Looking Back

Space Needles

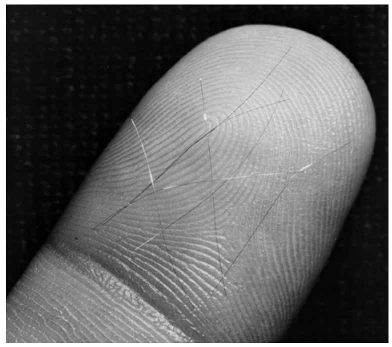
An orbiting belt of tiny dipoles took Lincoln Laboratory into space

It is difficult to imagine today how unreliable long-range communications were fifty years ago. But it was just at that time when communications for command and control became one of the Department of Defense's acute problems as U.S. military forces were dispersed worldwide.

Lincoln Laboratory's Project West Ford aimed to demonstrate long-range, reliable, survivable communications by scattering radio energy from a belt of orbiting dipoles. The idea was proposed by Walter Morrow (later director of Lincoln Laboratory) and Harold Meyer of Ramo-Wooldridge. The concept was an extension of Laboratory work in long-range communications that exploited scattering from the earth's ionosphere and troposphere. The dipole belt was to serve, in effect, as an artificial ionosphere.

The challenges were daunting. Successful link operation would require high-gain (0.15° beam) antennas, high-power transmitters, and sufficient numbers of energy-scattering dipoles to be present in the common volume of space where the transmit and receiving beams overlapped in the dipole belt. Received signals would have nasty characteristics—spread in frequency and time delay by the differential orbital velocities and positions of the dipoles dispersed in the belt.

The experimental system design converged on operation in the X-band with parabolic dishes 60 feet across. Every aspect of the West Ford program represented brand-new technology: 60 dB gain antennas, 40 kW transmitters, receiver/demodulators to handle the complex signals—and a belt of 480 million dipoles orbiting 2200 miles above the earth.



The West Ford dipoles were 0.7 inch long and 0.0007 inch in diameter.

The program faced fierce opposition from astronomers (optical and radio) who feared that the dipoles would obstruct their view. Others worried about the danger to other satellites of collisions with the dipoles. To mitigate these concerns, we designed the experimental dipole belt to have a short orbital life. In addition to judiciously specifying the initial orbit parameters, we gave the dipoles a high area-to-mass ratio to ensure that the solar radiation pressure acting on the dipoles would distort their circular orbits into highly elliptical ones. The orbital perigee would eventually dip to an altitude at which air resistance would sweep the dipoles out of orbit.

The first attempt at establishing the dipole belt, in October 1961, failed. The dipole-dispenser ejection mechanism didn't spin up, so no dipoles were released. With a redesigned dipole dispenser, a dipole belt was established in May 1963. Voice, data, and teletype were regularly transmitted between the West Ford stations at Millstone Hill in Massachusetts and Camp Parks in northern California—the first demonstration of reliable transcontinental military satellite communications. By late 1965, the dipole belt had been swept from orbit, right on schedule.

By then, it was clear that the future of space communications belonged not to orbiting passive dipoles but to satellites with active transponders. The Laboratory had already begun to develop a solid-state X-band satellite transponder.

Project West Ford put Lincoln Laboratory into the space business. In early 1963, the Department of Defense designated the Laboratory as the lead technology developer for military communications satellites. Some three years earlier, the Laboratory had been funded to develop a powerful ground terminal of the sort that a higher-capacity West Ford system would use. This terminal would also have a substantial radar capability by means of a plug-in box at the feed point. Thus, Lincoln Laboratory built the Haystack system, so named because its main job was to look for needles in space.

—DONALD MACLELLAN

MacLellan, a former assistant director of Lincoln Laboratory, has been involved with the Laboratory's space program since its inception.

FURTHER READING

1. Project West Ford, special issue of *Proc. IEEE*, vol. 52, no. 5, 1964.
2. I.I. Shapiro, "Last of the West Ford Dipoles," *Science*, vol. 154, no. 3755, 1966, pp. 1445–1448.