# COMSAT®

COMMUNICATIONS SATELLITE CORPORATION MAGAZINE

1981

NUMBER 3

# VIEWPOINT

*by Dr. Joseph V. Charyk*
*President and Chief Executive Officer*
*Communications Satellite Corporation*

Technology is built on a foundation composed of activities we call by the name "research and development." This axiom is as true for satellite communications as it is for any other field in the vanguard of our technological age.

Without R&D, there could never have been an Early Bird or Intelsat I, which in 1965 gave the world its first commercial transoceanic satellite communications. Without R&D, there could never have been an Intelsat V, with over five times the capacity of Early Bird, operating in two frequency bands and employing sophisticated methods of frequency reuse to achieve greater capacity. Without R&D, there could never have been a Marisat satellite system, whose use of different frequencies to separate customers and the ability to allocate power as desired among those customers was a technological first for commercial communications satellites. Without R&D, there could never have been an SBS system employing Time-Division Multiple-Access technology and operating in frequency bands that permit transmitting and receiving stations to be located at customer plants to provide the whole spectrum of communications services needed by modern industry.

At Comsat, R&D is the foundation upon which are built all of the achievements of our corporation—the Intelsat global satellite system, the Marisat system of maritime communcations satellites, the Comstar domestic system and the Satellite Business Systems space segment. At Comsat, this research and development function is principally centered at Comsat Laboratories located in Clarksburg, Maryland. There, approximately 500 people labor to bring forth the communications satellite breakthroughs of today that will be the commercially-viable space and ground systems of tomorrow.

Among the numerous achievements of Comsat Laboratories, some of which are described in this issue of Comsat Magazine, those having to do with our contributions to the Intelsat global satellite communications system are worthy of special attention. The Intelsat system now carries two-thirds of international communications traffic and recently Comsat achieved another milestone in leasing its 10,000th circuit in the Intelsat system. The Intelsat system has been successful because it has been responsive to sound technological change. The system has been able to reliably accommodate growth and by accommodating growth it has encouraged it.

Comsat Laboratories deserves much of the credit for the technological strength of the Intelsat system. We are confident that the continuing advances coming from the Laboratories today will insure that the Intelsat system remains the leading system for international communications for the rest of this century and beyond.

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Cover: Dr. Bryan S. Lee of the Antenna Department of Comsat Laboratories in the anechoic chamber at the Labs with an experimental optimized dual-polarized global coverage antenna. Coverage of Comsat Laboratories begins on page 5. Photo by William J. Megna.

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## From the Editor

A large part of Comsat Magazine #3 is devoted to Comsat Laboratories, Comsat's research and development center for satellite communications, and hence it is appropriate that the subjects on our cover are a facility at the Labs—the anechoic chamber—and an experimental product developed there—an optimized dual-polarized global coverage antenna.

"Anechoic" means "without echo." At Comsat Labs, the anechoic chamber is used to provide an electronic-echo-free environment for the testing of antennas that are under development. The spike-like projections evident in the photograph accomplish the echo-deadening task.

The device in the photograph, the optimized dual-polarized global coverage antenna, was designed by Earl Carpenter of the Antenna Department for possible use in a future family of Intelsat satellites. According to Daniel F. DiFonzo, Manager, Antennas, at Comsat Labs, the experimental antenna holds great promise because it demonstrates these advantages over existing global coverage antennas: It has improved signal strength along the edges of the coverage area, where signal strength is most important. And its orthogonally polarized signals are of such purity that they could be used to increase communications capacity and could serve as a calibration standard at the earth stations receiving the signals.

The new antenna is, of course, just one of several important new developments at Comsat Labs. You'll read about the others in the article beginning on page 6. One of the most significant developments ever to come out of Comsat Labs—Time-Division Multiple-Access (TDMA)—is presented in more detail for those desiring to understand this important technology in the article starting on page 14. SATNET, an experimental form of TDMA, is also a result of Labs efforts and efforts at Comsat headquarters. (See page 26.)

We also call your attention to the Intelsat system map (centerspread), and the shuttle is a topic in the interview with NASA's Dr. Weiss (page 31).

Stephen A. Saft

# N O T E S

## 1980 financial results reported

Comsat has reported consolidated Net Income of $38,290,000 for the year ended December 31, 1980, a decrease of $1,895,000 or five percent from $40,185,000 in 1979. Per share earnings for 1980 were $4.79, down 23 cents from $5.02 in 1979 on 8,000,014 shares.

