station (GES)

5.3.1 The GES consists of a dish antenna and electronics dedicated to communications operations through the satellite to and from the aircraft. It provides the interface between the satellite and fixed terrestrial voice and data networks such as Common ICAO Data Interchange Network (CIDIN), the public switched telephone network, private networks, and dedicated lines that might be used for time-critical applications. A GES may or may not be located at an ATS facility, depending on operational requirements and arrangements made between the satellite service provider and the civil aviation authority (see Figure 5).

5.3.2 The GES antenna typically is 9 to 13 metres in diameter and operates at C-band (4/6 GHz from/to the satellite). Alternative feeder link frequencies, for example at Ku-band (13/14 GHz), permit smaller antenna sizes and freedom from potential terrestrial interference, but at the expense of a greater effect of rain attenuation.

5.4 Aircraft earth station (AES)

5.4.1 The AES is comprised of an on-board transmitter/receiver unit that includes modulators, demodulators, signal processors and voice codecs; internal controllers; one or more radio frequency power amplifiers, and the antenna sub-system (see Figure 5 and Figure 6).

6. AMSS channels and band

6.1 The radio links between satellite and aircraft are implemented using three types of channels for packet data which have been given the letter designations P, R and T; and a fourth, designated C-channel, which designates a circuit-mode channel for voice and data (see Figure 7).

6.2 The P-channel is a time division multiplexed continuous packet data channel from GES to AES which carries signalling and user data. Aircraft must continuously monitor this channel after log-on to a GES.

6.3 The R-channel is a multiple access channel, used in the AES to GES direction, which carries signalling and user data. It uses the "slotted aloha" protocol to permit random access by multiple aircraft. A GES continuously monitors its R-channels.

6.4 The T-channel is a reservation time division multiple access (TDMA) channel used from AES to GES only. A GES receiving a request from an AES through the R-channel for T-channel capacity reserves time slots for AES transmissions according to message length. The sending AES then transmits messages in the reserved time slots according to priority.

6.5 The C-channel is a continuous, full-duplex frequency division multiple access (FDMA) channel used for voice and data and is allocated on demand through an R-channel from the AES, or assigned directly by the GES.

6.6 Rates

6.6.1 The P, R and T channels work at rates ranging from 600 bits/s to 10 500 bits/s, using A-BPSK modulation for channel rates of 2 400 bits/s and less, and A-QPSK modulation for channel rates higher than 2 400 bits/s. C-channels work at rates from 6 000 bits/s to 21 000 bits/s.

6.7 Band

6.7.1 Communications between aircraft and satellite operate in the 1.5 to 1.6 GHz frequency band, allocated for this purpose because of its suitable radio characteristics.

1 545 - 1 555 MHz from satellite to AES
1 646.5 - 1 656.5 MHz from AES to satellite

6.7.2 Channel spacing is such as to provide sufficient separation to reduce adjacent channel interference and ensure channel tuning in the presence of Doppler shift due to the relative velocity between the aircraft and the satellite.

6.7.3 Transmitter and receiver tuning increments are normally 2.5 kHz, therefore, the number of channels available in 10 MHz is approximately 400: Channels can be efficiently reused when spot beams are implemented.

6.7.4 The estimate for AMSS for the year 2010 is for 14.5 to 17.5 MHz of the exclusive allotment in each direction, which is considerably more than the 10 MHz now allotted in each direction. States should provide maximum support to ICAO at the next International Telecommunication Union (ITU) World Administrative Radio Conference (Malaga-1992) (WARC-92) when requesting the required band.

7. AMSS applications

7.1 Automatic dependent surveillance and direct pilot-controller data link communications using packet transmission are likely to be the first ATS applications of AMSS, especially in oceanic and remote areas.

