

AT THE SIGNAL ... VIA SATELLITE TIME

A successful 2-year experiment in broadcasting time and standard frequency signals from an earth satellite has been completed by the National Bureau of Standards.

Radiated downward from the National Aeronautics and Space Administration's ATS-3 satellite, the signals came in strong and stable. They blanketed the North and South American continents, much of the Atlantic and Pacific oceans and part of Europe and Africa, for a total of 40 percent of the earth's surface.

Satellite-relayed signals have high signal-to-noise ratios, wide bandwidth (permitting flexibility in signal input) and line-of-sight propagation paths free from fading. Signals with these characteristics are especially helpful in regulating and monitoring electric power, recording times of earthquakes and other events, monitoring automobile and airplane traffic, controlling timing of digital communications systems and performing other significant functions.

New Horizons

In the future, a satellite system based on this experiment may offer continuous time and frequency broadcasts as dependable as the local AM or FM radio station, covering a large global area with a timing accuracy better than one one-hundred-thousandth of a second.

Such a service would supplement the NBS time and frequency stations, WWV and WWVH, which are limited by noise and propagation path variations, and normally cover only 10 to 15 percent of the earth with equal reliability.

In the experiment, a frequency-

modulated 149-MHz (million cycles per second) carrier wave was transmitted for two 15-minute periods a day from the NBS Boulder, Colo., laboratories to the satellite, which then rebroadcast the signal back to earth on a 135-MHz carrier.

The satellite was given the speed needed to make one complete revolution in just 24 hours, which kept it poised 36 kilometers (22.4 miles) over a fixed point on the equator at about 70 degrees west longitude.

Global Outposts

Four NBS-equipped receiving stations, widely distributed around the point directly below the satellite, determined that these satellite disseminated signals had better than a 25-microsecond timing accuracy. The stations were located at NBS Boulder and Air Force Cambridge Research Laboratory, Mass., in North America; and at the Smithsonian Astrophysical Observatories at Arequipa, Peru and Natal, Brazil.

During the experiment conducted by D. Wayne Hanson, Wallace F. Hamilton and Alvin J. D. Clements of the NBS Time and Frequency Division, the satellite-relayed signals were based upon the NBS Frequency Standard and NBS Coordinated Universal Time, both maintained at the Boulder NBS Laboratories.¹ A standard frequency 1-kHz tone, second ticks, voice announcement of the time of day and satellite position and a time

code were relayed to the earth twice a day for 15-minute periods. The bandwidth for these signals was 30 kHz. Time recovery required simple techniques and simple path delay computations. Frequency was derived from audio frequency modulations or from time synchronization over a period of days.

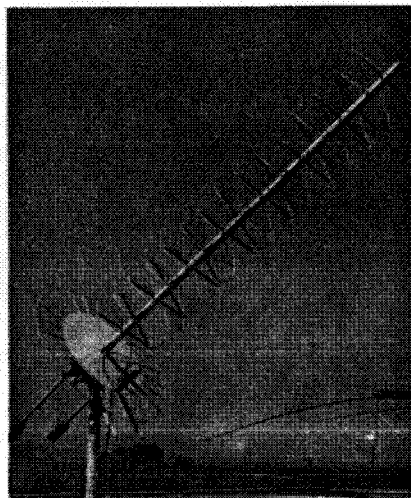
Accurate time recovery depended primarily upon accurate satellite-position information. A 300-meter path error, for instance, represented a 1-microsecond timing error. ATS-3, a geostationary satellite, maintained a relatively fixed position in the sky because it rotated synchronously around the earth. However, the satellite deviated from a perfect 24-hour circular equatorial orbit. By occasionally firing rockets on the satellite, scientists prevented the satellite from drifting too far from the desired location.

Charts prepared by NBS for users of the satellite-time dissemination service gave receiver-antenna pointing information and propagation-path time delays. The delay charts showed about one-fourth-second delay between the master clock and the user via the satellite, and were accurate to a few milliseconds.

Most users employed a simple antenna and inexpensive receiver for recognizable voice and second ticks reception. High-accuracy users needed a high-gain antenna and a receiver of high-sensitivity and selectivity. Accessory equipment was also needed to synchronize local time and frequency to satellite relayed signals.

Anticipating future needs, the Space Telecommunications World Administration Radio Conference at Geneva in June 1971 allocated a 400.1 ± 0.05 -MHz channel for satellite-to-earth time and frequency broadcasts. Additional experiments are needed for improving orbit determination, frequency dissemination and signal format. □

Time signals are sent to the satellite from this helical antenna located at NBS/Boulder.



¹ Hanson, D. W. and Hamilton, W. F., Time and Frequency Broadcast Experiments from ATS-3 Satellite, NBS Tech. Note 645 in press.