SATELLITE COMMUNICATIONS

BY STAN PRENTISS

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Introduction

In the chapters that follow you will find a thoroughly contemporary study of the various disciplines of satellite communications including their uplink/downlink transceivers and earth stations, as they exist today, and also some predictions of what they may be like tomorrow. Many major manufacturers and R & D designers throughout the industry have been consulted in order to make this book as comprehensive and useful as possible. As you will see, the various subjects have been carefully separated even though the many elements of satellite technology are closely interrelated—especially the video and audio portions. Once you have read and digested this book, I hope that each and every facet of geosynchronous satellite technology (from the hookup cable to the transponders and LNAs) will have been explained to your complete satisfaction.

Acknowledgments

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Considering the involvement of all those special people mentioned above and many more who remain unnamed due only to available space, you can easily understand that our effort has, in truth, involved a great portion of the entire satellite communications and earth station industry. We are priviledged to have been in contact with so many excellent and knowledgeable individuals whose time, effort, and generous response has made a great contribution to this book.

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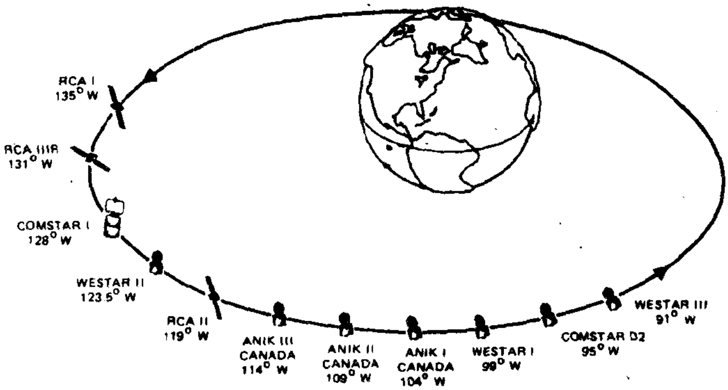
Chapter 1



Satellites in Orbit and Under Construction

Orbiting geosynchronous satellites are fast becoming the prime means of terrestrial communications. All the ships at sea, electronic newsprint and photographs, entertainment, religion, business transactions, aircraft, telephone, voice, video (analog as well as digital), and messages of any and all descriptions are passing in and out of space at frequencies between 3.7 and 17.0 GHz. Transmissions are cheaper, service has become highly reliable, well-designed transceiver systems produce excellent results without undue noise or other side effects, and cable television (CATV) has made a quantum jump in its programming as a result.

A conservative estimate places the number of foreign countries directly involved in satellite reception and/or transmission at 132, with well over 300 foreign earth stations in active operation. The U.S., of course, leads all the rest of the world with more than 12,000 earth stations for CATV alone, and at last reports one company was building 350 satellite antennas per month, better than 1,000 receivers a month, and several hundred low-noise amplifiers (LNAs) in the same period. This does not tally LNA outputs by Amplica, Avantek, or Microwave Associates, to name only a few. And by no means are these figures complete since they do not include Microdyne, Harris, RCA, and a host of other large and small manufacturers whose production is steadily increasing to accommodate continued demand. Consumer units are said to number over 200,000 and increasing at the rate of 20,000 a month.

Whether the pipelines will be filled in the early 1980s for both consumer and commercial units depends, largely, on the state of the economy. In the 1985-1986 period, however, direct broadcast satellite (DBS) service (for home viewers exclusively) with high-power space output at 12 GHz and 1- to 2-meter receiving dishes should come into full swing, increasing the 1982-1983 estimated total enormously. For the first time, urban reception of satellite programs will be possible since these 2.5- to 5-foot dishes can be mounted almost anywhere at nominal cost and will require no tracking rotation until several services in the pay-TV category are available to monthly subscribers. Depending on FCC approbation, such additions may come very slowly or very rapidly should the present open-market communications concept remain free or become suddenly restricted. After all, Congress and the White House have their say in these affairs, too; further, the FCC chairmanship could rotate as well and move away from laissez-faire to a more controlled program of restriction and expansion. Even so, only a certain number of any type of satellite can park geosynchronously at 22,000 miles altitude. So, the FCC must control the total numbers if not the actual operators. So far, over a dozen individual applications have been received at the Commission for 12-GHz downlink satellite spots. More are sure to follow as attractive launch facilities and commercial enticements grow. Two of these launchers are our own Space Shuttle and Europe's Ariane 4. Both are considerably cheaper than many of the rocket boosters that are currently available. At the moment, the Europeans are charging only 7% interest for payloads between 2,000 and 4,200 kilograms. However, the less expensive launches may be booked already for the foreseeable future with DBS as well as certain military missions in the process of launch or being scheduled.

