ACTS MOBILE SATCOM EXPERIMENTS

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ABSTRACT

Over the last decade, the demand for reliable mobile satellite communications (satcom) for voice, data, and video applications has increased dramatically. As consumer demand grows, the current spectrum allocation at L-band could become saturated. For this reason, NASA and the Jet Propulsion Laboratory are developing the Advanced Communications Technology Satellite (ACTS) mobile terminal (AMT) and are evaluating the feasibility of K/Ka-band (20/30 GHz) mobile satcom to meet these growing needs. U.S. industry and government, acting as co-partners, will evaluate K/Ka-band mobile satcom and develop new technologies by conducting a series of applications-oriented experiments. The ACTS and the AMT testbed will be used to conduct these mobile satcom experiments. The goals of the ACTS Mobile Experiments Program and the individual experiment configurations and objectives are further presented.

ACTS MOBILE EXPERIMENTS PROGRAM

The ACTS Mobile Experiments Program focusses on just one part of the ACTS Experiments Program. Included in the the latter of these two, are fixed terminal K/Ka-band experiments at T1 data rates (LBR-2 terminal experiments), fixed terminal K/Ka-band experiments at supercomputer data rates (600-800 Mbps, High Data Rate terminal experiments), mobile terminal experiments (2.4-384 kbps,AMT), and supervisory and control data application (SCADA) experiments (2.4 kbps, USAT's). The remainder of this paper will focus on the mobile terminal experiments. The goals of the AMT Experiments Program are as follows: (1) to prove the technologies and system concepts associated with the development of the AMT and ACTS for mobile satcom applications; (2) to characterize the K/Ka-band mobile satcom propagation channel for land-mobile and aeronautical-mobile purposes; (3) to seek out new applications for K/Ka-band mobile satcom; (4) to have U.S. industry and government participation in these experiments; and (5) to stimulate the commercialization of similar technological advances and satellite services. Approximately one dozen different experiments are being developed between JPL and a variety of industrial/government partners to help the program to meet all of these goals. The basic ideas of some of these experiments is provided in Figure 1.

While the development of mobile satcom technology at L-band has reached a mature stage, there are many challenges that need to be overcome to allow K/Ka-band mobile satcom to become a reality. A detailed description of the terminal development is provided in [1], however, the main technological challenges of the AMT are: (1) to develop small, tracking, high-gain K/Ka-band vehicular antennas; (2) to overcome the large Doppler shifts and frequency uncertainties associated with K/Ka-band mobile satcom; (3) to design power efficient and robust modulation/demodulation techniques; and (4) to compensate for the high attenuation effects experienced with rain and other environmental conditions at K/Ka-band. The development of the AMT, and its use in these experiments will help to expedite solutions to these technical challenges.

Volumes of data characterizing the satellite propagation channel at L-, C-, X-, and even Ku-bands have been collected and thoroughly analyzed, however, very little information exists about the K/Ka-band satellite propagation channel. A limited amount of fixed site ground-based terminal propagation data exists from several propagation experiments that have been performed by Virginia Polytechnic Institute using the Olympus satellite. This data includes signal propagation and rain attenuation information for a fixed terminal in the immediate Blacksburg, Virginia area. No mobile satcom propagation data, or data that has rain attenuation statistics for any other part of the U.S. exists at this time. Performance of the AMT experiments throughout the country will go a long way toward characterizing the mobile satcom K/Ka-band channel, as well as to establish attenuation statistics throughout the U.S.

Some of the most exciting and potentially lucrative applications for K/Ka-band mobile satcom are in the satellite news gathering (SNG) and aeronautical broadcast areas. Mobile communications capabilities for SNG are often limited. In locations where a cellular system is available, mobile voice communications are possible. In remote locations not covered by the cellular network, truly mobile communications are not always feasible. Typically, the SNG van will have to stop and set up fixed communications equipment to communicate with the broadcast station. This limits the response time for real-time and rapidly changing news events. For this type of application, mobile satcom would allow a quicker response to news events and the potential to provide a compressed video network feed to the SNG van while it is en route to these events.

Aeronautical point-to-multipoint mobile satcom capabilities, first proposed in late 1992, are limited to audio broadcasts of news and sporting events, and are not yet widely available on commercial aircraft. As this service is initiated and expands, it can be expected to include broadcast video transmissions as well. The bandwidths available and the small antenna sizes required to transmit and receive reasonably high data rates make K/Ka-band very suitable for this type of applications as well [2].

