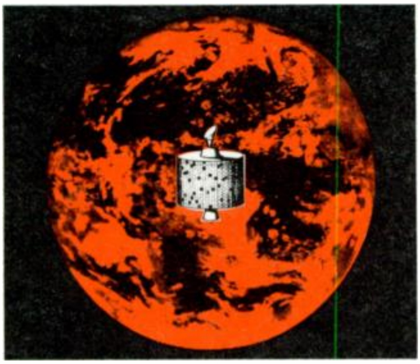
The Lenkurt DEMODULATOR

AUGUST 1969

DEVELOPMENTS IN SATELLITE COMMUNICATIONS



In the four short years since the launching of Early Bird there have been dramatic advancements in both satellite and earth station technology.

The Communications Satellite Act of 1962, a unique piece of legislation recommended by the late President Kennedy, called for the establishment of a new and unprecedented private corporation to act as an instrument of the United States in establishing a world-wide communications satellite system as quickly and expeditiously as practicable.

This Act by Congress did not attempt to prescribe the nature or form of the international arrangements, but left this responsibility to the President, the Department of State, and a new corporation which was formed a few months later, the Communications Satellite Corporation (COMSAT).

After holding discussions with a number of countries around the globe, COMSAT drafted the Interim Agreements and opened them for signature in August of 1964. The original body of signatories representing 11 countries, now represents over 68 countries and is known as the International Telecommunications Satellite Consortium (INTELSAT).

In the brief time since its founding, INTELSAT has become the largest international joint venture ever undertaken.

Under the Interim Agreements, COMSAT represents the United States in INTELSAT, has 53 percent ownership in the system, and acts as manager for the consortium. The Agreements provide joint ownership of the space segment of the global system, with voting power being proportionate to ownership of participants as representatives of the Interim Communication Satellite Committee (ICSC). Membership of the interim committee is composed of space segment owners or combinations of owners having quotas of 1.5% or more. The committee is the executive organ of INTELSAT while COMSAT is the manager.

Geo-Stationary Satellites

The successful launching and orbiting of Telstar and Relay in 1962, with their low, non-synchronous orbits and brief 30 minute transmission periods assured the future of active satellite repeaters.

Under a contract from the National Aeronautics and Space Administration (NASA) the synchronous*, geo-

*A satellite in synchronous, geo-stationary orbit travels around the earth at 6,870 miles per hour in a circular, easterly path 22,300 statute miles above the equator. Because it travels at the same angular velocity around the earth's center, it appears to stand still – hence the reference to such satellites as being "fixed" or "stationary".

