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EXPERIMENTS TO DETERMINE COMMUNICATION CAPABILITY OF THE ECHO II SATELLITE

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SUMMARY

This paper describes some of the experiments being conducted on the Echo II satellite, which was launched by GSFC on January 25, 1964. The objective of these experiments, being performed under the direction of Goddard Space Flight Center, is to determine the communication capability of the Echo II satellite, and also to provide information about the shape and surface characteristics of the satellite as a function of time.

EXPERIMENT PARTICIPANTS

The stations that have participated in the experiments described in this paper are at Collins Radio Company in Richardson, Texas, a suburb of Dallas, and the Naval Research Laboratory at Stumpneck, Maryland, 30 miles south of Washington, D. C.. Ohio State University at Columbus, has also begun participating in the Goddard experiments and it is anticipated that the Navy Electronics Lab at San Diego will begin to participate soon.

CIRCUIT CONFIGURATION, ECHO II COMMUNICATION EXPERIMENTS, DALLAS–STUMP NECK

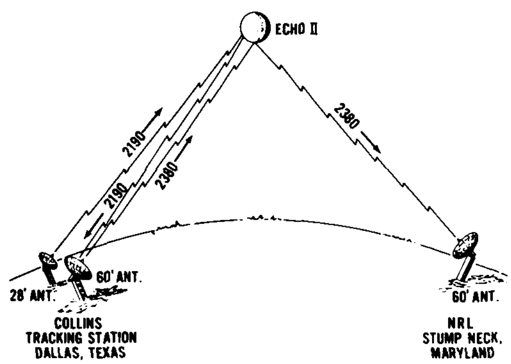

Figure 1

SYSTEM CONFIGURATION

The basic circuit configuration employed in the experiments is shown in Figure 1. The Collins facility utilizes a solid-surface, 60-foot parabolic antenna and a 10-kw transmitter to illuminate the Echo II satellite at 2380 Mc. The signal reflected from the satellite is received with a similar 60-foot parabolic antenna at the NRL facility. The signals are circularly polarized. To provide accurate pointing of the 60-foot antenna at Dallas, an automatic tracking radar system, operating at 2190 Mc, is employed. This consists of a separate 28-foot dish antenna with a 10-kw transmitter for illumination at 2190 Mc, together with the 60-foot antenna, which is equipped with an amplitude monopulse feed and phase-locked tracking receiver to receive the radar signals.

Figure 2 is a picture of Collins' 60-foot antenna. The transmitter and receiver front end are mounted on the antenna—just behind the reflector. Acquisition of the satellite is achieved by means of Goddard-furnished predictions combined with an automatic acquisition system.

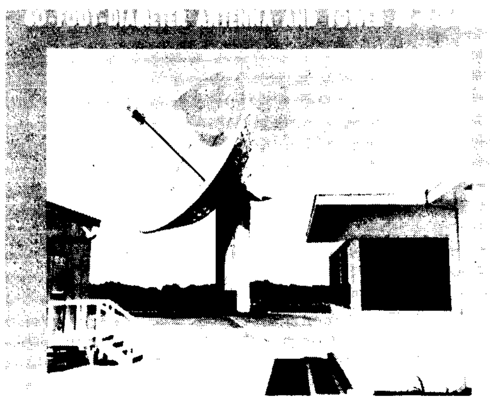

Figure 2

The NRL 60-foot antenna is normally controlled by a digital drive tape through an antenna programmer. An optical tracker is used to correct errors in the drive tape when the satellite is optically visible. Because of slight inaccuracies in the predictions, most of the experiments have been conducted at night so that signal fluctuations caused by mispointing of the antenna can be eliminated through the use of the optical tracker.

Figure 3 is a picture of NRL's antenna. The optical tracker cabin is the large box seen behind the reflector. The NRL receiver system utilizes a low noise TWT and a phase-locked i-f loop at 60 Mc to provide high sensitivity. Modified R-390 A/URR communication receivers serve as the primary envelope demodulators for the experiments.

Both the NRL and Collins' facilities are equipped with a variety of strip-charts and magnetic tape recorders for recording the experimental data. Both facilities are also equipped with bore-sight cameras so that the pointing errors can be accurately determined.

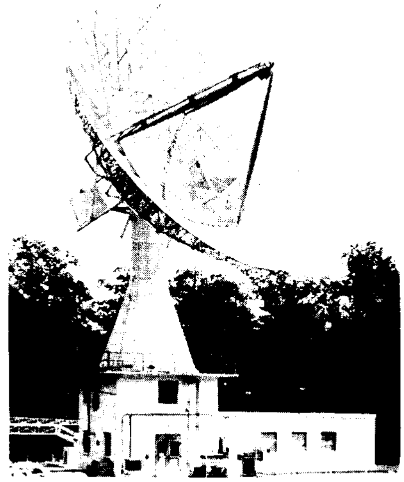

Figure 3

EXPERIMENTS

The experiments are divided into two categories: the first, to determine directly and quantitatively, the characteristics of the Echo II satellite as a radio frequency reflector, and the second, to verify by demonstration, some of the communication capabilities of the Echo II satellite. The tests in the first category include measurement of the received signal level. This test provides data for determining the effective cross-sectional area of the satellite and signal fading and scintillation characteristics.

