NASA's K/Ka-band Broadband Aeronautical Terminal for Duplex Satellite Video Communications

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INTRODUCTION

The Jet Propulsion Laboratory (JPL) has recently begun the development of a Broadband Aeronautical Terminal (BAT) for duplex video satellite communications on commercial or business class aircraft. The BAT is designed for use with NASA's K/Ka-band Advanced Communications Technology Satellite (ACTS).

The BAT system will provide the systems and technology groundwork for an eventual commercial K/Ka-band aeronautical satellite communication system. With industry/government partnerships, three main goals will be addressed by the BAT task: 1) develop, characterize and demonstrate the performance of an ACTS based high data rate aeronautical communications system; 2) assess the performance of current video compression algorithms in an aeronautical satellite communication link; and 3) characterize the propagation effects of the K/Ka-band channel for aeronautical communications.

DISCUSSION

The BAT will be developed and installed in the first aircraft in two years. Flight communications experiments will commence in Fall, 1995, during the last year of NASA's currently planned two-year support of the satellite. The initial experiments to be conducted with the BAT system will demonstrate duplex video communications between the aeronautical terminal in flight, anywhere above the CONUS, and a fixed ground station located at the ACTS master control station at the NASA Lewis Research Center (LeRC) in Cleveland, Ohio, as shown in Figure 1. Via the ACTS satellite such flight experiments may be conducted anywhere around the Earth where a line-of-sight view of ACTS is available. Initially the BAT will be installed in a Saberliner business class jet. Rockwell will provide the Saberliner aircraft for the initial BAT experiments, having already established a partnership with JPL for this effort. Other industry partnerships, now in negotiations, will allow installation and flight tests of the BAT in a commercial jumbo jet such as a Boeing 747.

ACTS was launched by the Space Shuttle and commenced operations in November 1993. ACTS is geostationary at 100 deg West longitude, over the mid-western U.S. The ACTS uplink is at 30 GHz, and its downlink is at 20 GHz. The ACTS steerable beam will track the aircraft to provide the mobile communications, and a fixed spot beam will provide communication with the fixed terminal at NASA LeRC.

Use of the K and Ka frequency bands provides the potential for large commercial growth but introduces a greater sensitivity to the weather than with already nearly at full capacity, and the K/Ka band allocation has much more bandwidth than lower bands, so K/Ka band is less likely to become congested. Although, K/Ka band suffers much greater from the effects of weather. Rain/cloud attenuation is more significant at 20/30 GHz than lower bands. For an aeronautical terminal though, these weather effects are only of concern when flying below the clouds. At cruise altitudes above the clouds such weather effects are insignificant.

The BAT system is "broadband" because it provides communication rates that far exceed that offered by voice systems now in operation, which utilize rates on the order of 10 Kbps. The BAT will demonstrate data rates of 384 Kbps in the forward link (to the aircraft) and 112 Kbps in the return link (from the aircraft). These rates allow full-motion, compressed video communication. A video coder/decoder (codec) translates between the video signals and a digital communication link.

The BAT consists of the subsystems shown in the Mobile Terminal identified in Figure 2. The main subsystems are the antenna, block converter, modem, video codec and video interface. The antenna subsystem consists of two assemblies: the main antenna, which mounts externally to the fuselage, and a control electronics assembly, mounted inside the cabin. The antenna is required to track the satellite over elevation angles down to 5 deg below the aircraft horizon, at an angular rate up to 60 deg/sec. The antenna RF requirements are summarized by a transmit EIRP of 46 dBW and a receive G/T of O dB/K, both with circular polarization. The main antenna assembly is allocated a maximum weight of 50 pounds and protrudes no further than 8 inches from the fuselage. The antenna control system monitors the signal level strength of a beacon sent by the satellite and received through the antenna to keep the antenna trained in the direction of the satellite. The antenna radome will present minimal protrusion from the fuselage and be aerodynamically shaped. The block converter translates between the sky frequencies of 20 and 30 GHz and a modem intermediate frequency of 70 MHz, with a bandwidth of 30 MHz. The modem implements the digital communications. It must compensate for Doppler of 25 KHz with Doppler rates up to 1 KHz/see. A modem performance of a bit error rate of 10-6 is expected at a Eb/No signal energy to noise spectral density level of 6 dB. The video codec provides full motion capability at the data rates of 384/1 12 Kbps, with NTSC video input.