Another exciting new area for this technology is disaster and emergency medical service. More lives and property can be saved by providing rapidly deployed voice, data, and video communications to an area struck by a natural disaster such as an earthquake or forest fire.

In meeting all of the goals of this program, and developing new applications for mobile satcom technology, NASA and JPL have been actively seeking industrial and government participation in the development of these experiments. By conducting the program in this manner, JPL achieves several goals inherent to the program. U.S. industry decides what technologies are important, and the program provides the R&D to prove the high-risk technologies. The U.S. economy benefits with the development of new industrial capabilities and services. Approximately one dozen different experiments are being developed under the ACTS Mobile Experiments Program. A description of these experiments is provided in the following section.

ACTS MOBILE EXPERIMENTS

The ACTS Mobile experiments fall into two broad categories, land-mobile experiments and aeronautical-mobile experiments. The following sections provide a brief description of the experiments and the potential influence of the experiment on the U.S. marketplace.

Land-Mobile Experiments

The initial land-mobile experiment will be an internal NASA/JPL experiment during which the terminal and satellite technology are verified, and the land-mobile satcom propagation channel is characterized. The experiment set-up is presented in Figure 2. The main objective of this experiment is to provide full-duplex voice, data, and low rate video communicant ions at 2.4/4.8/9.6/64 kbps between a fixed terminal and a mobile terminal. For the first experiment, a small, mechanically-steered reflector antenna will be used. A second, follow-on land-mobile technology verification experiment has the same basic set-up and objectives, but, uses a small, mechanically-steered active array antenna. Such a system could provide additional capacity augmentation for current L-band satellite systems, as well as open up a whole new service with the video communications.

Following this experiment, a secure land-mobile experiment will be conducted in conjunction with the National Communications Systems (NCS). This experiment set-up is basically identical to the initial land-mobile experiments, however, the secure communications is provided by interfacing a secure telephone unit (STU-III) to the AMT. The main objective of this experiment is to provide secure full-duplex voice and data communications for national security and emergency disaster applications. A second follow-on secure experiment will involve an identical scenario, but substituting the small, mechanically-steered active array antenna for the reflector antenna.

Another of the land-mobile experiments involving disaster/emergency preparedness communications is the Emergency Medical Experiment. This experiment is being performed in conjunction with the EMSAT Corporation. During a typical paramedic call, communication is lost when the paramedic enters a building to handle a situation. For this experiment, the AMT will be interfaced to the base station of a portable transceiver. The paramedic will have the portable transceiver with him when he enters the building. The communications link will be initiated by the paramedic, to the AMT located outside, to the fixed station via ACTS, and finally through a land-line back to the hospital.

An experiment with a similar application to the Emergency Medical Experiment is the Telemedicine Experiment, to be performed in conjunction with the University of Washington Medical Center, located in Seattle, Washington. Many areas in rural America have extremely limited access to proper medical care and facilities. This experiment will provide medical imaging capabilities such as X-ray transmission from remote locations via ACTS and the AMT to the University of Washington Medical Center for diagnoses. The experiment set-up is provided in Figure 3. The operational data rates for this experiment are 2.4/4.8/9.6/64 kbps.

Currently on the ACTS/AMT Experiments docket are two separate SNG related experiments. The first experiment, performed in conjunction with IDB Communications, involves transmitting a remote live radio signal back to the broadcast station for retransmission. The second SNG experiment, performed in conjunction with NBC, involves a similar terminal configuration. Both of the experiments will improve current communications capabilities for remote, mobile SNG broadcasting, and will demonstrate low rate network video return feed.

Another experiment, performed in conjunction with CBS Radio, involves the transmission of high quality audio and music using a MUSICAM Perceptual Coder interfaced to the AMT. The initial experiment set-up tests the transmission of high quality mono audio at 64 kbps. Upon completion of this experiment, a second, more sophisticated experiment is performed that tests the transmission of high quality stereo audio at 128 kbps. The audio codec utilized in this experiment monitors the received signal quality, and varies the "degree of coding" necessary to maintain the link. In addition to code variation, the audio codec also adjusts the audio quality as required to maintain the link. The audio codec varies the bandwidth of the coded signal from 5 kHz to 20 kHz, and switches between stereo and mono audio, depending upon the link conditions.