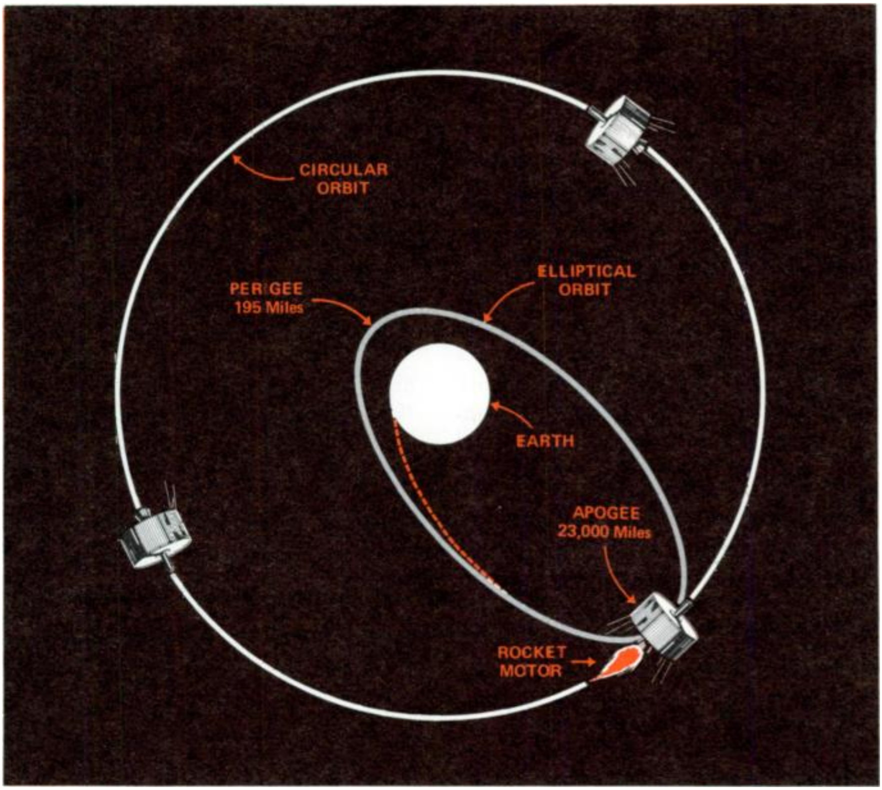


Figure 1. Accomplishing a synchronous, geo-stationary orbit requires the satellite be launched in an elliptical orbit, whose apogee aproximates 22,300 statute miles. When the satellite approaches this point an apogee rocket motor, on command from the ground, is fired emplacing the satellite in "fixed" orbit. Additional thrusters are employed from time to time to maintain proper attitude and earth alignment.

stationary satellite series termed SYNCOM was developed. SYNCOM I, intended for a synchronous equatorial orbit 22,300 miles above the earth early in 1963, failed to operate. SYNCOM II was launched later that year. SYNCOM III was placed in a stationary, equatorial orbit over the Pacific Ocean in mid-1964. The SYNCOM series dispelled any final doubts about the feasibility of a geo-stationary satellite communications network.

It is an interesting historical note that the concept of a geo-stationary satellite was first published in October, 1945 in an article entitled "Extra Terrestrial Relays" by British scientist, A.C. Clarke. Although Mr. Clarke's article seemed pure fiction to many at the time, it now stands as a prophecy to the events which have come to pass.

Clarke's idea of a satellite 22,300 miles above the earth in a stationary 24-hour orbit anticipated the actual event by some eighteen years.

The world's first commercial communication satellite was orbited April 6, 1965. This synchronous satellite, named Early Bird, was placed in a geo-stationary equatorial orbit over the Atlantic Ocean. From its vantage point 22,300 miles above the Atlantic, Early Bird linked North America and Europe with 240 high-quality voice circuits and made live television commercially available across the Atlantic for the first time. Early Bird, although the oldest communication satellite, has far exceeded its expected lifetime of 18 months and is still operating.

Since Early Bird

In the four short years since Early Bird was launched, six larger and more powerful satellites have successfully been placed in operation over the equatorial regions of the Atlantic, Pacific and Indian Oceans.

Early Bird, designated INTELSAT I, was the first of the INTELSAT series. By September 1967 four INTELSAT II satellites had been launched; the first of these failed to achieve orbit due to a malfunction of the apogee motor. The second was successfully parked in orbit over the Pacific Ocean, while the third was positioned, as planned, 6° W longitude over the Atlantic Ocean. The fourth of the INTELSAT II satellites was emplaced above the Pacific Ocean at 176° E longitude, only 2° W of the previous Pacific Ocean satellite.

INTELSAT I and II satellites were designed with 240 channel capacities, about one fifth the channel capacity of the INTELSAT III satellites which followed.

By May of 1969, three INTELSAT III satellites had been placed in orbit, one each over the Atlantic, Pacific and Indian Oceans. These three solar powered, 130 watt, giant satellites are capable of handling 1200 separate two-way telephone conversations, or four TV channels, or any combination of the two. In actual practice, part of their bandwidth has been assigned for TV use and the remainder for telephone, telegraph, data and facsimile communications.

There were seven commercial INTELSAT satellites over the equator in fixed, operational orbits by June of 1969 (See Figure 3). The objective, according to COMSAT's schedule, is to have an additional INTELSAT III satellite in orbit (over the Atlantic Ocean) by fall of 1969.