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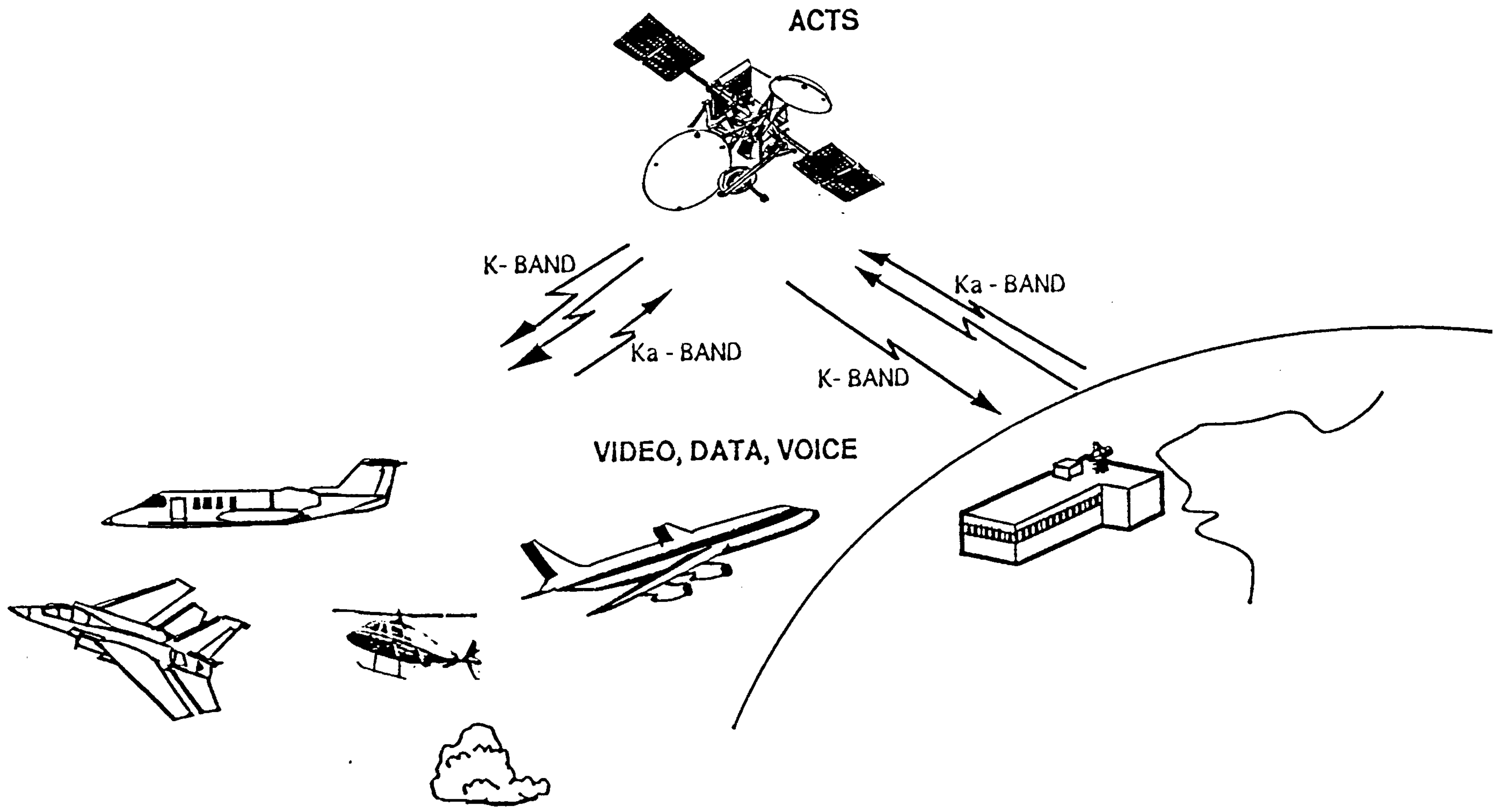

Figure 1. Broadband Aeronautical Terminal System Overview

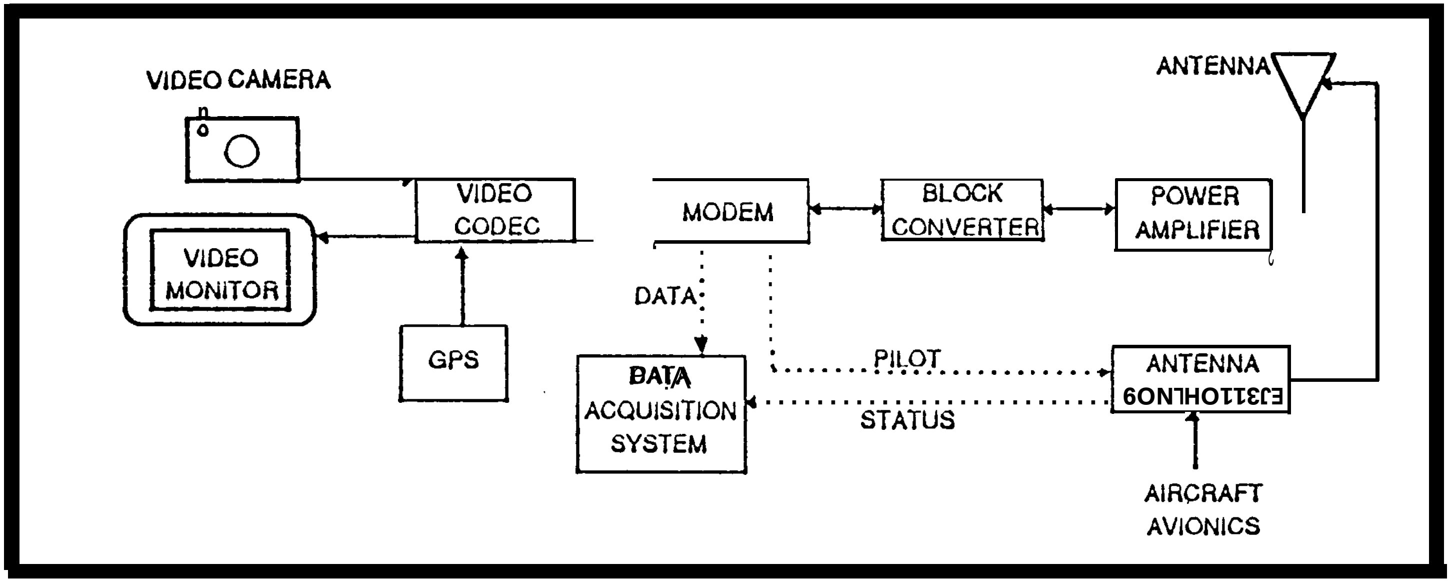

Figure 2. Broadband Aeronautical Terminal Block Diagram