In the meantime, Indonesia is building earth stations in rapid succession, and Mexico and Latin America are also installing over 100 receiving stations, not to mention all the other commercial receptors served by Marisat, Intelesat, etc., which we will be discussing later in the chapter.

Spacecraft, too, are changing rapidly with far greater design-lifetimes than heretofore. Hughes HS376, for example, will be built to operate for from 7 to 10 years and cost between twenty and forty million, including an internal propulsion motor. Already, some Intelsat IV's have been in use for 10 or 11 years, and manufacturers are now beginning to look at 15-year components. In the future, there will be larger satellites, even clusters, or outright space stations. At the moment, those in the 2-kilogram class are the largest, and will occupy about half of the Shuttle's payload capacity. A limiting factor to date has been the on-board fuel for station keeping exercises. When that fuel runs out the satellite cannot be maintained in precise synchronous orbit and its earth stations, therefore, cannot successfully track and therefore lose the signal.

SATELLITE BUSINESS SYSTEMS

Meanwhile, Satellite Business Systems (SBS) has begun using the 14/12 GHz uplink/downlink service in what it calls wideband digital integration (Fig. 1-1). It transmits all forms of business communications and is designed for working organizations with large volumes of traffic. Smaller receiving dishes make urban reception practical and feasible with 5.5- to 7.7-meter receptors, permitting locations at key company sites. Digital transmission techniques offer considerable security, along with random traffic interleaving from the various sources, in addition to a customer-controlled "bulk encryption capability" which will become available shortly. Communications Network Service transmits between 2400 and "several" megabits per second. Most customers, SBS says, will "use CNS for long distance telephone services."

Just before publication, SBS has also announced plans for 1983 service in medium-to-high-speed data communications. The FCC has already requested to approve the applications of data speeds in the kilobit range of 56, 112, 224, 448, and 896, in addition to 1.344 and 1.544 megabits per sec for point-to-point simplex and duplex transmissions, as well as point-to-multipoint broadcast transmissions. DNS earth stations will have rf terminals with 3.6-meter or a few 4.7-meter antennas and TDMA (time-division multiple access) controllers. This will be called the data network service (DNS) and will offer lower volume rates than communications network service (CNS), which is designed for very high capacity earth stations already in service. Digital video transmissions are part of this new program in the Ku-band. SBS tracking and telemetry stations are located at Castle Rock, Colorado, and Clarksburg, Maryland, with headquarters in McLean, Virginia. The system is expected to have 120 earth stations in operation by the end of 1983.

At the moment, the biggest question facing the satellite industry is a Federal Communications Commission ruling to limit fixed satellite service "birds" to only 2° separation, instead of the 4° they

