Aeronautical Satellite Development 1963 -1972
A Summary

My involvement began in late 1963 when I was assigned to a team at Hughes Aircraft which had been given the task of developing satellite communications applications. Syncom 2 was in orbit and the age of satellite communication had begun. As the junior member of the team, I was assigned mobile applications. A brief study of the problem indicated that for truly mobile communications the user should be able to make use of a simple dipole antenna (or aircraft blade antenna) and that the optimum frequency would be in the 150 mhz to 450 mhz range. The telemetry and command system of Syncom 2 operated in the VHF band at 136 mhz and 148 mhz. this led to a proposal to use this spacecraft to demonstrate satellite to aircraft communications. The efforts of personnel at Hughes, NASA, Air Transport Association, Bendix, Pan-Am as well as the FAA and the US Weather Bureau are described herein.

Significant early contributors were Frank White (ATA); William Pulford and Harry Betsill (Bendix); Meredith Eick, Lou Greenbaum, and Roland Boucher (Hughes); Ben McLeod, Bob Bohanon and Waldo Lynch (Pan Am); Pat Corrigan and Bob Darcy (NASA Goddard) and members of the antenna department at Boeing. Many other organizations were to become involved over the next nine years.

Receiving Tests with Syncom 2, 1963-64

This period began with reception test on a satellite simulator in the lab followed by the reception of satellite signals on a dipole antenna and finally the reception on a Pan AM 707. Potential degradation of reception due to Faraday rotation and both galactic and man-made noise were also examined. The first year also demonstrated the possibility of using the Syncom 2 command-

enable audio tone for teletype communications. This was first demonstrated in the laboratory with a satellite simulator; then with a simple ground station simulating expected aircraft performance. Ground to air communications was demonstrated on 21 November from the NASA /Hughes ground station at Camp Roberts, California to Bendix equipment and engineers aboard a Pan Am flight en route from San Francisco to Honolulu.

Two Way Communications Syncom 2 and ATS -1 VHF Experiment, 1965

This year saw the first the two-way air-ground satellite communications. It took place on January 27, 1965 between NASA/Hughes station at Camp Roberts, California and the Bendix equipment aboard a Pan Am flight out of Hong Kong. Further tests were conducted during the year.

Within weeks of the test of January 27 NASA asked Hughes to develop a VHF repeater experiment for the NASA/Hughes Advanced Technology Satellite ATS-1. This experiment was managed at different times by Roland Boucher and Bill Penprase of Hughes and Pat Corrigan of NASA Goddard. I am sorry that I am quite fuzzy about events at this time. When returning home January 28, I was told that my father had contacted meningitis; he died after a brief illness. The next event that I really remember was the solution to an antenna temperature problem.

The antenna for the VHF experiment had been proposed to be mounted on the microwave end of the spacecraft; NASA repositioned it to the apogee motor end. The antenna now had to withstand the heat and blast forces from the rocket exhaust. I proposed to manufacture the dipole elements from beryllium to absorb the terrific heat without failure; NASA agreed and also decided to flame coat the completed antenna with a ceramic material to provide additional protection. Shortly after this I was named acting program manager for the VHF Experiment on

ATS-1. This program is described in the quarterly reports (two in 1965, two in 1966, and the final report in 1966).

ATS-1 Launched: Air-Gground Voice Communications Demonstrated, 1966

The year was spent in the development of the VHF experiment and its new eight-element beryllium deployable antenna and planning for the involvement of the airline industry to be ready for aircraft tests with ATS-1 that was to be launched in December. I presented a paper to the aviation community In July titled "Satellites for VHF Aeronautical Communications - Present and Future." Executives from nearly a dozen major airlines from all over the world came to visit Hughes to see the progress for themselves. When ATS-1 was launched on December 7, 1966, aircraft from all over the world were equipped with satellite compatible communication sets. As I remember Pan Am was joined by TWA, United, Quantas, and a other foreign airlines. All reported that the signal was loud and clear except for a small amount of antenna spin modulation (walking feet). This was most apparent at the edges of coverage. It was all but eliminated in a later test on a Pan Am flight from New York to Brazil when the satellite antenna beam was pointed to the center of the flight path.

More ATS-1 Tests, VHF Experiment on ATS-3, Circular Polarization, 1967

In early January I decided to see if it was possible to receive FM music transmissions from ATS-1. The FM modulation (bandwidth) was increased 10 db and the aircraft blade antenna replaced with a simple three-element Yaggi. I modified an inexpensive Sony FM portable radio and tried it . It worked. The inexpensive Sony portable had an IF bandwidth of nearly 500 khz yet it received music transmitted from ATS -1.

The year saw many airlines participate in successful communications through ATS-1. The U.S. Coast Guard became involved with communication tests on the Klamath, the Staten island, and the USCGC Glacier. Hughes authorized me set up a VHF terminal in my home which became known as ARINC Los Angeles. A large number of audio tapes of the communications test were made of both aircraft and shipboard communications.

In May I presented a paper on VHF Satellites for maritime mobile communications before the Radio Technical Commission for Maritime Services. It was well received.

The VHF Experiment on ATS-3 used linear RF amplifiers in place of the Class C amplifiers on ATS-1. Linearity was important because it greatly reduced the intermodulation distortion inherent in multi-channel transmitters. This causes users at microwave frequencies to operate their spacecraft transmitters well below peak power (transmitter back-off). The VHF transmitters were solid state and used a class A/B final stage, The DC power required was reduced 0.5 db for every 1 db of back off. This was a very important discovery since power is a very expensive commodity on any spacecraft.