7.2 In high-density continental areas, the integration of ADS and SSR data could enhance the SSR surveillance function by providing coverage at low altitudes and blind areas and improving the ground tracking of aircraft, increase the level of surveillance redundancy, and allow the integrity of the navigation system to be monitored. AMSS will also permit the direct digital data interchange between air and ground expert systems which will increase ATS capacity and improve airspace utilization. ATC expert systems which will perform much of the current controller's routine work, will be the only way to efficiently cope with the increase of air traffic forecast for the near future (forecasts for Central Europe show that by the year 2000 aircraft movements will be 100 per cent greater than in 1987).

7.3 AMSS will also provide global AOC, AAC and APC communications coverage (voice and data).

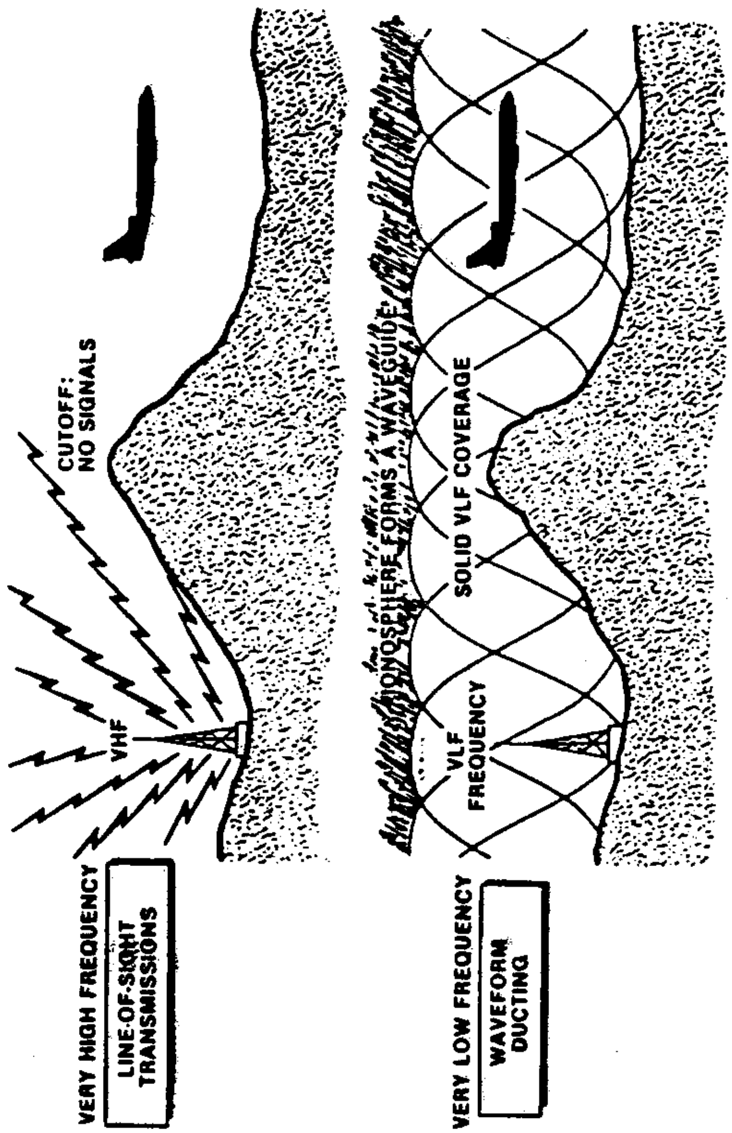
VERY HIGH FREQUENCY
LINE-OF-SIGHT TRANSMISSIONS
VHF
CUTOFF: NO SIGNALS
VERY LOW FREQUENCY
WAVEFORM DUCTING
VLF FREQUENCY
IONOSPHERE FORMS A WAVEGUIDE
SOLID VLF COVERAGE