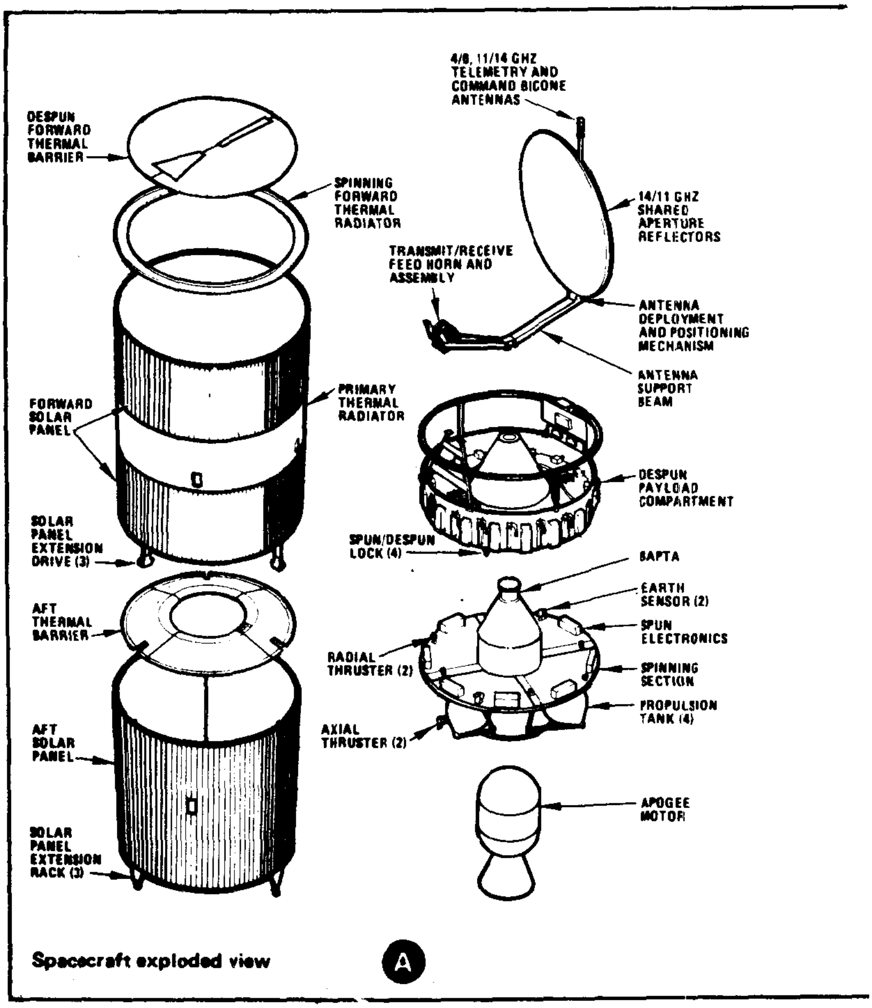
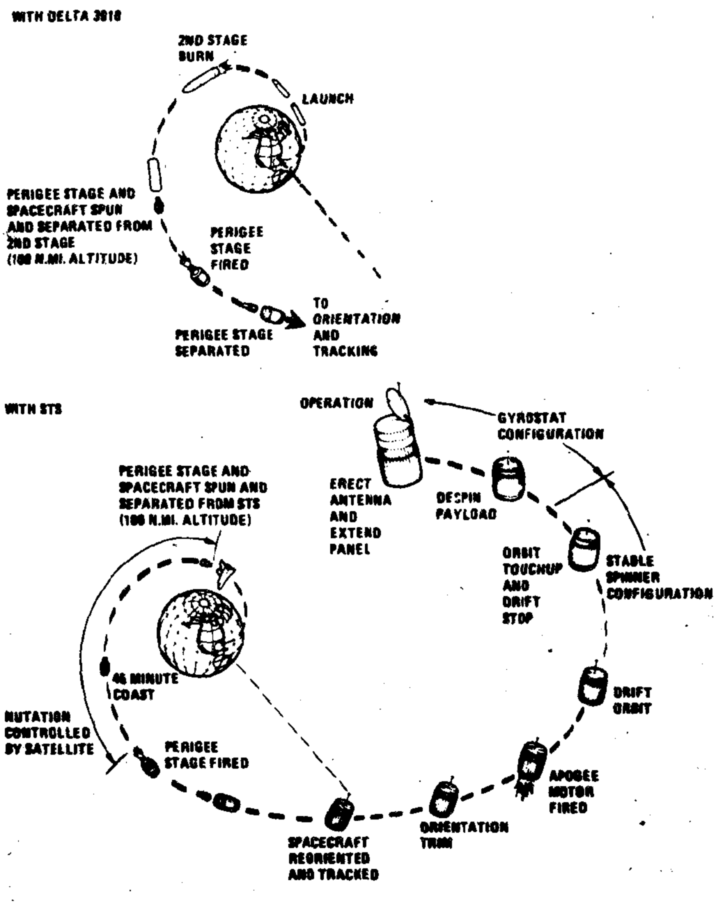


Fig. 1-1. The SBS spacecraft built by Hughes (A) and the launch sequences (B) (courtesy of Hughes Aircraft).

now enjoy. That would make addition parking space available but could also increase noise factors, add to both user and transmission bit costs, and require more precise station keeping. Many people in the industry expect some sort of initial compromise will eventually be adopted when the Commission finally mandates the proposal sometime in the future. Eventually in the next decade 2° will become mandatory.

