# THE E-SAT 300: A MOBILE SATELLITE COMMUNICATIONS ANTENNA SYSTEM FOR AIRCRAFT

Mohamed A. Abdelrazik
Senior Electronic Systems Engineer
E-Systems, Inc., Greenville Division,
Greenville, Texas, USA 75401

## Abstract

This paper summarizes the design history and highlights advantages of a mechanically steered antenna system that meets the operational requirements of INMARSAT's Aeronautical Standard. This antenna system is capable of installation on aircraft as small as Gulfstream IV. Connected to the digital communication terminal, the system will provide voice and data capabilities through the INMARSAT network. Mechanical steering provides the system with a very wide angular coverage of 360° in azimuth and from -30° to +90° in elevation with no keyhole voids.

## Introduction

The quality of Satellite communication links to aircraft is superior to the HF links presently used. HF links are susceptible to weather conditions and are subject to high levels of interference. The unique feature of satellite communication is the ability to establish clear, reliable, global, full duplex links to aircraft. In addition to voice capabilities, dependable satellite communication links can also be used to enhance the safety of flight by providing air traffic control and air operations control data to aircraft. These links can also be used to provide aircraft passengers with telephone, telex, and facsimile services.

E-Systems has been a pioneer in the research leading to the development of airborne commercial satellite communication terminals for use on aircraft varying in size from Boeing 747 to Gulfstream IV [1]. Research efforts began in 1981 and has resulted in the development of three generations of airborne satellite communication systems capable of utilizing the existing network of the International Maritime Satellite Organization (INMARSAT). The first and second generation systems (E-SAT-100 and E-SAT-200 models) utilize mechanically steered helical array antenna systems. These antenna systems meet the technical requirements for INMARSAT Standard-A services. Standard-A requirements, developed originally for use by the maritime industry, require a minimum antenna system Figure- of-Merit of -4.0 dBK. The E-SAT-100 and E-SAT-200 systems were developed for Head-of-State (HOS) aircraft. Three HOS systems have been commissioned for service. The antenna system for the third generation system, the E-SAT-300, will be described in detail in the next sections.

## The INMARSAT Aeronautical Standard

After realizing the potential for satellite communication links to aircraft INMARSAT released, in 1986, their initial definition for an Aeronautical Standard service. The final detailed specifications for this standard are under development in cooperation with manufacturing representatives of the industry and with the Airline Electronic Engineering Committee (AEEC) of Aeronautical Radio, Inc. (ARINC). Equipment meeting the INMARSAT Aeronautical Standard will provide aircraft with multiple channel voice and data services. The antenna system must meet the requirements shown in Table 1.

## E-SAT-300 Antenna System Description

The E-SAT-300 Antenna System has been designed by E-Systems to meet the requirements of the Aeronautical Standard of INMARSAT and ARINC 741 Characteristics [2, 3]. The system has been developed for commerical applications such as on airlines and executive aircraft. The E-SAT-300 Antenna System, shown in Figure 1, consists of an Antenna, Pedestal, and an Antenna Control Unit (ACU). The Antenna is a single tapered helical element, 10-inches in length, with 7 conducting turns wound on a laminated fiberglass tube. The measured gain of the antenna is 12.6 dBIC and the Antenna System Figure-of-Merit exceeds the requirement of -13.0 dBK.

The Pedestal is used to point and steer the single element helix antenna in both the azimuth and elevation directions. It utilizes command inputs from the ACU to the servo motors housed on the Pedestal for the steering function. The Pedestal also serves as the electrical and signal interface. A slip ring/flex lead and single-port rotary joint coupling provides low loss paths for control, data and RF signal routing from the Antenna and servo drive components to the ACU and to the Diplexer/Low Noise Amplifier located in the pressurized area of the aircraft. Figure 2 shows the major design features, structural members and dimensions of the Antenna/Pedestal Assembly as well as the relationships and clearances within the radome. The Pedestal has the ability to point the antenna to any location 360° in azimuth, and from -30 to +90° in elevation, including compensation for all aircraft maneuvers such as heading, pitch and roll. The Pedestal utilizes a differential mount concept that requires a minimum swept volume. Installation requires minimum aircraft fuselage penetration.

A radome houses the Antenna/Pedestal Assembly and provides protection from harsh atmospheric conditions while providing aerodynamic design to minimize drag. The radome has a maximum height of 14.75 inches and a length of 110 inches. The radome provides minimum attenuation and reflection of received and transmitted L-Band signals (less than 0.4 dB). Figure 3 shows the Antenna/Pedestal Assembly, radome, radome support structure, and mounting technique on top of an aircraft fuselage. The weight of the Antenna/Pedestal Assembly, radome and radome support structure is less than 85 pounds.

## Advantages of E-SAT-300 Antenna System

The E-SAT-300 Antenna system is mechanically steered in both the azimuth and elevation directions. Mechanically steered antenna systems have the advantage of maintaining consistent gain, side lobes and axial ratio characteristics regardless of steering angle. This provides these systems with a very wide angular coverage 360° in azimuth and from -30° to +90° in elevation with no keyhole voids. Keyhole voids result when antenna systems degrade in performance below operational specifications as a result of scan loss. This effectively reduces Satellite Communication coverage when satellites fall within keyhole areas.

Because of its simplicity the E-SAT-300 Antenna System has fewer electronic components than phased array designs. This makes the system easy to install and to maintain. The E-SAT-300 antenna system is designed for a Mean Time Between Failure (MTBF) above 30,000 hours.