Figure 1

THE ADVANTAGES OF SPACE-BASED TRANSMITTERS

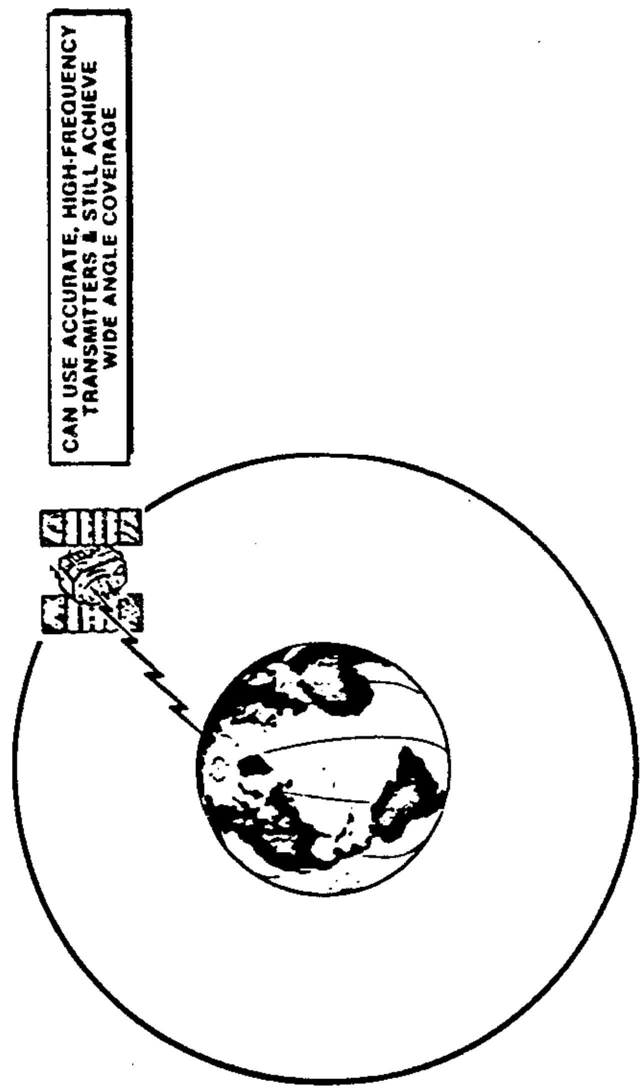

Figure 2

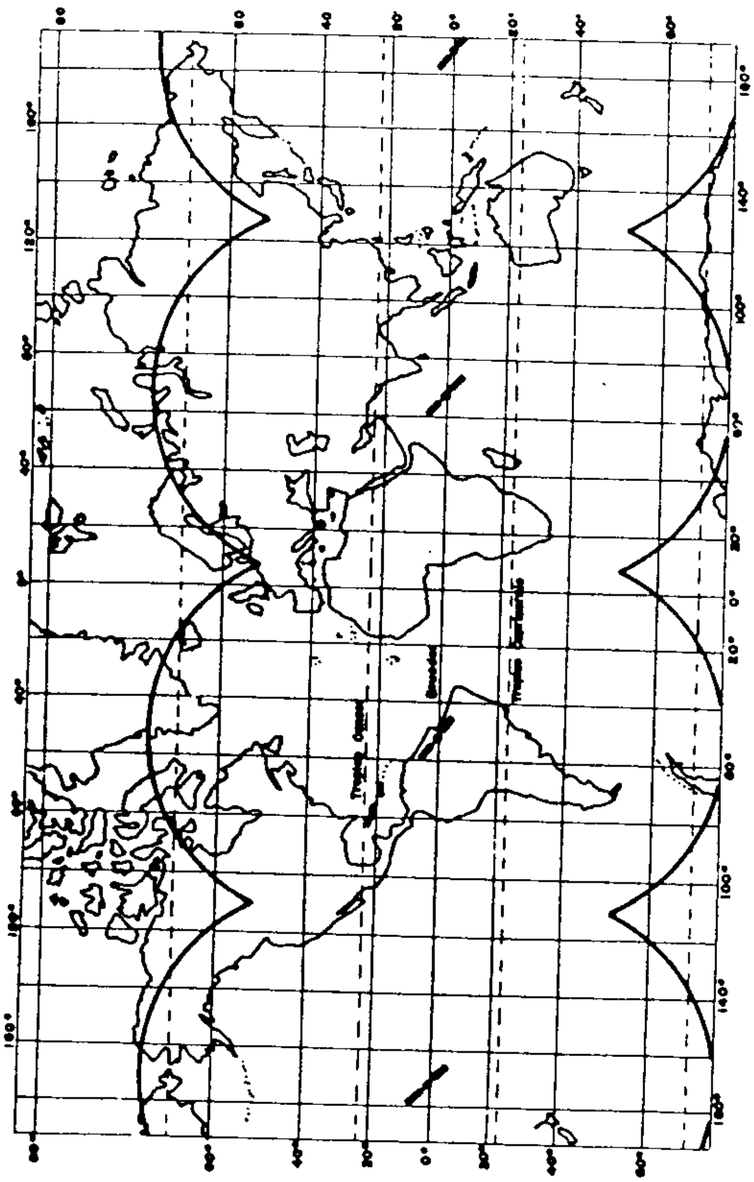

Figure 3

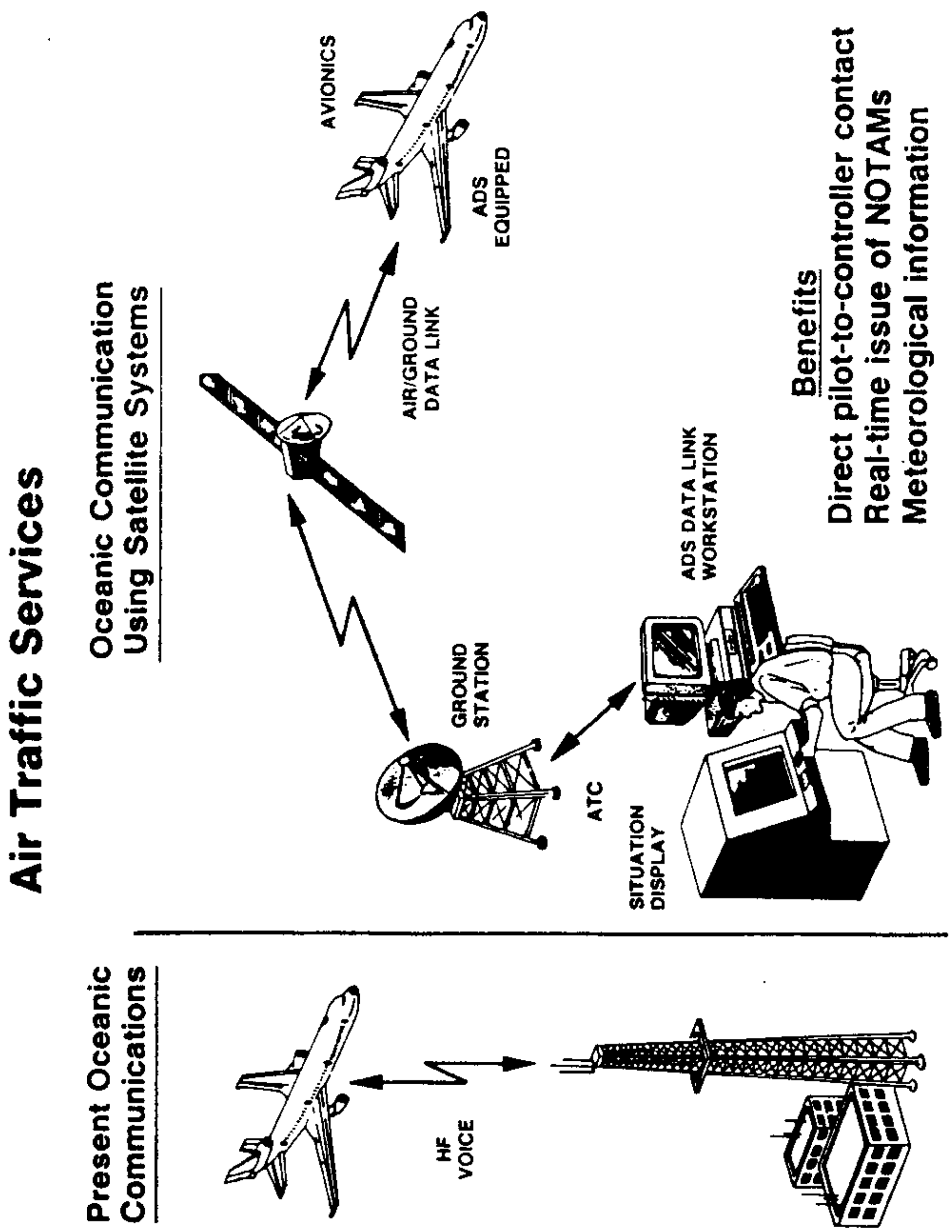
Air Traffic Services
Present Oceanic Communications
HF VOICE
Oceanic Communication Using Satellite Systems
GROUND STATION
AIR/GROUND DATA LINK
AVIONICS
ADS EQUIPPED
ATC
SITUATION DISPLAY
ADS DATA LINK WORKSTATION
Benefits
Direct pilot-to-controller contact
Real-time issue of NOTAMs
Meteorological information