In contrast to the communications system of the INTELSAT III series, which includes two earth coverage transponders, the INTELSAT IV satellites will have a communications system that includes twelve transponders. Each of these receiver-transmitters is an independent frequency translator and amplifier. One of the unique features of the INTELSAT IV satellites will be the ability to switch the transponders in orbit to cover the precise earth area desired. This flexibility will make it posssible to adjust the satellite's capability to changing communications requirements. (Figure 2).

Using solar cells, the INTELSAT IV will generate more than 500 watts of power, about four times that of the INTELSAT III. This new model is expected to provide about 3600 circuits if all transponders are used for earth coverage, but as many as 9000 circuits if maximum use of spot coverage is made. It is expected that the mix of transponders will be such that each of these satellites will have a functioning capacity of at least 5000 circuits.

Earth Stations

The possibilities confirmed by the success of the synchronous satellite were revolutionary. With a minimum of three satellites, global coverage could be achieved. This would provide telephone, radio and television services, a vast communication and navigation service for aircraft and shipping, and many more applications.

The immediate implication of geostationary satellites greatly concerned earth station technology and mechanics. The huge tracking station antennas would require only very limited movement to follow a "fixed" satellite. This

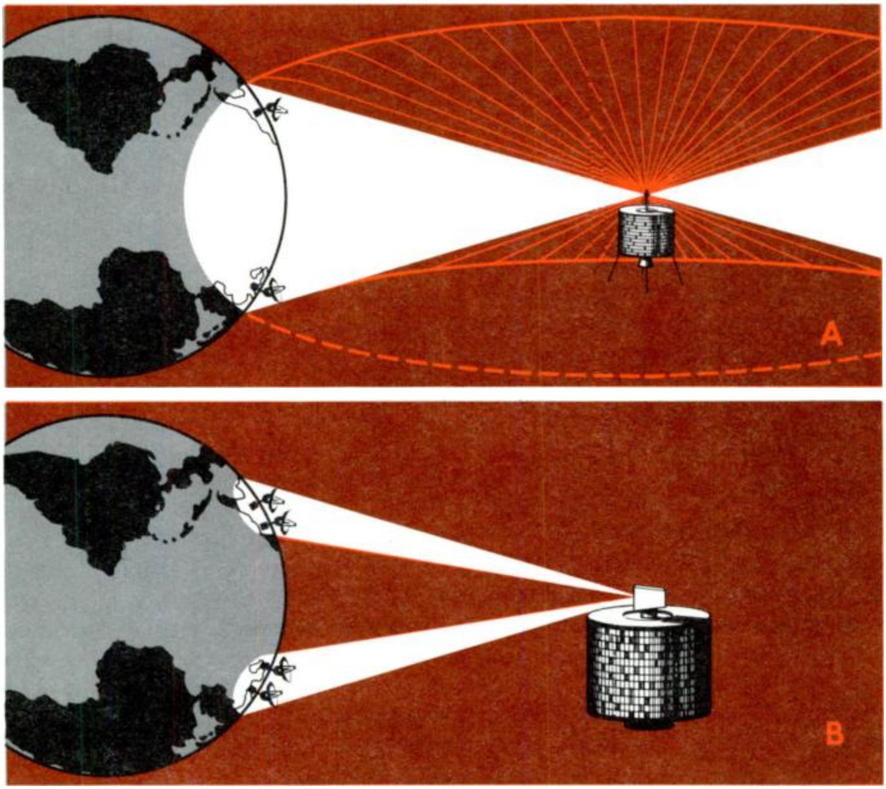


Figure 2. Early Bird employs a toroidal transmission pattern (A) which loses much rf energy to space. The proposed INTELSAT IV satellites will employ a more sophisicated and efficient transmission pattern (B).

would permit tremendous savings in the cost of material and maintenance. Further, because the tracking station would be operating with a synchronous satellite, the variable path-delay compensation required for operating a system of moving satellites as well as the complex hand-over problems created as a satellite passes from one earth station area to another, would become unnecessary.

Simplifying earth station technology, particularly the complex tracking requirements, not only allowed more attention to be focused on the development of new and better radio equipment, it realistically meant that many more earth stations could be erected in less time at less expense.

