

TRANSPORTABLE EARTH STATION OPERATIONS IN PEKING

L. A. GREENBAUM
Manager
Satellite Ground Systems
Space and Communications Group
Hughes Aircraft Company

Summary During the month of February 1972 a group of ten Hughes Aircraft Company and two Western Union International engineers had the fortunate opportunity to travel to the People's Republic of China to install and operate the satellite earth station used in support of President Nixon's historic visit.

Hughes Aircraft Company, Space and Communications Group was under contract to Western Union International, who in turn held the contract to provide the satellite communications equipment utilized in Peking. The team of Hughes and WUI had provided a similar communications facility to the Shah of Iran during the ceremonies marking the 2500th Anniversary of the Persian Empire in October of 1971.

Introduction With the development of synchronous communication satellites, it became apparent that there would be a need for highly mobile earth stations in addition to the obvious international telephony applications. Hughes Aircraft Company has been involved in developing transportable stations for the past several years, which have been used to bring live television and telephony from remote areas. A transportable station was sent to Bogota, Colombia in 1968 to transmit television of Pope Paul's visit there; again in 1968 the same station, with some modification relayed television of the Olympic Games, being held in Mexico, to Japan. In 1971 a station was dispatched to Iran to cover the 2500th Anniversary of the Persian Empire. The latest, and most critical assignment for the Hughes transportable station was that of accompanying President Nixon to the People's Republic of China.

Hughes' history in providing special-event communications parallels the Hughes development of the synchronous communication satellite. Hughes has, on several occasions in the past, performed such services to demonstrate the capability and encourage the use of satellite communications. This type of program started with the transmission of television of the 1964 Olympic Games from Japan through the NASA/Hughes Syncom 3 satellite. That transmission may well mark the advent of international commercial television. In 1968 Hughes provided the transportable earth station to televise, through the

NASA/ Hughes ATS 3, Pope Paul's historic visit to Bogota, Colombia. This mission offered a good demonstration of the effectiveness of small communication satellite terminals in providing coverage to the world of significant television events.

Western Union International has provided live television coverage of all the Apollo splash-downs since Apollo VII.

In the summer of 1971 Hughes and WUI agreed to undertake a task for the Shah of Iran to provide video and telephone communications from Persepolis, Iran through the Indian Ocean Intelsat III. It was felt at that time that if such a mission could be done successfully that it would provide an impetus for providing such service for the forthcoming Presidential mission to China. The Iranian mission was in fact a very successful rehearsal for the Peking mission.

Mission Description The Peking mission required providing one uplink color video channel, 60 two-way telephone channels, and 24 full duplex teletype channels. All of this traffic was handled from Peking through the Pacific Intelsat satellite to the Comsat earth station at Jamesburg, California. Initially, the Pacific Intelsat III was used; during the last two weeks of the mission, including the Presidential visit, the Hughes/ Intelsat IV became operational as the prime Pacific Intelsat spacecraft. Table 1 lists the technical parameters.

Once the information arrived at the Comsat, Jamesburg station, the television signals were sent through AT&T facilities to the network television studios in New York. The telephony was handed over to AT&T at Jamesburg and handled as normal international traffic through the AT&T overseas switchboard at Oakland, California. During the week of the President's visit to China, regular commercial telephone calls were being made to and from the American party in the PRC via AT&T and Intelsat through the earth station in China.

The contract called for all of the people and equipment to leave Los Angeles on 28 January; people and part of the equipment to arrive in Peking on 1 February, and the remainder of the equipment to arrive on 2 February. The major portion of the earth station was shipped to China on a leased Saturn Airlines stretched C130 aircraft. The equipment was to be installed and operational as soon as possible after arrival. It wasn't known at that time how soon after the station was operational that the Chinese would actually allow communications to begin. However, the plan was to be ready to radiate as soon as possible after arrival.

In planning the Peking mission, all of the technical people associated with the task operated in a very constrained environment. There was, of course, minimal opportunity for technical exchange with the Chinese and little information on the operating environment.