Figure 4

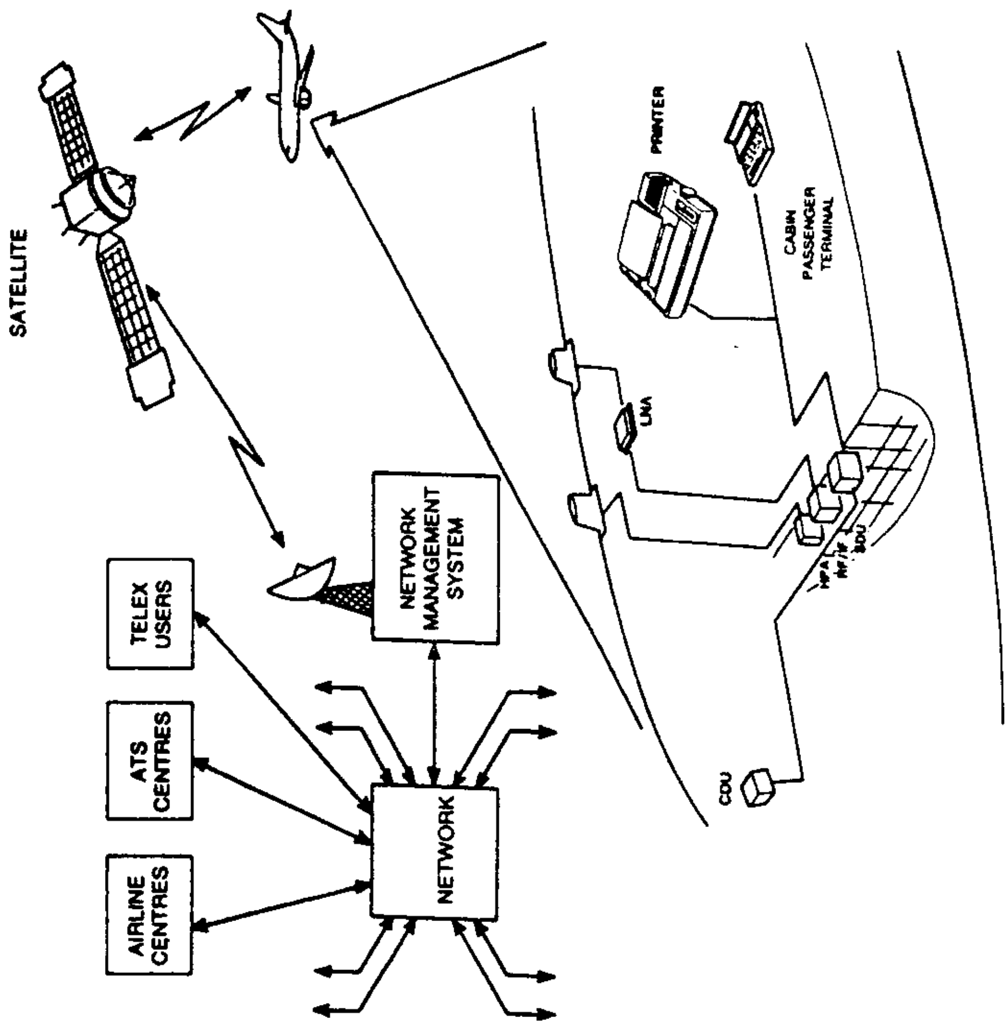
SATELLITE
PRINTER
CABIN
PASSENGER
TERMINAL
LNA
HPA
RF/IF
SDU
CDU
NETWORK
MANAGEMENT
SYSTEM
TELEX
USERS
ATS
CENTRES
AIRLINE
CENTRES
NETWORK

