TELESTAR

AT&T developed the first modern communications satellite and launched it in 1962. Then the company planned to link the entire globe with a network of orbiting transmitters, but not everyone thought that was a good idea.

BY ROBERT ZIMMERMAN

On July 10, 1962, in Washington, D.C., Vice President Lyndon B. Johnson picked up the telephone to chat with Frederick Kappel, the chairman of American Telephone and Telegraph (AT&T). Kappel was calling from Andover, Maine. For about two minutes the men traded platitudes about the potential benefits of satellite communications and the need for government and industry to work together. Then they thanked each other and hung up.

While their conversation is hardly as well remembered as Alexander Graham Bell’s “Mr. Watson, come here, I want to see you,” its historical significance was just as great. This telephone chat, which was broadcast to millions of viewers on all three television networks then in existence, was the first conversation transmitted by satellite (or at least Kappel’s half was; because of a shortage of channels, Johnson’s words were carried on ordinary land lines). The next day the same satellite transmitted the first transatlantic television broadcast, with a tape of Yves Montand singing “La Chansonette” to the world from France. Britain’s segment consisted of a live transmission of slides and test patterns, climaxed with a short speech by the deputy chief engineer of the British Post Office.

These events were made possible by Telstar, the first com-
Technicians prepare AT&T's Telstar for its July 1962 launch by mating it to the third stage of a Thor-Delta rocket.
munications satellite to be privately built and the first that could usefully transmit live voice and television signals. It demonstrated the viability of many satellite design features that are still in use today, from solar panels to the choice of wavelengths for transmission. More important, its success demonstrated once again the importance of letting research geeks play with large amounts of dollars—and the value of opening outer space to private enterprise. Unfortunately, this last lesson was lost on the nation’s policymakers.

The idea of satellite communications had come directly on the heels of World War II. Arthur C. Clarke, then a radar expert in the Royal Air Force and later a prominent science fiction writer, published the first such scheme—strikingly similar to modern satellite-communications networks—in the October 1945 issue of Wireless World. A year later, as part of a Project RAND (later RAND Corporation) study prepared for the U.S. Army Air Forces, Prof. Louis Ridenour of the University of Pennsylvania proposed a similar plan.

Not until the mid-1950s, however, did members of the research department at Bell Telephone Laboratories in Holmdel, New Jersey, start looking seriously at the challenge of actually building such satellites. In October 1953 John R. Pierce, the director of electronics research for Bell Labs (and a sometime science fiction writer himself under the name J. J. Coupling), delivered an address on this subject before the Princeton, New Jersey, section of the Institute of Radio Engineers. In his talk, which was subsequently published, Pierce described some of the technical problems that would be involved.

At the time, the need for a dependable global telecommunications system was becoming overwhelming. While conventional radio signals could sometimes make the leap across oceans, varying ionospheric conditions made such methods unreliable. And though AT&T would complete its first telephone cable across the Atlantic in 1956, that cable would handle only 36 conversations at a time and would cost $42 million.

In his Princeton address, Pierce focused on two basic problems. First there was the question of whether a passive reflective or an active repeater satellite would be best. A passive reflective satellite is nothing more than a large reflecting surface (a foil-coated balloon, for example) off which a radio signal is bounced. Such a satellite is fairly easy to build but requires a very large and expensive ground antenna, because by the time the signal gets back to earth, its strength will have decayed to $10^{-18}$ of its original intensity. As early as January 1946 the U.S. Army Signal Corps had used a natural passive reflective satellite—the moon—to bounce messages between Washington, D.C., and Hawaii. It worked as an experiment to prove the feasibility of space communication, but the moon’s great distance and slow orbit around the earth made it impractical for regular use (though military communications were routinely relayed to and from Hawaii via the moon between 1956 and 1962).

An active repeater satellite, by contrast, receives the radio signal and amplifies it before beaming it back to earth. This amplification means that the ground stations can be smaller and less expensive. The satellite itself, however, is much more complex, carrying its own receiver, transmitter (at a different frequency from the incoming message, to avoid interference), and internal power system. It also needs a way to aim its receiving and transmitting antennas, and its delicate electronics face a much greater threat than a simple balloon from the hostile environment of space.