Preliminary arrangements and technical discussions concerning the earth station operation and the communication paths in general were handled by the two advance parties to the People's Republic of China. The second advance party, which spent the first week of January in the PRC handled most of the technical arrangements. When preparing for such a mission, considerable time would normally be spent in direct discussions with the people responsible for the service. However, the obviously unique conditions surrounding this mission did not allow for such interchange. Although the lack of such discussions was cause for concern, the excellent work done by the advance party team members and the extremely cooperative attitude of the technicians and engineers of the PRC more than compensated for the lack of early discussions.

The attitude of the host engineers and the competence of the Chinese communications people were pleasant surprises during this mission. Later in the paper we will discuss this subject in more detail.

It was known before going to China that all of the video information would be created by the U.S. television network pool and firm working agreements and technical interfaces were made with the network engineers. The plan called for the television studio to be about 100 yards from the earth station and that the network video signals would be fed to the station on a coaxial cable (which the network people brought with them).

However, the telephone plant and the interconnections with the Chinese system was something that we knew we would have to work out in real time after we arrived in China. Standard Chinese electrical power is 50-cycle, 250-volt, which of course was not usable in our all 60-cycle, 220-volt system so we planned to bring our own diesel power plants.

Station Description Figure 1 is a basic block diagram of the transportable earth station used in the Peking mission. As can be seen, the station in essence provides fully redundant up and down links to and from the satellite, interfacing with the various users at baseband. Although standard in basic configuration in a number of ways, this earth station has been optimized for its application as a highly transportable facility that can be configured to support a number of different kinds of missions in addition to communications missions.

For instance, the station has been reconfigured since the Peking mission into a telemetry and command earth station to support the launch of Anik I, the Canadian Domestic Satellite, under contract to Telesat of Canada. This assignment involves the setting up of the station on Guam and receiving telemetry, sending commands, and ranging to the satellite during its transfer orbit prior to its injection into synchronous orbit.

The station is designed as a flexible facility and is available to provide Hughes with a broad spectrum of capability in support of its various satellite activities.