Although traffic growth is considerable even now, when



Launch sequences

B

computer-to-computer exchange begins, massive transfers of information are projected. Work-at-home terminals are also under study even as industry looks at the possibility of decentralizing to the more sparsely populated portions of the country such as Idaho, South Dakota, and Montana. In addition to huge data communications programs, there's teleconferencing, plus the prospect of electronic mail at rates of a page per second with costs of only pennies per page. Considering that government alone spends upwards of four billion dollars per year in travel, all this means a complete reorientation in the conduct of both government and private business during the coming decade. The vendor (seller) of the future, we're told, must also be a first-rate consultant with personality to match, and he or she will be paid accordingly. Well-modulated voices, good looks, and sharp wits, apparently, are to continue in ever increasing demand.

COMSAT

The Communications Satellite Corporation, a huge space services and communications conglomerate formed in February 1963, remains an enormous factor in the space industry. Following Congressional passage of the Communications Satellite Act in 1962, COMSAT and then INTELSAT (Fig. 1-2) emerged which, with its six or more active satellites in synchronous 22.240 mile orbits over the Atlantic, Pacific, and Indian Oceans, (at the equator) now carries about two-thirds of all transoceanic traffic. Under international joint ownership, INTELSAT has a 105-nation owner-equity of some 729 million dollars, with COMSAT as the U.S. representative. INTELSAT maintains and operates all space vehicles and traffic. The earth

Fig. 1-2. The INTELSAT V operating in the 11/14 and 4/6 GHz bands delivering 12,000 circuits and two TV channels (courtesy of COMSAT).

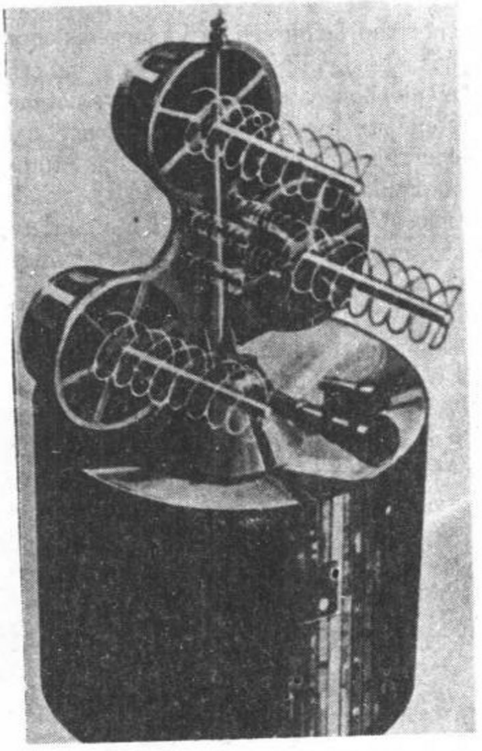


Fig. 1-3. The MARISAT with L/C and C/L band repeaters. The design life is 5 years (courtesy of COMSAT).

stations in the various member countries are government owned or privately owned. Most countries except the Russian Warsaw Pact group are members.

MARISAT, as a joint venture of COMSAT General and three other international carriers, Fig. 1-3, has three multifrequency satellites serving the Indian, Atlantic, and Pacific Oceans. Its mission provides modern satellite communications to ships at sea, including the U.S. Navy, and commercial shipping. More than 600 commercial ships and offshore drilling rigs are now equipped with MARISAT terminals; COMSAT supplies over 200. Great Britain also leases some capacity in the Atlantic. These satellites have only a 5-year design life, but are expected to continue in service much longer. Another maritime satellite organization in which COMSAT has a large interest is called INMARSAT, which stands for International Maritime Satellite Organization. Over 30 nations are members of this group which began operations in 1982.

COMSTAR (Fig. 1-4), the final operational satellite grouping under COMSAT (General), has four satellites in operation, all leased to American Telephone and Telegraph for its long-distance telephone network. Each has a design life of seven years and can handle 18,000 simultaneous telephone conversations. Seven of the earth stations in this system are owned by AT&T (four) and GTE(three). COMSAT General has monitoring stations at Southbury, Connecticut and Santa Paula, California.