When Early Bird went into service in 1965, there were only a few experimental earth stations in the United, States, Japan, and Europe. By mid-1969, 25 earth stations were operating in 15 different countries. And 21 additional earth stations in 14 countries were either under construction or contract. This made a total of 46 stations in 29 countries (See Figure 3), around the world, with many more in the planning stage.

In spite of the fact that the INTELSAT group is not part of the space segment, it is understandable that they necessarily dictate the critical characteristics for each earth station interrelating with its satellites. A "standard" station specification has been

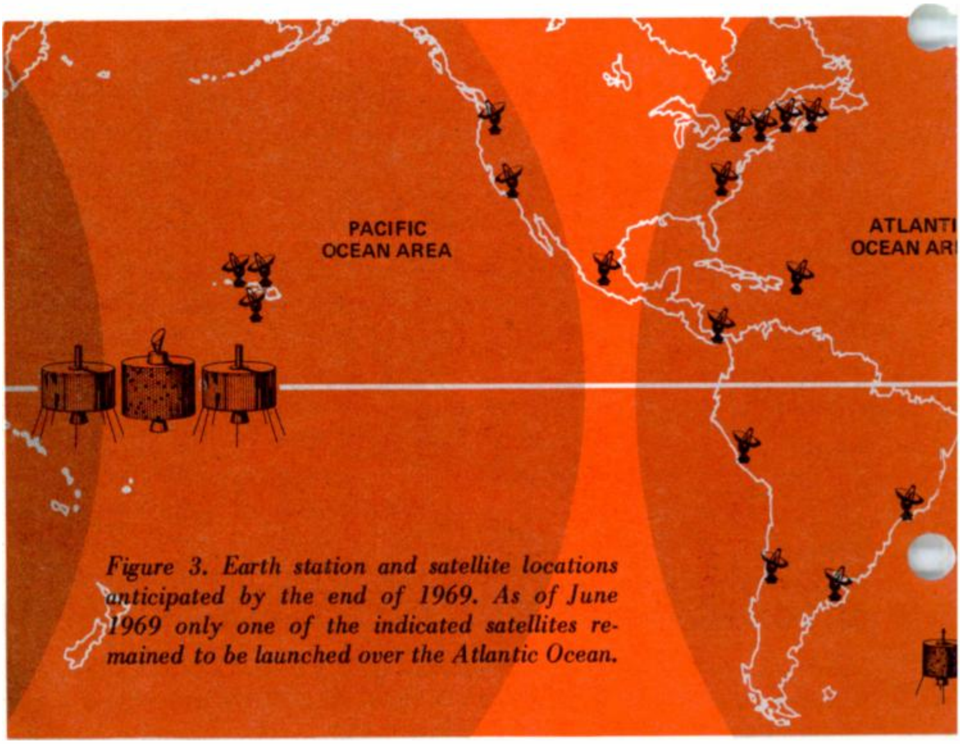


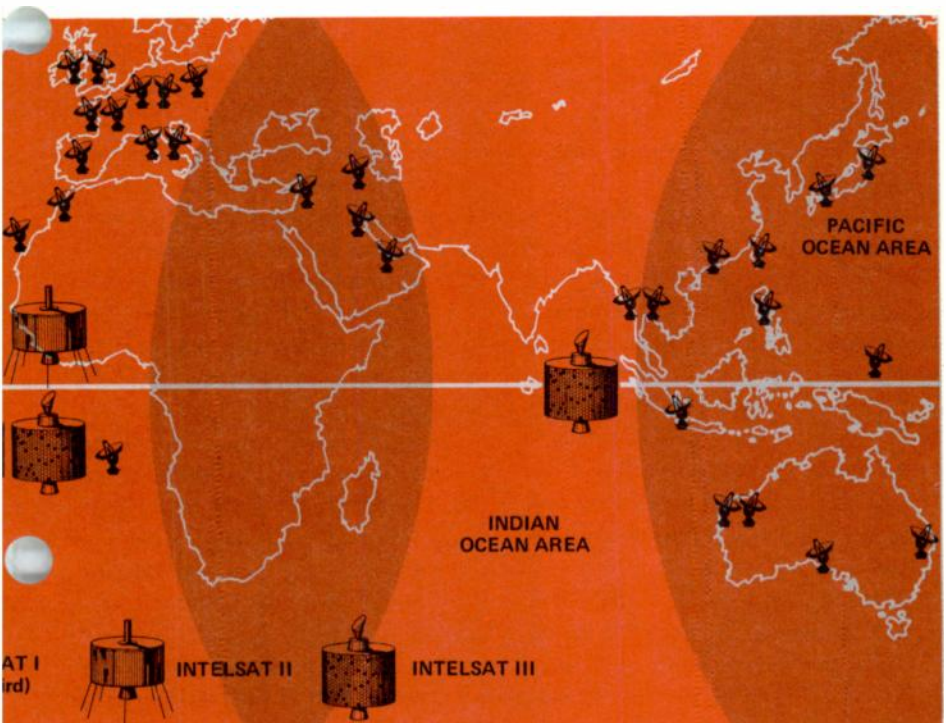
Figure 3. Earth station and satellite locations anticipated by the end of 1969. As of June 1969 only one of the indicated satellites remained to be launched over the Atlantic Ocean.

written to cover technical characteristics which may in any way affect the operation of the space segment or the use of it by any other earth station. Many features are specifically defined, such as the ratio of antenna gain to noise temperature, side lobe levels, maintenance of the transmit