A military experiment for the AMT is performed in conjunction with the Army -C ECOM. This "Comm-on-the-Move" experiment outfits a HMMWV with the RF portion of the AMT, interfaced with a SINCGARS radio to provide mobile satcom, on the move, back to a fixed terminal. This experiment improves the current military communications capabilities.

A satellite/terrestrial personal communications network (PCN) experiment will be performed in conjunction with Bellcore. This experiment defines practical limitations of present personal satellite communications technology and develops hard data to direct the future course of technology development. Merging the current terrestrial-based equipment with the satellite-based equipment will further enhance the systems capabilities. This experiment has two different configurations. The first set-up interlaces a hand-held personal computer to the AMT for the transmission and retrieval of data and E-Mail messages. The second configuration interfaces the AMT to a modified cellular radio system for wireless remote paging.

Aeronautical-Mobile Experiments

The initial aeronautical-mobile experiment is a NASA/JPL effort that verifies the terminal and satellite technologies. The aeronautical-mobile satcom propagation channel is characterized during the cruise phase of fright. The aeronautical mobile terminal equipment incorporates the land-mobile AMT equipment, with the exception of the land-mobile antennas. For this experiment, three separate electronically-steered phased array antennas are used. Due to the limited EIRP and G/T specifications on these antennas, the experiment is limited to voice and data transmission at a rate of 4.8 kbps.

The experiment with the most visibility and most potential profit are the broadband aeronautical experiments. A full description of these experiments is found in [2]. Two distinct groups are interested in applications of this type. Military organizations, such as the U.S. Air Force will transmit imaging from an aircraft back to a fixed station terminal for analysis. Commercial organizations, such as U.S. airlines, will provide passenger cabin broadcast video and return line "office-in-the-sky" capabilities such as voice and FAX transmissions. Initial iink budget analyses shows that terminal development for these experiment can support data rates up to 384 kbps on the forward iink (fixed terminal to mobile terminal), and up to 112 kbps on the return link (mobile terminal to fixed terminal). The experiment set-up is shown in Figure 4.

For the commercial applications experiment, a broadband aeronautical working group is being formed to assist with the experiment and terminal development. The members of this working group come from a variety of interests in U.S. industry including aircraft manufacturers, airline carriers, satellite service providers, aeronautical avionics manufacturers, video compression companies, broadcasters. Active participation by U.S. industry in this experiment will heip stimulate the commercialization of the service. A commercially operated system providing compressed video broadcasts for passengers could be in service as early as the turn of the century.

ACTS/AMT EXPERIMENTS SCHEDULE

The experiment period begins at the start of October, 1993, and is scheduie to run a two year period through the end of September, 1995. With the exception of the initial land-mobile experiment, two experiments will be in operation continuously for this two year period.

SUMMARY

The ACTS Mobile Experiments Program includes development of severai mobile satcom technologies. The various experiments are joint efforts between U.S. industry and government. The experiments facilitate technological verification of the terminal and satellite, the development of new satcom applications and commercial ventures, participation in the experiments by U.S. industry and government, and ultimately will stimulate the U.S. economy through the development of new industries.

REFERENCES

[1] Agan, M.J., et. al., “The ACTS Mobile Terminal: Poised for Launch,” IMSC Conference 1993.

[2] Abbe, B. S., et. al., "ACTS Broadband Aeronautical Experiment,” IMSC Conference 1993.