Figure 4 is a typical record of the received signal strength versus time as received at the NRL facility. As you can see, the peak signal

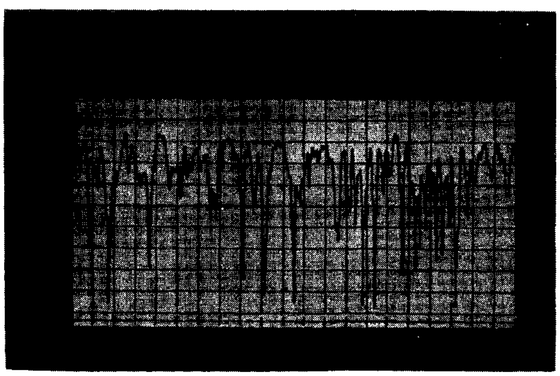

Figure 4

level is about -100 dbm. Average fluctuations in the signal caused by the satellite are on the order of ±5 db; short deep fades of up to 20 db occur frequently. The scintillations or (amplitude-variations) are due to the irregularities of the satellite's surface. To date the various experimental measurements have not indicated any change in the satellite's structural characteristics between the time when it was first observed on the sixth revolution and the present time. This is in contrast to Echo I which showed significant changes over the same time period. Correlation has not been observed during these experiments between the reflected r-f signal fluctuations and the rotation of the satellite as determined from the satellite's beacon telemetry signals.

The bandwidth capability of the satellite is indicated by determining the degree of correlation of the received signal level of two carriers separated in frequency. Each carrier is received separately with narrow band receivers, and the amplitude variations of the receiver outputs are then compared to determine the degree of correlation. Up to the present time, the degree of correlation between the fluctuations in the amplitude of the carriers, separated by 12 Mcs, has been very good, (close to 100%) as is shown in Figure 5. The two lower traces are the two received signals. The upper trace is the difference of the two signals and illustrates the high degree of correlation. This experiment has been conducted at spacings of 70 and 190 Mcs, but the acquired data has not yet been analyzed. Quick look analysis, however, indicates as

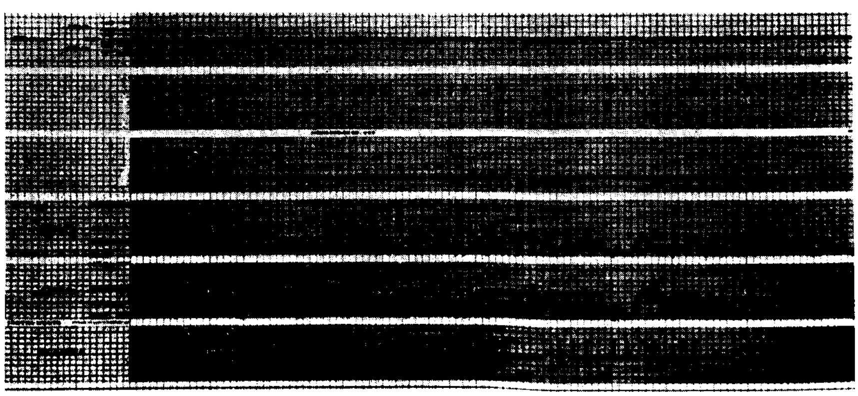

Figure 5

expected, a lower degree of correlation at 70 Mcs, and still lower degree of correlation at 190 Mcs than at the 12 Mcs spacing.

Demonstrational type experiments include an audio-frequency transmission test utilizing tones, voise and music. Facsimile and digital data transmissions also are included in the demonstrational experiments.

Figure 6 shows examples of facsimile transmission that has been obtained over the Echo II satellite circuit. The facsimile signals were

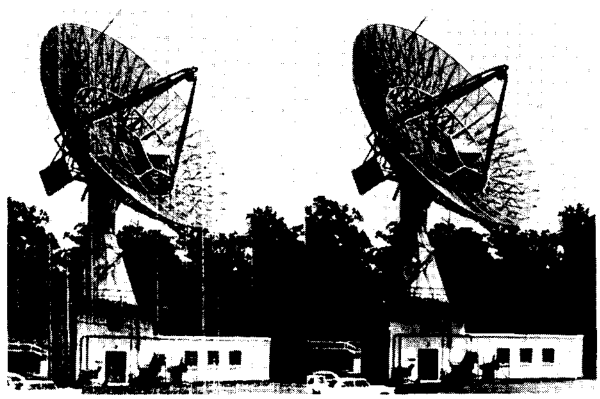

Figure 6

pre-recorded on magnetic tape and speeded up by a factor of 4 during transmission to produce an increased information bandwidth ana shorten the length of time of picture transmission. The picture on the rıght was made directly from the master tape. The other on the left was reproduced from a magnetic tape recording of the received signal over the satellite circuit. The vertical streaks are caused by the deep fades in the signal. Voice and music transmissions have been made using FM with modulation frequencies of 30 to 15,000 cycles and with a deviation of ±15 kcs. Except for an occasional hiss of noise caused by fades, the received voice and music is a duplicate of that on the original tape.

It must be pointed out that large quantities of data are being acquired from these experiments, a good portion of which will be reduced and analyzed in detail. The results will be made available after the conclusion of the experiment program.

The conclusions reached from the experiments so far are as follows:

1. These experiments indicate no change in the reflectivity characteristics of the satellite since the initial experiment conducted on the sixth orbit. This verifies that the satellite has met the design objective of becoming a rigidized structure.
2. Echo II has a bandwidth capability of at least 12 Mcs.
3. Echo II has good voice, music, and facsimile transmission capability.
4. The transmission characteristics of the Echo II circuit of over 1,000 miles, compare favorably with those of tropospheric scatter circuits and micro-wave point-to-point circuits of considerably less distance.
5. Tracking and station operation quickly become routine with no major problems involved.