e.i.r.p. (effective isotropic radiated power) in the direction of the satellite to within ±0.5 dB of the nominal value, polarization, tracking modes, steering capabilities, RF out-of-band emission and amplitude frequency characteristics – to mention a few.

Improvements in earth station technology have not always received the same publicity as the launching and orbiting of the various satellites because of the more spectacular nature of the latter. There have been, however, some rather exciting developments in earth station systems. Some of these have been in specific response to unique problems accentuated by the satellite system. Lenkurt's 931C Echo Suppressor was especially designed for this type of service. The solid-state 931C suppresses the echos which are a problem partly due to the tremendous distances radio signals travel through space, to and from the extra-terrestrial satellites.

Molniya and Others

The Soviet Union, on October 4, 1957, launched Sputnik I. This event heralded man's first step into the field



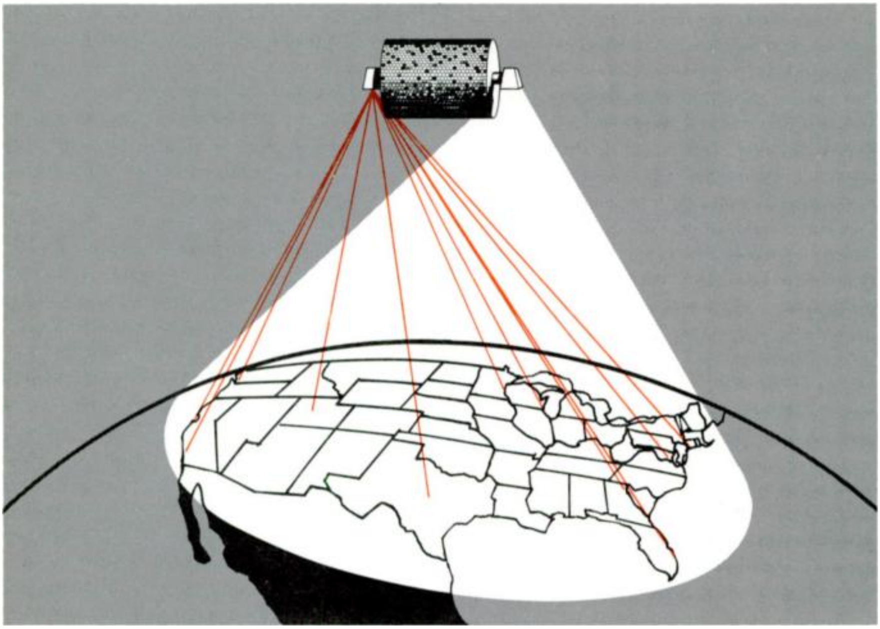


Figure 4. Advanced domestic satellites will use more efficient "direct beam" transmission.

of earth satellites with special attention going to the Soviet Union.