Pierce’s second concern was whether geosynchronous orbit would be the best location for communications satellites. In this type of orbit, 22,300 miles above the equator, a satellite’s period of rotation exactly matches that of...
the earth, so the satellite remains fixed over the same spot. This arrangement greatly simplifies the task of building ground stations, since it is not necessary to track the satellite in its orbit across the sky. Clarke’s 1945 proposal had suggested that the entire earth could be linked with only three geosynchronous communications satellites.

At such an orbital height, however, the time delay for sending a signal back and forth would be about half a second. Pierce believed this delay would make telephone conversations difficult. The delay would also accentuate the natural echo that occurs in every telephone transmission. On the ground, short signal distances make this echo imperceptible, but with the vast distances involved in geosynchronous orbit, it would be clearly audible. At the time, AT&T’s engineers saw no way to suppress this echo. Furthermore, a geosynchronous satellite would require a very sophisticated attitude-control system to keep it from drifting out of its orbit. And the lower the altitude, the easier it would be to get there with the rockets then available. These problems would eventually make Pierce favor a low orbit, at least for the initial test. This would mean that the satellite could be used only during certain hours when it was in view of both the transmitting and the receiving stations.

By 1959 Bell Labs researchers had decided that active repeater satellites would be the most feasible. Research on a simplified version of this technology was already proceeding elsewhere. In December 1958 the Signal Corps and the Air Force launched a satellite that could receive voice or teletype messages, store them, and then amplify and retransmit them when the receiving ground station came within range. It worked for only thirteen days. In October 1960 an improved model used ultrahigh frequencies to transmit teletype, voice, and photographs at much greater speed. It lasted seventeen days before failing. Despite their brief active lives, these satellites were a promising start. Still, a satellite that could receive, amplify, and retransmit messages without any delay would be much more useful—and complicated.

In August 1959 Leroy C. Tillotson, head of the laboratory’s radio-systems research department, proposed that AT&T should build and launch an experimental active repeater satellite. Tillotson made this proposal partly because he realized that the company already possessed “most of the tools to do the job.” Indeed, in the last decade, its researchers had developed a number of new electronic devices, many of which had direct application to satellite technology.

In 1947 Bell Labs scientists had invented the transistor. This epochal invention was much smaller, longer lasting, and more reliable than the vacuum tube and required much less power. Telstar’s 1,064 transistors would allow it to be compact enough to be launched into space. Then, in 1954, Bell Labs scientists invented the silicon-based photovoltaic cell. Without this device for producing electrical power from sunlight, Telstar’s onboard systems could never have functioned.

The next thing the AT&T satellite would need was a compact instrument capable of amplifying a radio signal about 10,000 times. (Transistor-based electronics would boost the total amplification to a factor of 10,000,000,000.) The answer lay in the traveling-wave tube, which had been invented by
Rudolf Kompfner, a future Bell Labs researcher, in 1943, when he was at Birmingham University in England. Telstar's traveling-wave amplifier was slightly bigger than a pencil; a foot long and less than an inch in diameter. The ground station had a traveling-wave amplifier four feet in length. Pierce had realized the potential of Kompfner's invention early on and had done much work to develop its theory and applications, publishing a textbook on the subject in 1950.

Operating in conjunction with the traveling-wave tube was the maser. This device, first built at Bell Labs in 1954, was installed in the ground stations. It reduced the background radio noise in the received signal by a factor of 100 by amplifying the signal much more than the noise. Telstar's ground stations used solid-state ruby masers cooled with liquid helium, a design that had been patented in 1961 by a pair of Bell Labs researchers.

All the spacecraft's equipment—the traveling-wave tube, antennas, power supply, batteries, and everything else—had to fit inside a sphere less than three feet in diameter, weighing no more than 180 pounds. Nonetheless, by July 1960 design work had advanced enough that AT&T could announce its intention of building a constellation of 50 satellites, circling the earth in 3,000- to 6,000-mile-high polar orbits, arranged to provide coverage to the globe's entire surface at all times. These satellites would be linked to the already existing terrestrial telephone network by 26 ground stations scattered worldwide.