Figure 5

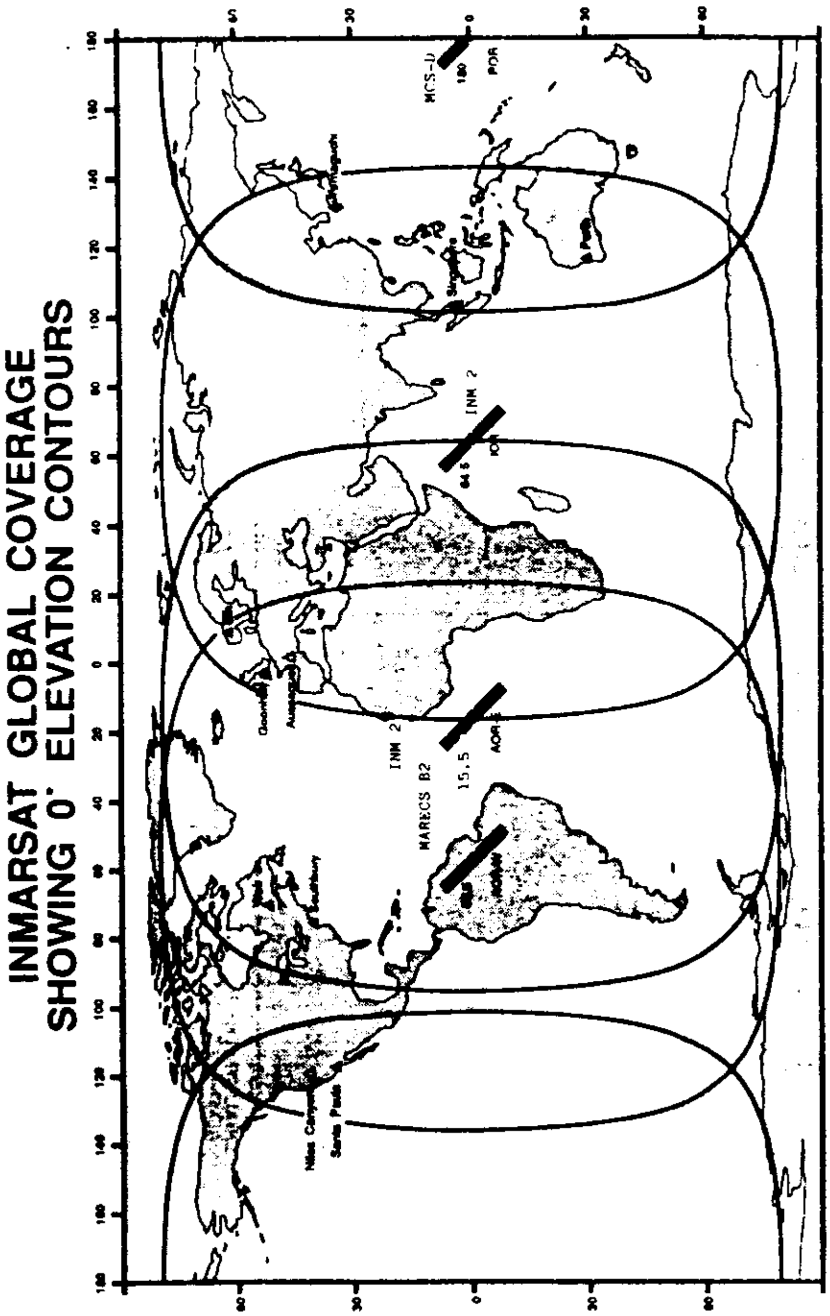
INMARSAT GLOBAL COVERAGE
SHOWING 0° ELEVATION CONTOURS
MCS-D
180
POR
INM 2
64.5
IOR
INM 2
MARECS B2
15.5
AOR