Only seventeen days after the launching of Early Bird, the Soviet Union successfully orbited their Molniya I on April 23, 1965. Molniya I was Russia's first experimental communications satellite. This active repeater satellite followed a highly elliptical orbit ranging from about 300 miles above the earth to more than 24,000 miles transmitting all forms of communication between Moscow and Vladivostok.

To date, Russia has launched several Molniya-class satellites in 12 hour elliptical orbits. Successful transmissions of many types of signals, including color television, have been carried out in joint experiments with the French. While the Russian satellites have an apparent lack of channel capacity, they do boast, among other things, high-powered transmitters. The Molniya has a command receiver, 40-watt transmitter, two reserve transmitters, and two steerable parabolic antennas.

Of the various nations which are non-members to the INTELSATgroup, the Soviet Union is the most noteworthy. Even though they do not have a synchronous, geo-stationary satellite, the Soviet Union has constructed a network of earth stations and, by using several Molniya-class satellites, have established a domestic satellite communication system.

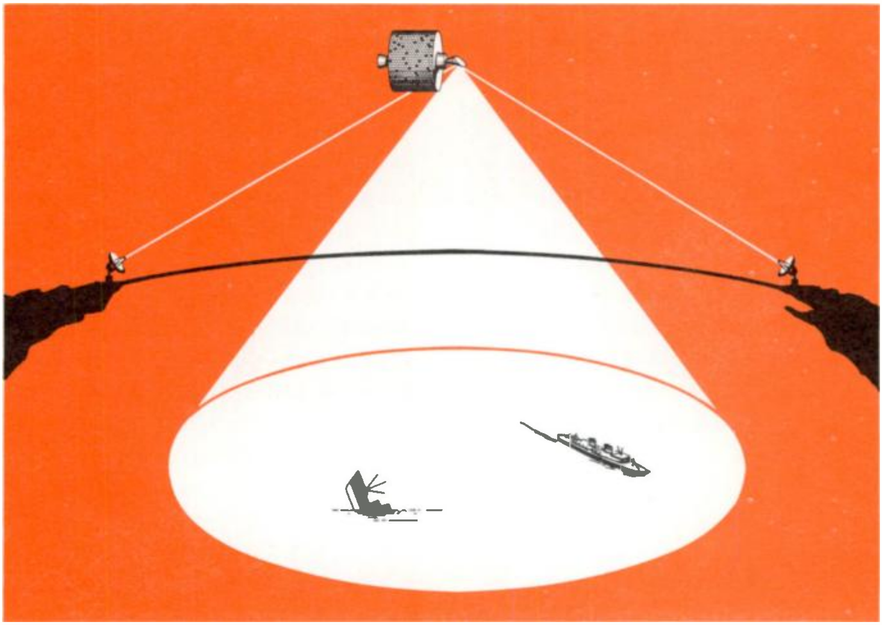


Figure 5. Unlike trans-oceanic cables, satellites can provide immediate communications at sea.

Frequency Utilization

All INTELSAT satellites presently employ radio frequencies within 500-MHz bands allocated for that purpose by the International Telecommunications Union (ITU) Radio Regulations. Earth station-to-satellite transmissions have been assigned frequencies in the 5925 to 6425 MHz band. Satellite-to-earth station transmissions use frequencies in the 3700 to 4200 MHz band. These frequency bands are shared on an equal right-of-use basis with terrestrial microwave systems.

The desirable range of frequencies for international communications lies within the range of 1 to 10 GHz. It is expected that the present band allocations will have been exploited within the next ten years.

A more efficient use of bandwidth has resulted from the increased power of the INTELSAT III and IV satellites. Even though this makes it possible to decrease the per channel bandwidth, it will still be necessary to look for new bands to allocate for exclusive satellite communications use.