The aerodynamically shaped radome causes a small increase in aerodynamic drag on aircraft. Calculations predict an increase of 0.05% in airplane drag when installed on a Boeing model 747-400 at fuselage station 1650. This is equivalent to 3 miles of added fuel in a 6000 mile journey.

Current advances in antenna technology and the above advantages suggest that Satellite Communications will revoluntionize the nature of communications on aircraft in the next few years.

## References


[1] Abdelrazik, M. A. and Houston, R. S., 1985, "Mobile Satellite Communications for Aircraft", Proceeding of the Satellite Communications, International Communications & Broadcasting Conference held in London, December 1985, Online Publications, UK.

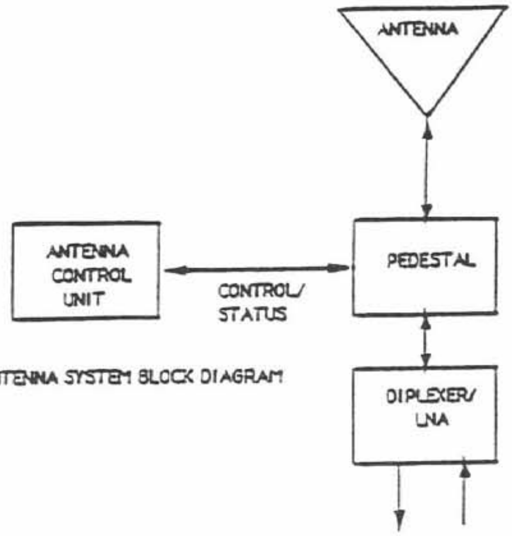
[2] INMARSAT Aeronautical System Definition Manual, Version 1.8, January 1989, Published by INMARSAT, 40 Melton Street, London, NW1 2EQ, England.

[3] Aviation Satellite Communication System, ARINC Characteristic 741-1, November 1988, Published by ARINC, 2551 Riva Road, Annapolis, Maryland.


TABLE 1

INMARSAT Aeronautical Standard High Gain Antenna System Requirements

| | |
|---|---|
| Transmit Frequency | 1626.5 - 1660.5 MHz |
| Receive Frequency | 1530 - 1559 MHz |
| Minimum Gain | 12.0 dBIC |
| Minimum G/T | -13.0 dBK |
| Side Lobes | -13 dB at and above ±45° from Boresight |
| Axial Ratio | 6 dB (RHC) |




E-SAT 300 ANTENNA SYSTEM BLOCK DIAGRAM

FIGURE 1

## E-SAT 300 Antenna Pedestal

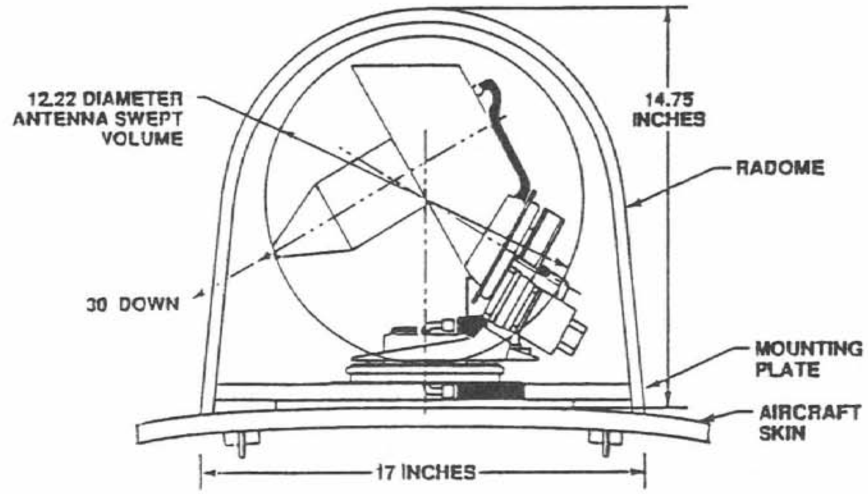



FIGURE 2

## E-Systems E-SAT 300 Antenna Installation Kit

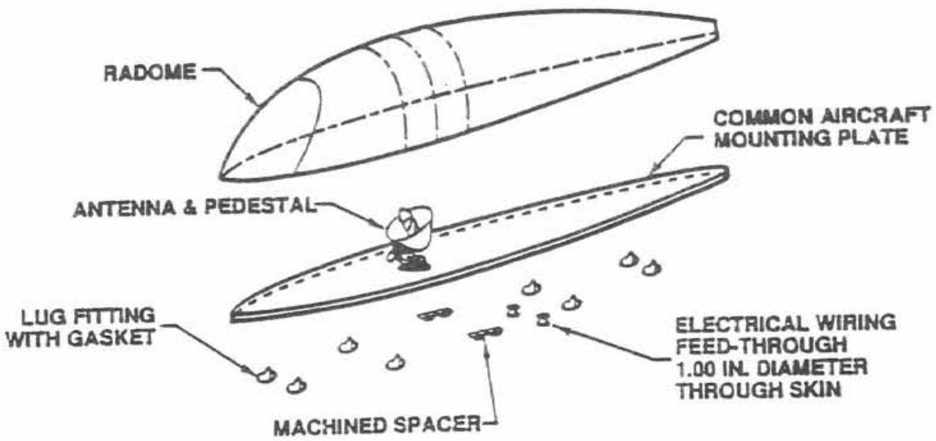



FIGURE 3