Before building the entire constellation, however, AT&T decided to proceed with Tilotson's proposed test satellite, now dubbed Telstar. It would have a capacity superior to AT&T's undersea cables, with the ability to transmit one television channel, 60 two-way voice circuits (only 12 of which could be used at one time because of ground-equipment limitations), or 600 one-way voice circuits. Because Telstar's planned orbit would pass through the recently discovered Van Allen radiation belts, the satellite would carry electronic sensors to measure the belts' strength. In 1960 no one knew if electronic equipment could survive the Van Allen radiation, so the satellite's endurance over time would help engineers determine how much radiation shielding future space equipment would need.

Telstar engineers developed a number of techniques that would be useful in building later satellites. For example, they found a way to mount 3,600 solar cells on the outside of the spacecraft so that they could produce sufficient power (about 15 watts) to run the satellite's systems while also resisting the Van Allen belt radiation. The solution was to mount the cells on a ceramic base in a platinum frame and protect them from radiation with a translucent layer of artificial sapphire.

Telstar gave birth to new concepts in fabrication procedure as well. Because it would be impossible to make any repairs once the satellite was launched, each of its 15,000 components was picked from a sampling of identical parts to find the one with the fewest imperfections. It was then tested several times, fitted into a subassembly (which was tested again), and sealed in foam. After assembly in a dust-free "clean room," the satellite (which was actually one of four identical models built; a second was launched as Telstar II in July 1963) was subjected to a series of tests meant to simulate the vibrations of a launch and the environment of space.

The engineering that went into Telstar's ground stations was as challenging and as important as the engineering of the satellite itself. AT&T had some experience with ground stations from its role in the August 1960 launch of the passive reflective satellite Echo 1. This was a 100-foot inflatable foil-coated balloon that orbited at an altitude of 1,000 miles. (It was launched in folded form inside a cylinder and inflated when it reached orbital height.) Echo 1 was a NASA project, but Bell Labs provided ground-station facilities. It operated for almost eight years, bouncing pictures and sound recordings across the Atlantic Ocean and from coast to coast.

On the basis of what it had learned from Echo 1, AT&T decided to build a huge experimental receiver. It settled on a horn-shaped antenna that weighed 370 tons, stood 177 feet high, and could be moved on a 70-foot circular track to follow Telstar as it traveled across the sky. Inside a "radome" that protected it against the weather, the antenna funneled the radio signal from its 68-foot mouth down to a base only two inches across. The antenna was carefully situated in a bowl-like valley in Andover, Maine, where the topography and rural location protected it from interference by other terrestrial radio signals. Andover was an ironic choice to inaugurate satellite telecommunications; its local telephone service still relied on party lines and hand-cranked phones.
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After six months of negotiations, NASA agreed in 1961 to supply AT&T with a three-stage Thor-Delta rocket, though it came at an extremely high cost. On top of the $50 million or so AT&T had laid out for development and construction of the satellite, the company had to pay NASA $3 million for all costs associated with the rocket, the launch, and ground support. NASA also got worldwide rights to any patents AT&T might develop from the satellite, and it could license these patents royalty-free to any third party. In essence, AT&T had to sign away any potential earnings it could have made from its own research.

Finally, on the morning of July 10, 1962, less than five years after Sputnik, Telstar was launched from Cape Canaveral. That evening the satellite transmitted to France and Britain a picture of the American flag flying over the Andover antenna dome, accompanied by recordings of “America the Beautiful” and “The Star-Spangled Banner.” The first fifteen-minute-long television broadcast soon followed. These tests came on Telstar’s sixth orbit, 15 hours after launch.

Over the next six months more than 650 transmission tests and demonstrations were performed between stations in the United States, Britain, and France, sending multichannel telephone, telegraph, facsimile, and television signals. As with many innovative prototypes, however, Telstar’s career in active service was brief. The Van Allen belts proved more damaging than anyone had expected, causing the satellite’s transistors to fail one by one. In November 1962 Telstar’s command system went out, and though engineers managed to reactivate it for seven weeks beginning in January, the satellite’s operational life was effectively over.