Expansive Ideas

Modern satellites are capable of transmitting all forms of communications simultaneously – telephone, telegraph, television, data and facsimile. Satellites can operate competitively with cable networks and have the advantage of multipoint, multiple access. This means that synchronous satellites, in geo-stationary orbits can make possible direct communications between all countries having earth stations within a satellite's line of sight, eliminating much of the circuitous routing which has been so characteristic of international communications. A large number of innovations and expansions can be expected during the next decade.

A pilot domestic satellite program has been proposed to make available the benefits of satellite technology to the people of the United States. The development and use of "direct beam" transmission (See Figure 4) is now being planned.

In addition to people, computers in one country are now talking with increasing frequency to computers in other countries, and at speeds 20 times greater than anything possible by more conventional means.

High-quality telephone service is now becoming available from the United States to a growing number of countries that were previously difficult to reach by cable or short wave transmission.

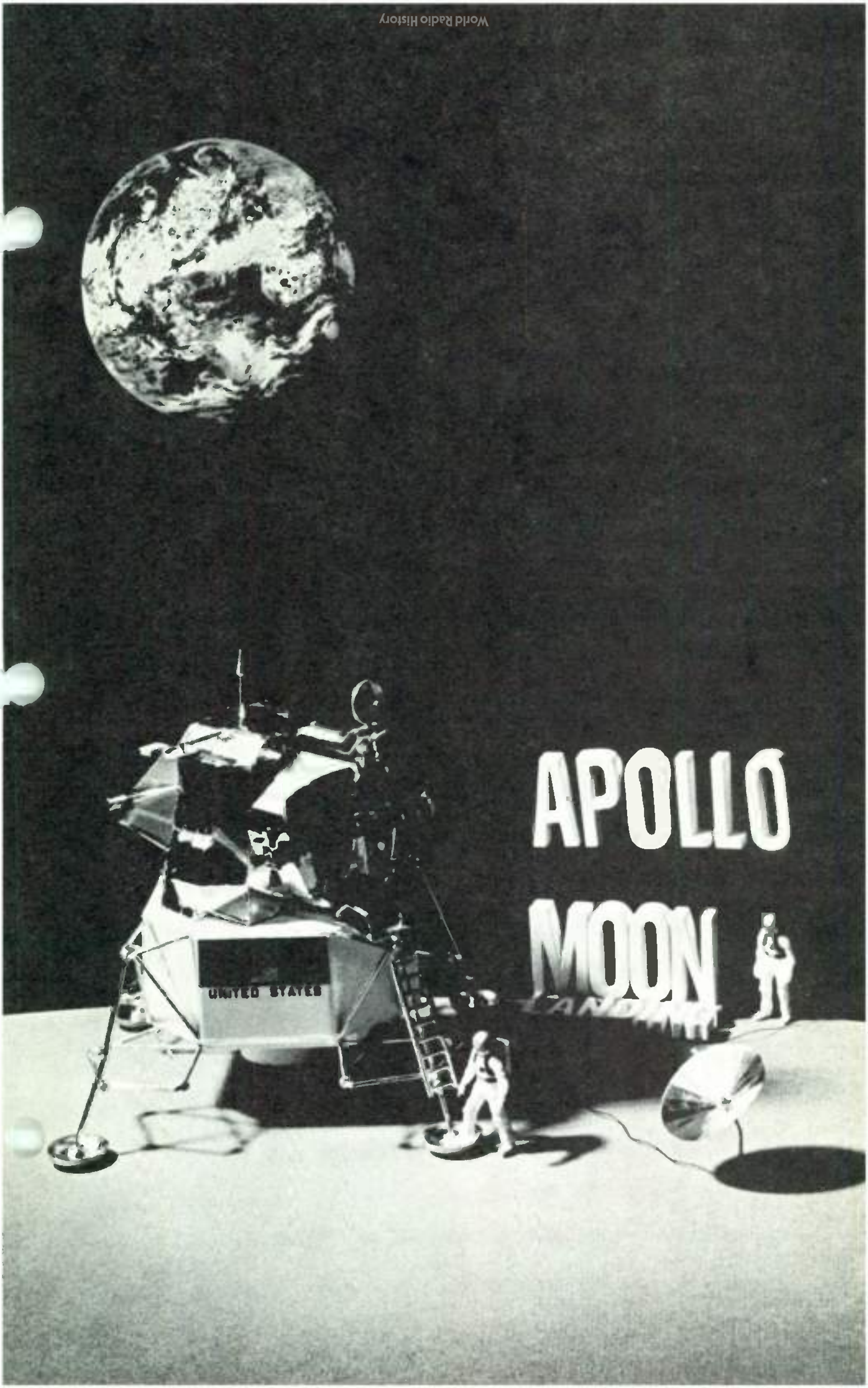
Entire news pages can be transmitted via facsimile across the ocean and reproduced a matter of hours after the original publication.