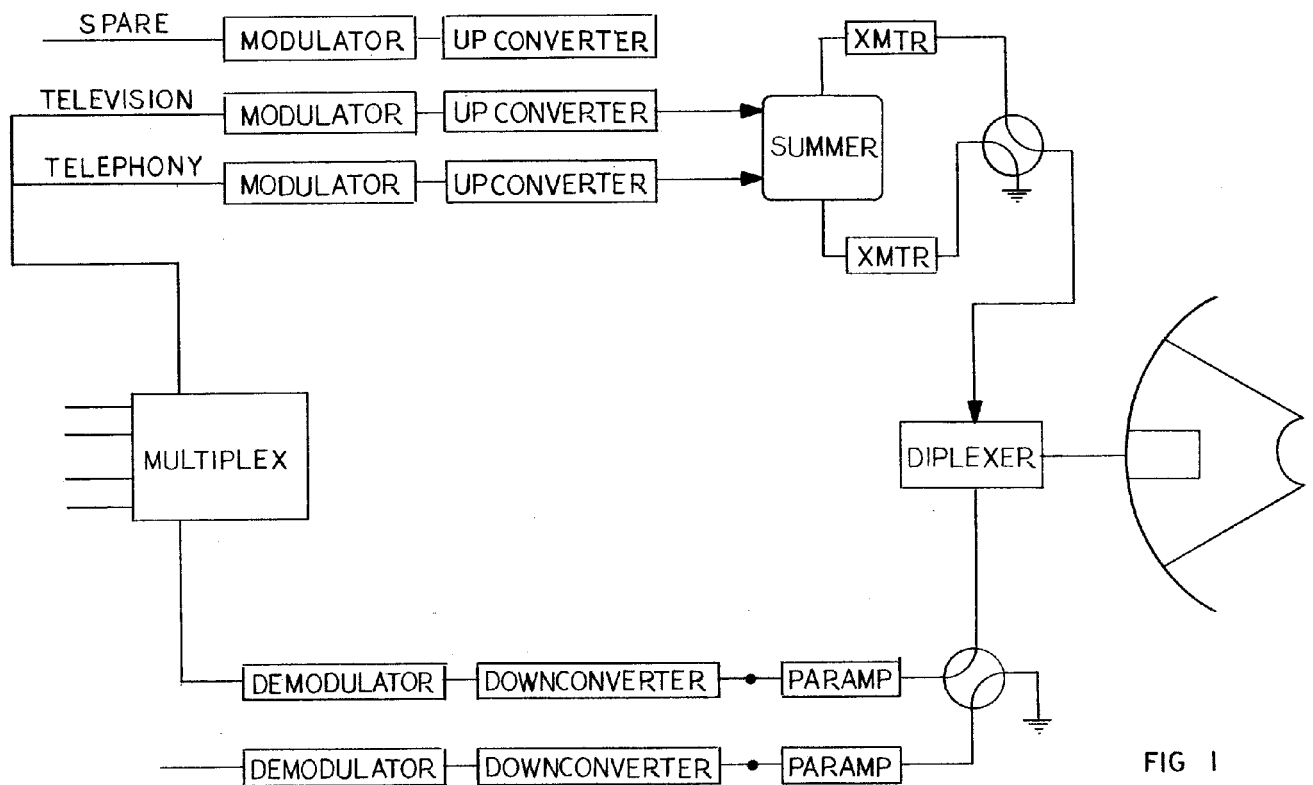


FIG 1

When configured for a communications mission such as Peking, the earth station is packaged in two large shelters which, when in place, are connected ' forming a single room. Figure 2 shows the two shelters during their installation in China. In simplest form, each shelter contains half the earth station. In addition to the shelters, the basic earth station components include the antenna, two heat exchangers, and two diesels.

The antenna system is composed of a 24-foot parabolic antenna, Cassegrain feed system, and a rather novel mount. The basic main reflector is composed of six sections, or petals, and a center section. The antenna is manufactured from honeycomb fiberglass with a sprayed aluminum surface. Figure 2 also shows the antenna disassembled (in the foreground), while Figure 3 shows the antenna in its assembled configuration. The fiberglass construction allows for erection of the antenna in the field without requiring any heavy machinery, such as cranes. Looking again at Figure 2, one can see the latches around the edges of the panels which are used to lock together the six petals and the center section. The unique latch and guide pin assembly is used to fasten the various sections of the antenna together and provides a very reliable field erectable antenna.

The feed system is a standard/receive Cassegrain antenna system. The feed may be used either linearly or circularly polarized. For the Intelsat operations it was configured circularly. The antenna mount provides for limited motion in both azimuth and elevation. In the Peking configuration there was 10 degrees of motion available in each axis. The

antenna is not auto-tracking but is manually pointable through the use of motor drives. With the limited motions of existing Intelsat spacecraft, manual Pointing, although a little inconvenient, offers no difficulty for this type of mission. Antenna pointing is accomplished by monitoring the receive signal and occasionally “peaking” the antenna pointing. A very convenient and reliable way to point the antenna is to monitor the station’s own down link signal and steering to maximize the signal. It was found when operating with the Pacific Intelsat IV that corrections were required on the order of once every several hours.

As can be seen from Figure 3, the operating angle in Peking was rather low, about 9.5 degrees when operating with Intelsat IV.

Looking again at the block diagram in Figure 1, the receive subsystem has two RF preamplifiers, one a cooled parametric amplifier with an effective temperature of 30°K and a second uncooled paramp with a noise temperature of 90°K. Both preamplifiers are installed directly at the output of the antenna feed. Figure 3 shows the tent on top of the shelter, directly behind the antenna, that forms the feed room where the preamplifiers are located. As mentioned earlier, the last mission several months before the Peking mission, involved erecting the station at Persepolis, Iran. The daytime temperatures in Persepolis reached the low 100’s, in Peking the nighttime temperatures were around 10°F. When setting up for the Peking mission, we had to replace all our air conditioners with electric heaters; stabilizing the temperature in the feed room was one of the initial annoying problems.