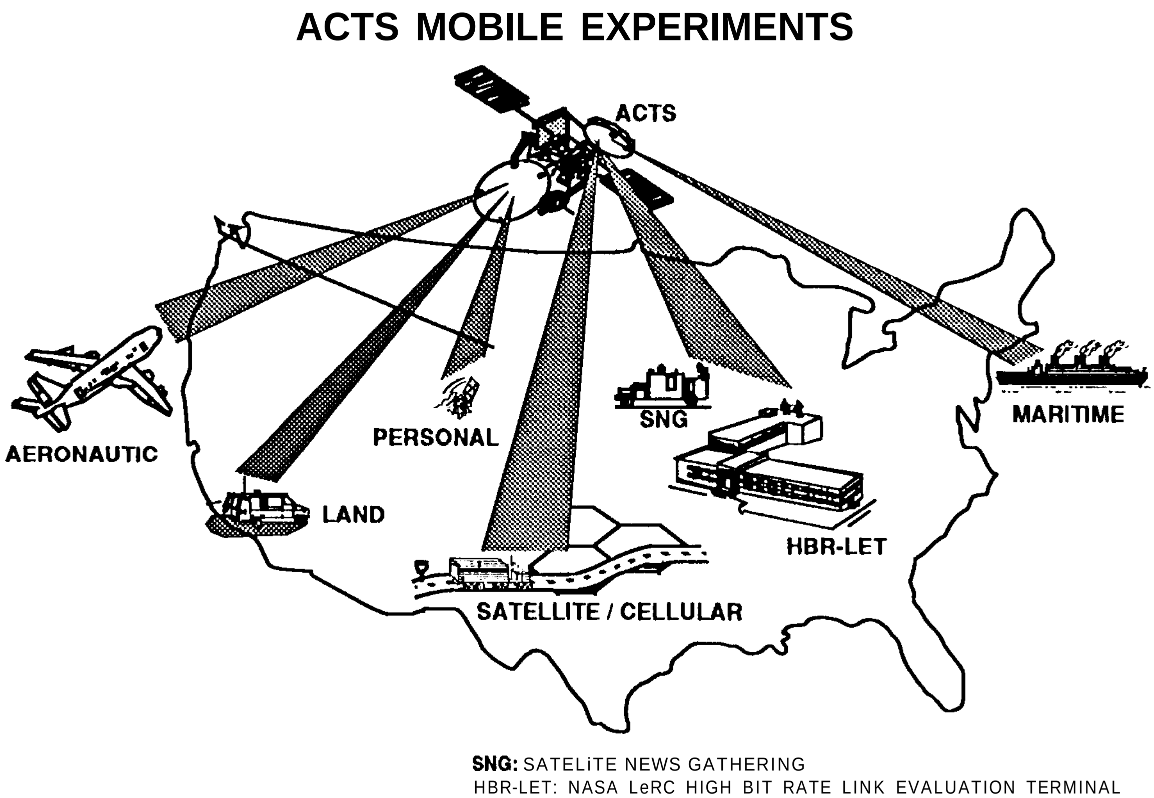

Figure 1 ACTS Mobile Experiments

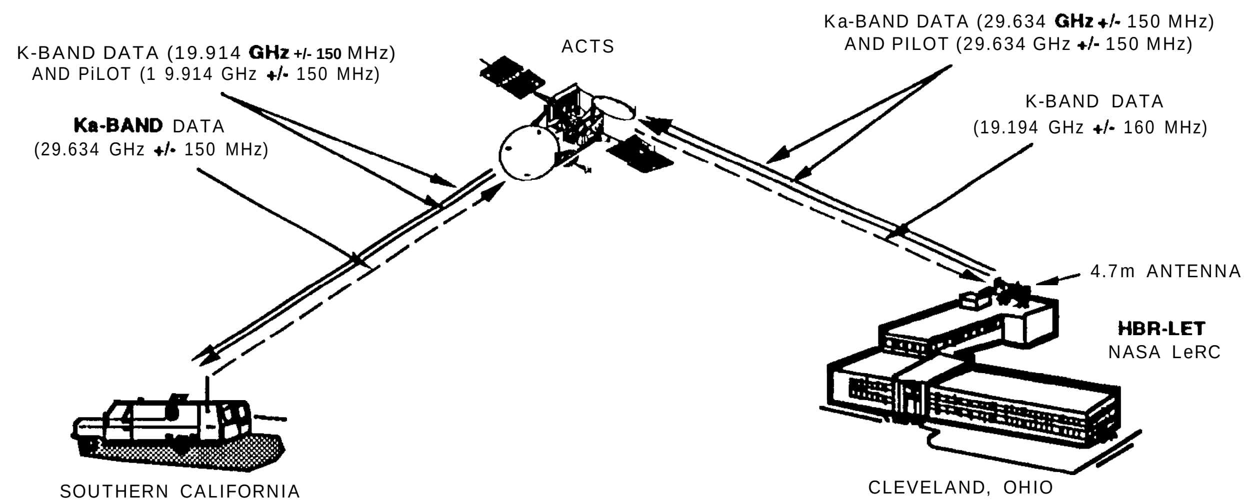

Figure 2 Land-Mobile Experiment Configuration