Weather maps are already being quickly transmitted via facsimilie from one country to another to assist intercontinental airline pilots in charting plans for flights.

Passenger and cargo data has also been transmitted across the Atlantic to customs officials in the United States while a plane was in flight. With all the necessary information on hand inspectors were able to speed passengers and cargo through customs.

Satellites will soon make available maritime communications systems at sea which will compare, in quality and reliability with services now commonplace on land. This can mean the potential saving of hundreds of ships that are lost at sea each year, many without any communication.

The most dramatic role of the communications satellites is the part they play in the space program. Atlantic and Pacific satellites of the INTELSAT II series are a key part of the communications system developed for NASA's Project Apollo – the moonlanding program.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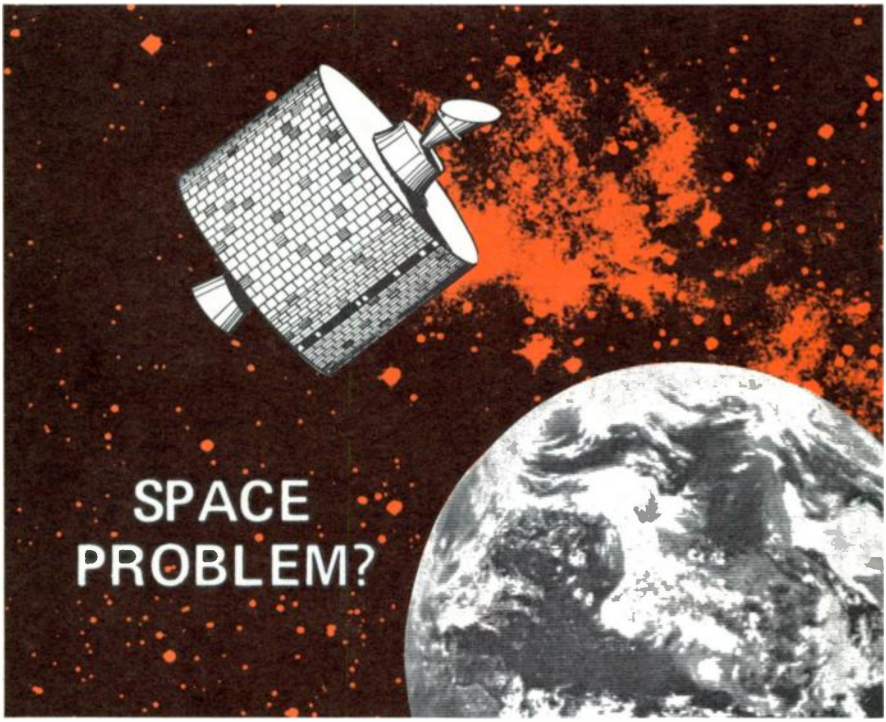

Lenkurt's solid-state 931C Echo Suppressor eliminates the echo encountered in satellite, transoceanic and transcontinental circuits. Featuring micro-electronic design with reliable printed circuit construction, this equipment will operate end-to-end with Western Electric's 3A and other suppressors meeting CCITT recommendations. For further information, write Lenkurt, Dept. C134.

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