Begun but not yet serviceable (1982), COMSAT has another subsidiary—this time wholly owned—that promises even greater diversity than those already named. The U.S. consumer now becomes the direct beneficiary, when the FCC gives its grudging approval. Satellite Television Corporation, with headquarters at 1301 Pennsylvania Ave., N.W., Washington, D.C. 20004, applied to the FCC on December 17, 1980 for permission to start up its three-channel pay-TV system with two experimental satellites for the Eastern U.S. time zone (Fig. 1-5), both operational and the extra transponder in backup. Eventually, all of the U.S. mainland and Alaska-Hawaii would be covered by four of these 14 GHz uplink and 12 GHz downlink, relatively high powered satellites spaced 20° apart in geosynchronous orbits. While the FCC continues to consider, STC on March 8, 1982 has released technical specifications

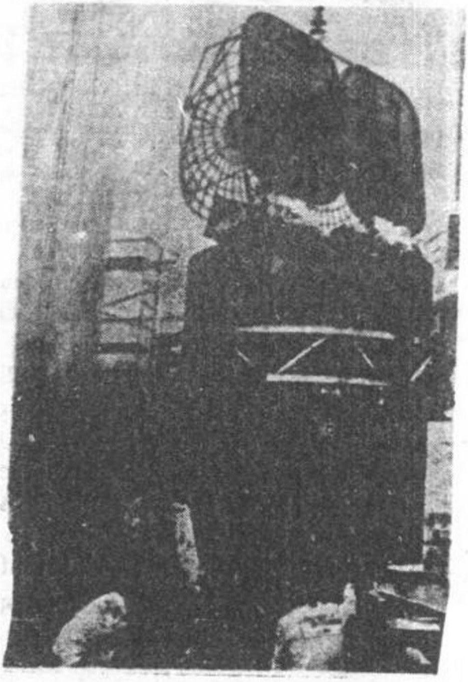


Fig. 1-4. COMSTAR handles 18,000 phone calls and has 24 transponders used by AT&T (courtesy of COMSAT).

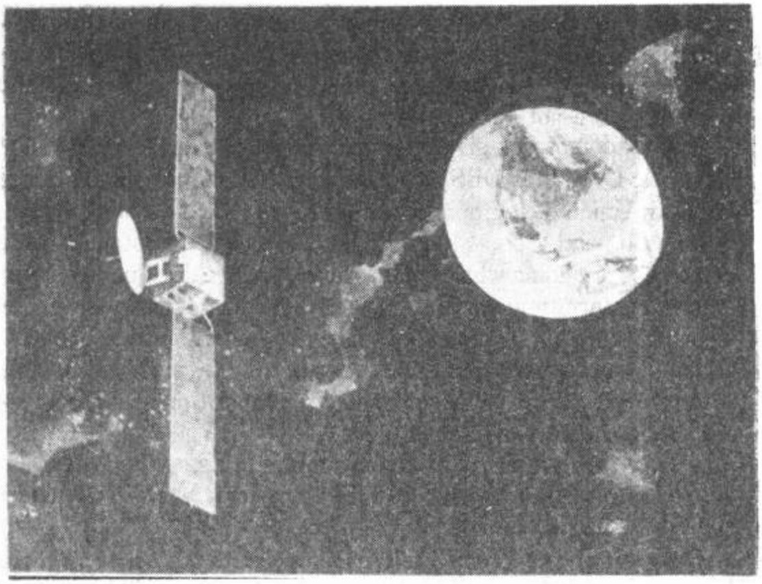


Fig. 1-5. Artist's conception of an STC satellite. Power for each channel is 185 watts (courtesy of Satellite TV Corp.).

for home TVRO dishes (plus attendant electronics) which are parabolic reflectors of 2.5-feet in diameter, with a low-noise downconverter attached to the reflector. From there, a cable will carry the received intelligence (at about 1 GHz) directly to an FM demodulator, channel selector, and AM video modulator. Nonspecific downlink frequencies are between 12.2 and 12.7 GHz. STC's descrambler units are not included in these specifications.

STC in the meantime, however, has let contracts for its first two satellites to RCA Astro Electronics, which won contracts over competitors Ford Aerospace, General Electric, and Hughes Aircraft. With FCC conditional approval already secured, pending the outcome of the RARC Regional Administrative Radio Conference in Geneva, set for June 1983. These satellites are to begin working our Eastern time zone, with others to follow covering the rest of the country. STC has also purchased 40 acres of land northwest of Las Vegas for its broadcasting center and contracted for architectural engineering and equipment location setup. RCA Astro Electronics experts to take somewhat more than three years to construct these first two space vehicles, so launch and service is not expected until late 1985 or early 1986, approximately 6-12 months slippage from initially announced dates.

At the same time, COMSAT laboratories are even now testing