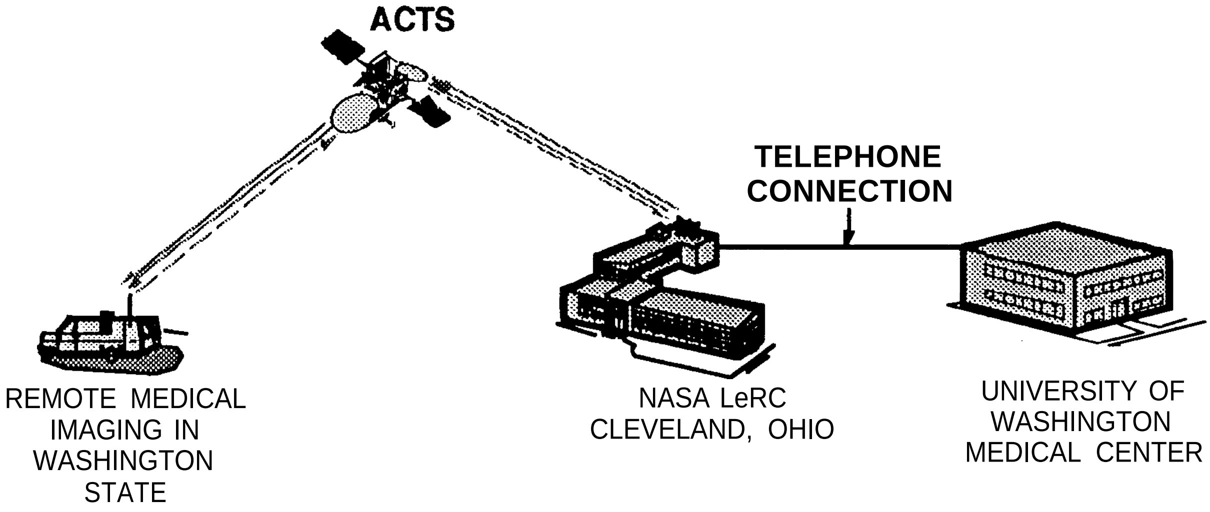

Figure 3 Telemedicine Experiment Configuration

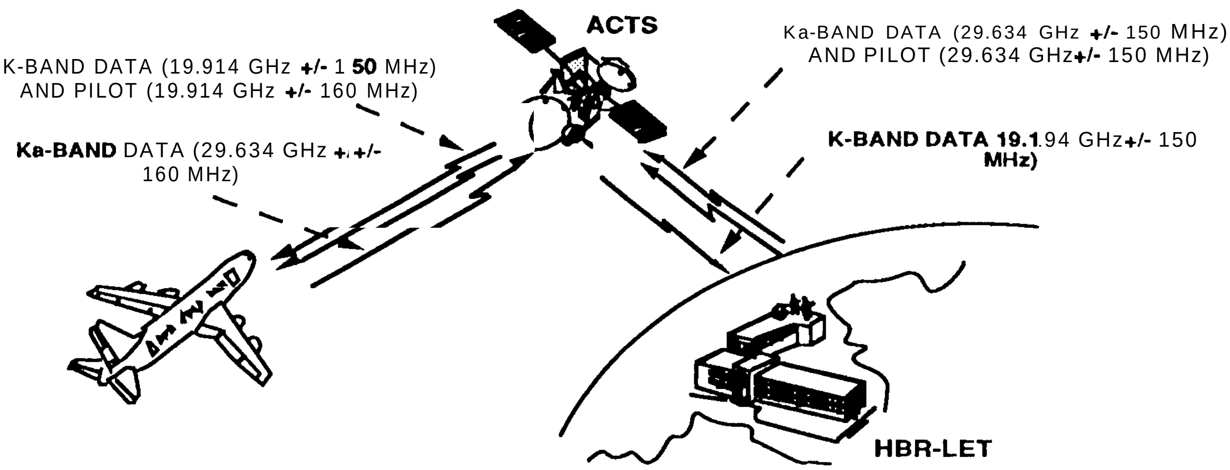

Figure 4 Broadband Aeronautical Experiment Configuration