Despite the success of Telstar and Telstar II, and even though RCA (with its Relay, similar to Telstar and launched in December 1962) and Hughes Aircraft (with its Syncom series, first launched successfully in July 1963) were proceeding with their own experimental satellite communications systems, Congress and President John F. Kennedy were unwilling to let private competition determine this new technology’s future. Less than two months after Telstar’s first broadcast, Congress passed an act that ended up stifling the domestic satellite industry for nearly a decade.

The most vociferous objections to private control of the industry came from liberals who distrusted anything that would benefit big business. Their opposition was so persistent that for the first time in 35 years, the Senate had to resort to a closure petition to end a filibuster—and not, in that turbulent summer of 1962, on a matter related to desegregation, racial discrimination, or voting rights, but on the Communications Satellite Act, which had sailed through the House with little opposition in May. Yet despite all the overheated rhetoric, the issue was more complicated than just achieving the proper balance between public and private ownership.

Telstar and its successor satellites would be both a space project and a communications network. That dual nature was the source of the problem, for precedent had established that the former category was public and the latter private. With the Cold War still raging (the Cuban missile crisis would break out later that year), the government was anxious to keep a tight watch on any technology that might have security applications. Moreover, since the space technology industry had been nurtured and was continuing to grow on large amounts of government money, many in Washington thought the government should have a say in how that technology was used. Another concern was whether AT&T’s dominant position in communications would leave room for other companies to compete on even terms.

Finally, the Kennedy administration faced an irresistible temptation to use satellite communications as a tool for its foreign and domestic policy goals—serving unprofitable areas, encouraging international participation, and ensuring low rates. Each of these restrictions, of course, would make satellite communications less attractive as a business proposition, but with demand rising at such a great pace, there would surely be enough profit to go around.

The Communications Satellite Act, which Kennedy signed into law on August 31, was an attempt to reconcile all these concerns. It placed all American satellite communications under control of a federally managed, privately owned corporate monopoly, the Communications Satel-
By the late 1960s, Intelsat was beaming television, radio, and telephone signals to the most isolated parts of the globe.

dozen companies, including AT&T, had applied for permission to build their own satellite systems. The first private satellite to be launched under this regime was Western Union’s Westar I, in April 1974.

In the nearly three decades since the shift to open skies, the results of this competition have been striking. By 1985 seven companies were operating their own private networks of geosynchronous satellites to serve the United States. The four-company oligopoly on ground stations has been demolished, as today more than 10 million homes have satellite dishes that bypass both cable companies and over-the-air television broadcasts.

But television is just one facet of the industry. Companies have also launched dozens of satellites to provide telephone and other data-transfer capabilities to industry, allowing trucking companies to track the movements of their vehicles, stores to transfer credit-card data to banks, and paging companies to keep their customers wherever they might be standing. Several private companies also have satellites that provide reasonably priced high-resolution photographs of the earth’s surface for use in agriculture, fishing, news reporting, mineralogy, and a host of other purposes.

These successes illustrate the failure of the 1962 Satellite Communications Act. Though the technology of the 1960s was sophisticated enough to produce profitable and useful commercial satellites, as shown by Intelsat, the act effectively barred companies from establishing competitive satellite systems. This competition would have been financially profitable for all involved and would have improved phone service worldwide. It would also have sparked innovation in the rocket industry, which instead has undergone a 40-year stagnation. Comsat accomplished a lot in its period of monopoly, but open competition could have accomplished even more.

Today the outlook for private space-based commerce is bright. Since 1997 the majority of all space activity has been commercial, with government launches no longer dominating the market, a change that reflects both technological advances and an easing of international tensions. Some experts predict the launch of more than a thousand commercial satellites over the next 10 years, providing telephone, television, radio, Global Positioning System, remote sensing, and many other services. While it took a strong government push to get the space age started, only private enterprise could integrate its fruits into our lives in so many different and important ways.