Figure 6

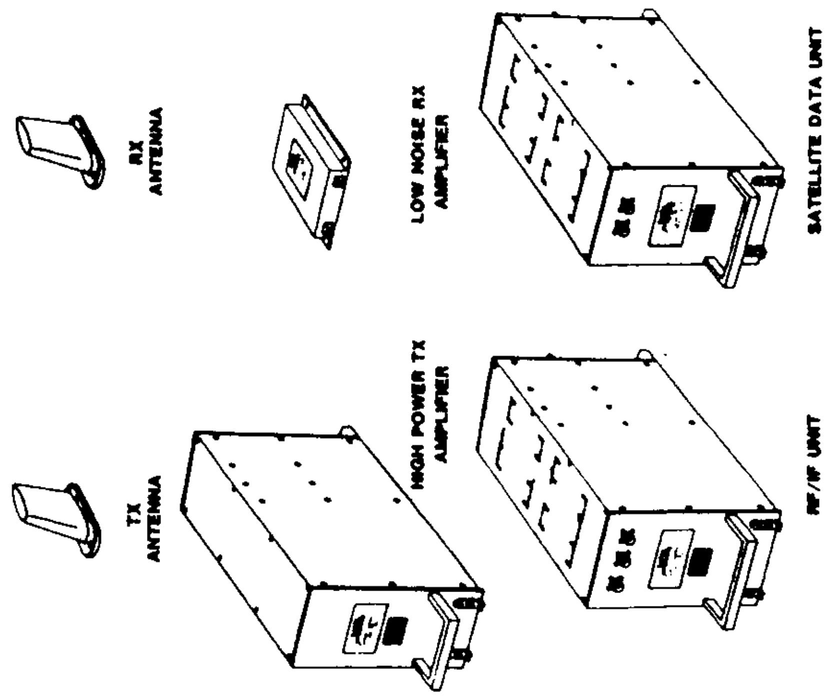
TX ANTENNA
RX ANTENNA
HIGH POWER TX AMPLIFIER
LOW NOISE RX AMPLIFIER
RF/IF UNIT
SATELLITE DATA UNIT