The remainder of the feed system is composed of redundant dual conversion down converters and redundant threshold extended demodulators.

The Peking mission required that two carriers be radiated simultaneously, one video and one telephony uplink. The assigned frequencies positioned the carriers near enough in frequency so that both carriers were within the 50 MHz passband of the high power amplifiers. Thus we see on the block diagram on Figure 1 that two up converter outputs were summed and sent to the transmitters. Either transmitter could be selected for on-line use, the second was available as backup.

The transmitters have a 15-KW rated output tube (Varian 884D). During this mission, approximately 200 watts of RF power was required for the telephony carrier and 2000 watts for the video carrier.

Standard Intelsat engineering service circuit orderwire equipment was available to communicate with the other Intelsat earth stations. During this mission all communications were with Jamesburg.

Telephony Interfaces The earth station was set up at the Peking airport, approximately 20 miles from downtown Peking. The telephone plant that the PRC provided for the American party was somewhat unique. All the Americans, except for the President and his immediate staff, stayed at the Nationalities Palace Hotel in downtown Peking. The Chinese provided a 50-pair cable from the hotel switchboard directly to the earth station. We understand, although we never saw it, that there was a negative resistance amplifier somewhere down the length of the cable. All of the telephones which were made available to the American party, press and technicians, were extensions on this hotel switchboard. In addition, the Chinese had a microwave link which came from downtown Peking to the airport. When it became apparent that the fifty conductor cable was a few channels too small, the Chinese provided additional circuit capacity via the microwave link.

We provided, as part of the earth station, a two-wire interface with the Chinese multiconductor cable. The earth station equipment included the echo suppressors, the two-to-four wire hybrids and line drivers, as well as the 60-channel multiplex. Also provided at the earth station was some special signalling equipment which converted the Chinese ring tones to U.S. standard and conversely converted the U.S. tones to Chinese standards. This equipment allowed signalling between U.S. and Chinese switchboards. The Chinese provided English-speaking telephone operators and operated the hotel switchboard as a normal overseas telephone facility.

The Chinese technicians brought the multiconductor telephone cable directly to our racks. We found the color coding scheme unique - all the pairs were red and white - the cable had to be rung end-to-end in order to identify pairs. We had a bad shock when we first connected this interfacility cable to our hardware; the characteristic impedance of the cable turned out to be 330 ohms instead of the traditional 600 ohms. This mismatch caused a major unbalance in our telephone hybrids and an intolerable echo on our telephone channels. After lengthy discussion and a great deal of help from the White House Communications Agency team and consultations with the Western Electric engineers in the U.S., we designed and built impedance matching networks for each telephone line. Fortunately, we had sufficient bits and pieces in our spare parts to get through this unpleasantness.

The checkout of the telephone system from that point on went very smoothly. The line from town and all of the Chinese equipment connected to it was generally very well behaved during the entire mission. We had a minimal amount of the normal kinds of problems and we learned to recognize the Chinese equivalent of "it's OK leaving here". But by and large the system performed well. When operating with the Intelsat IV spacecraft, the average test tone to noise was 56 dBmOp, which is better than CCIR standards.

The Chinese had telephones which were part of this system at several locations, all tied to the hotel switchboard. All the telephones in the hotel had accesses to the earth station. A special facility was established in the building next door to the Nationalities Palace to serve as a press center. All the telephones there were also tied to the hotel switchboard. Telephones were provided at the airport complex that included the television studios and the earth station to allow access to the system And communications from this site back to the hotel.

In addition, there were telephones with direct access to the earth station from the television studios. These phone lines became the program coordination, technical direction, and commentary lines used by the television and radio people. In addition, a broadband, 8-kHz channel was available for television program sound.

Telex service was provided at the television studios and at the press center. The interface, installation and checkout of this hardware got us rather deeply engrossed with the Chinese. The teletype from the press center came to the earth station over a Chinese teletype multiplex. At the earth station facilities, the teletype was brought to channel and given to us on hard wire. The teletype from the television studios was brought to the earth station directly.