At low elevation angles multi-path can cause a significant loss in signal for short periods of time as the reflected signal alternately cancels and adds to the direct signal. Circular polarization can eliminate this problem when used by both receiver and transmitter, (field tests with Tacsat verified this in 1969) Hughes designed and tested circular polarized replacements for the dipole antenna elements on ATS-3. Unfortunately NASA did not approve their use. Meanwhile Boeing designed a circular polarized flush mounted VHF antenna for the 747.

C. A. Petry at ARINC worked with the airlines and FAA to produce ARINC Specification No. 546. This specification described the performance and installation properties of a new spacecraft

compatible aircraft radio set. When the first Boeing 747 was delivered to Pan Am, it was equipped with and ARINC 546 communication transceiver and a circular polarized antenna. This aircraft was equipped for satellite to aircraft communications. ATS-3 was launched successfully on November 5, 1967.

Hughes designed a small inexpensive VHF terminal for the US Coast Guard which was installed on the icebreaker, USCGC Glacier. This ship was used to resupply the Antarctic base. That winter,1967/1968, sun spot activity a was great and HF radio was unusable for long periods of time. The $4000 Hughes satellite terminal got through every time.

Working with Comsat and the International Community,1968

Hughes supported Comsat, NASA, ARIC, and the ATA as well as members of the international community to promote air-ground satellite communications. In September Hughes submitted a proposal to Comsat for a VHF Aeronautical Satellite.

NASA contracted with Philco Ford and General Electric /Hughes for a study program to define future ATS spacecraft models (F and G). The Philco-Ford design concept was chosen for development.

Pope Paul visit to Bogota Columbia 1968

In the spring Hughes was asked if it were possible to broadcast ,through satellite, the up-coming visit of the Pope Paul VI to Bogota, Columbia scheduled in August. The Early Bird satellites operated by Comsat were designed to operate with an 85 foot ground antenna . Time and cost precluded using this approach. I suggested to the group that ATS-3 could be used and that a 15 foot diameter antenna would be sufficient if the prototype 10,000 watt transmitter recently completed at Hughes Fullerton could be made available. I also suggested that the

Pope's terminal contain a VHF communication set in case the telephone service from Bogota to Hughes CA prove unsuitable. NASA agreed to make ATS-3 available, and one month before the expected arrival of the Pope in Columbia we were given the go ahead. Time was short, so I approved the purchase for immediate delivery of a 15-foot antenna from Gabriel's Horns in New Hampshire.

We ordered immediate delivery of a modified tilt up box from a garbage truck manufacture to be used serve as the terminal structure to house the Fullerton transmitter and other equipment. The FM video modulator was a borrowed prototype of the spacecraft unit used to transmit Spin Scan Camera Video. The FM voice sub carrier was generated by a Boonton signal generator. A VHF terminal similar to the one on the Glacier was installed and a 3 element Yaggi used for transmit and receive. The station was flown to Bogota in a USAF C-130 and set up in less than one week.

At first glance one might think that we were forced to transmit blind since we could not possibly receive video on a 15 foot antenna. Fortunately the video signal has a very large amount of energy in the blanking pulse and is transmitted at the 30 hz frame rate. We tracked the ATS-3 using this narrow band signal and plotted optimum antenna pointing angles with two carpenters tape measures mounted to the antenna gimbals. Later we used the VHF link to talk directly with the NASA ground stations to verify signal saturation levels in the spacecraft. After the successful transmission of the visit of the Pope to Bogota by this first mobile satellite transmitting station it went to Iran to transmit the 2500th anniversary of the Persian Empire to the world, then on February 5, 1972 a C-130 flew it to China for the historic visit by President Nixon.

Comsat Plan, CCIR Conference in Geneva, 1969

Hughes provided technical assisted to Comsat and others as requested throughout the year to support its proposal for a VHF Aeronautical Satellite. We prepared a brochure titled “ Aerosat Commercial VHF Communications via Satellite."

That fall I was selected as a representative of the State Department to the CCIR conference on satellite communications. Thanks to the efforts of Captain Charles Dorian and others we were able to convince the group to authorize VHF aircraft communications by satellite. France led the opposition and unfortunately they played politics better than we did. As I understand it, they got NASA to oppose Aerosat by agreeing to support the Space Shuttle. In any case I received a phone call in Geneva from Hughes saying its all over as NASA pulled the plug.

1970-1972

Flight tests continued, presentations were made all the way up to the office of the President (Nixon). I was offered a position in the Office of The President but declined. I had spent nearly almost 10 years in the pursuit of a VHF Aeronautical Satellite to no avail. Completely independent of my employment with Hughes, I had developed the concept of an electrical powered battlefield surveillance drone and a solar-powered high altitude spy plane. It was time to accept the offer to join the Office of the President or to start a new company to pursue this new field. I left Hughes Aircraft in January 1973. The prototype electric powered battlefield drone flew that year and a proof of concept model of the spy plane flew on solar power alone in 1974

30th Anniversary Celebration Aeronautical Satellite Communications, 1995

On September 29, 1995 Ben McLeod and Bob Bohanan (both from Pan American) organized a 30th anniversary celebration in Washington DC. Personnel from ATA, ARINC, Bendix, Comsat,

FAA, FCC, Hughes, NASA and or course Pan Am were in attendance. We all were all thrilled that the aging Frank White was able to attend and were sad that other important contributors from Comsat, Collins Radio, and the US Coast Guard were unavailable or deceased.

This brief description of events almost 50 yeas ago are correct to the best of my recollection. Serious students of this era may contact Bill Pulford formerly of Bendix who is still in good health and Bob Bohanon who is now with American Airlines in Dallas, Texas.