Figure 7

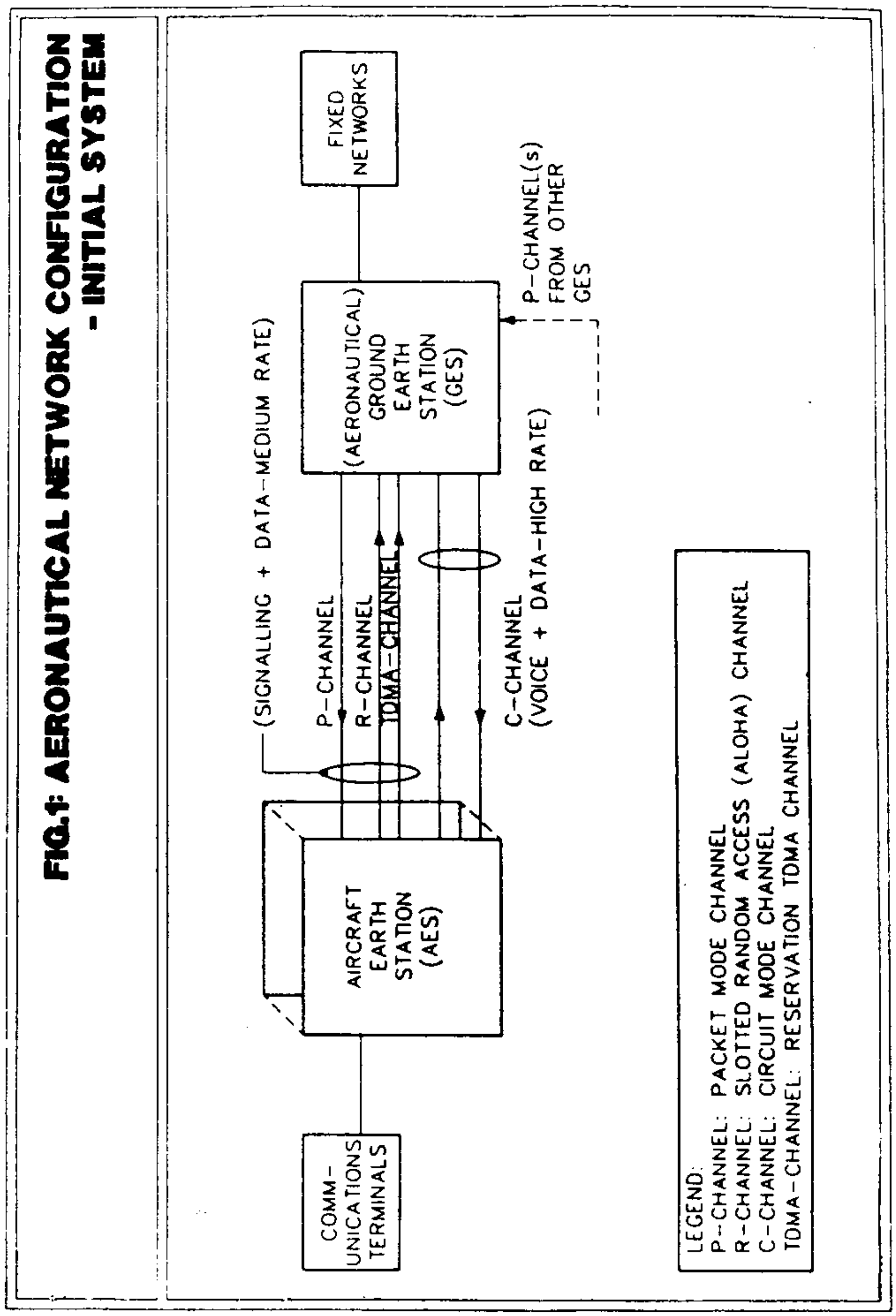
FIG.1: AERONAUTICAL NETWORK CONFIGURATION - INITIAL SYSTEM
COMM-UNICATIONS TERMINALS
AIRCRAFT EARTH STATION (AES)
(SIGNALLING + DATA-MEDIUM RATE)
P-CHANNEL
R-CHANNEL
TDMA-CHANNEL
C-CHANNEL (VOICE + DATA-HIGH RATE)
(AERONAUTICAL) GROUND EARTH STATION (GES)
P-CHANNEL(s) FROM OTHER GES
FIXED NETWORKS
LEGEND:
P-CHANNEL: PACKET MODE CHANNEL
R-CHANNEL: SLOTTED RANDOM ACCESS (ALOHA) CHANNEL
C-CHANNEL: CIRCUIT MODE CHANNEL
TDMA-CHANNEL: RESERVATION TDMA CHANNEL

Figure 8