The Chinese communications plant as we saw it seemed to be extremely limited. There were very few telephones and apparently very little inter-city telephone service.

Peking has a single television channel which broadcasts black and white pictures. Their television sets are small but appear to be adequate.

Chinese/U.S. Personnel Interface The entire operation in China was a thrilling and delightful experience. The Chinese people who worked with us were competent, qualified engineers who went far out of their way during our stay to make us feel welcome. The hospitality of our Chinese hosts seemed to be boundless. They provided excellent hotel facilities, fed us elegantly, and entertained us continually. We had a great deal of opportunity to tour the historic sites in and around Peking. We were shown such places as the Great Wall, the Forbidden City, and the Tombs of the Ming Emperors. Actually, we all had more invitations to go sightseeing than any of us had time for. If we were disappointed at all, it was perhaps in the area of seeing modern China. We did not have an opportunity to see any of the Chinese communications facilities or any of their factories. We did, however, see some of their schools, stores, and theater.

The Chinese assigned counterparts to all of us. These were engineers who worked with us and both assisted and learned how the station operated. We could not converse directly with most of the Chinese engineers, however; translators were always present. There were

generally three to five Chinese engineers at the station. They were very interested in all aspects of the earth station and were well prepared to question us about specific details. We were asked to, and did provide stand-up lectures on the earth station and all of its various subsystems. An interesting point is that many of the Chinese technical people could read and write English; their problem in conversing directly with us was that they had never heard the language spoken.

We found the Chinese rather easy to deal with inasmuch as decisions could be made and action taken. One, in fact, learned early in the mission not to agree too readily because once a course was decided upon, it was very likely to be implemented before any change in plan could be made.

The mutual respect gained by the PRC and our team for the dedicated work in making the operation a success was extremely gratifying. The weeks of working together led to a rapport and camaraderie quite evident to all personnel involved.

TABLE 1
TECHNICAL PARAMETERS OF PEKING
TRANSPORTABLE EARTH STATION

Transmit Frequency	5.9 to 6.966
Receive Frequency	3.8 to 4.266
Antenna Size	24 ft
Receive Gain (4 GHz)	47.5 dB
Transmit Gain (6 GHz)	50.5 dB
Transmitter Power (maximum)	13 KW
Receiver Noise Temperature	30°K
System Noise Temperature (10° elevation)	80°K
Video Channels	1 NTSC Color
Telephone Channels	60
Generator Capacity (each)	100 KW
Total Weight of Station	53,000 Pounds



Figure 2 - Shelters and Antenna Before Assembly

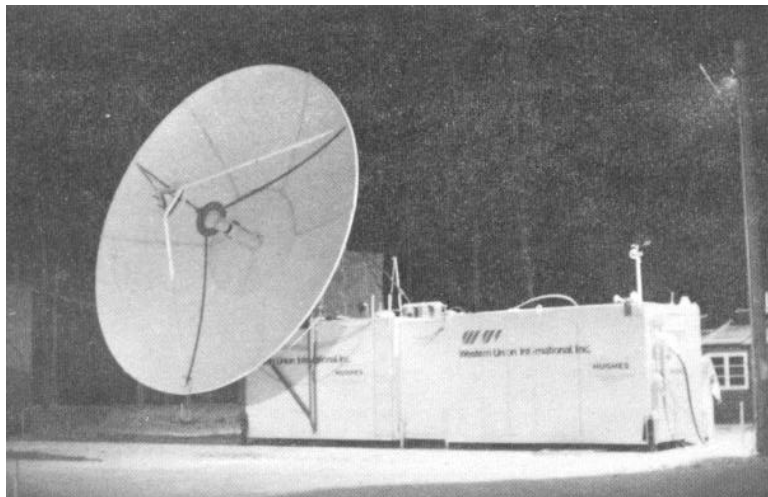


Figure 3 - Assembled Earth Station