The decrease in Net Income is attributable primarily to Comsat's share of losses in Satellite Business Systems and reduced usage of the Marisat system by the U.S. Navy. SBS, which is expected to begin operations this spring, is the partnership formed by Aetna Life & Casualty, IBM and Comsat General Corporation, Comsat's wholly owned subsidiary, to provide communications satellite services primarily for U.S. domestic customers.

Operating Revenues for 1980 totaled $299,726,000, an increase of $37, 091,000 above 1979. Operating Expenses for 1980, including income taxes, totaled $255,780,000, up $34,947,000 from 1979.

Net Operating Income for 1980 was $43,946,000, an increase of $2,144,000 from 1979. This increase was attributable primarily to gains from the services Comsat provides through the internationally owned Intelsat global satellite system and came despite a five percent rate reduction in Comsat's Intelsat services in February 1980. The Intelsat increase was partially offset by reduced usage of the Marisat system by the U.S. Navy.

Included in Other Income (Expense)-Net is Comsat's share of losses of—and amortization of certain costs relating to—SBS, which reduced Net Income for 1980 by $12,428,000. The reduction attributable to SBS for 1979 was $5,078,000.

When compared with the fourth quarter of 1979, consolidated Net Income for the fourth quarter of 1980 increased by $2,179,000, and earnings per share increased by $0.28 from $0.94 to $1.22.

Operating Revenues for the fourth quarter of 1980 were up $12,503,000 from last year, Operating Expenses were up $9,630,000 and Net Operating Income increased by $2,873,000.

Other Income (Expense)-Net increased from an expense of $1,400,000 for the fourth quarter of 1979 to an expense of $2,094,000 for the fourth quarter of 1980.

## Inmarsat establishing satellite communications system

The International Maritime Satellite Organization (Inmarsat), which came into existence in July 1979 with the primary purpose of establishing and operating a maritime telecommunications system, is well on its way to achieving its first objective, the establishment of the Inmarsat satellite communication system.

In November 1979, the Inmarsat Council authorized the Director General, Olof Lundberg of Sweden, to award three contracts totaling approximately $180 million for the lease of satellite capacity. The satellite facilities procured through these contracts will constitute Inmarsat's first satellite communications system and will operate through 1988. Comsat General, on behalf of the Marisat Joint Venture, was awarded a contract for lease of Marisat capacity in the Pacific Ocean Region; the European Space Agency (ESA) will lease capacity in two Marecs satellites in the Indian Ocean Region and the Pacific Ocean Region; and Intelsat will lease maritime communications services capacity in three Intelsat V satellites in the Indian Ocean Region and the Atlantic Ocean Region. The system is expected to become operational in early 1982, making available to shipping and offshore industries such services as telex, telephone, facsimile and data.

Inmarsat is carefully planning a smooth and efficient transition from Marisat to Inmarsat by developing ship earth station performance standards that will permit all ship terminals using the Marisat system also to be able to use the Inmarsat system and by developing network coordination services which will be required when two or more coast earth stations are working with one satellite. Network coordination services will be provided by Comsat for the Atlantic Ocean Region and by KDD for the Indian Ocean Region and the Pacific Ocean Region.

In addition to the coast earth stations at Santa Paula, California; Southbury, Connecticut; and Yamaguchi, Japan, that are presently servicing the Marisat system, six more coast earth stations are expected to become operational to serve the Inmarsat system over the next two years. They will be located at Ibaraki, Japan; Eik, Norway; Umm-Al-Aish, Kuwait; Fucino, Italy; Goonhilly, UK; and Singapore. Nine more coast earth stations are under consideration for 1983 and twelve after 1984.

Inmarsat's most recent Council session was hosted by the Australian Signatory in Sydney from February 11-18, 1981. The highlights of this meeting were the accession of Oman and Liberia to the organization, bringing its membership to 34 countries; approval by the Council of the establishment of a control center in the Inmarsat headquarters in London; a decision not to charge for distress alert or distress calls and to undertake a study on whether or not Inmarsat should charge for follow-up distress or alert calls; Council agreement to include recommended environmental standards in the ship earth station specifications being prepared for final Council approval at its June session. Type approval procedures for ship earth station models and administrative procedures for commissioning of ship earth stations will also be considered by the Council in June. The Director General will advise Signatories of those countries that have decided to make the environmental standards mandatory.

## Radiation Systems manufacturing, selling Torus antennas

Comsat and Radiation Systems, Inc., have entered into an agreement which authorizes RSI to manufacture and sell a variety of Comsat-designed Multiple Beam Torus Antennas. Initially, RSI intends to market the Torus antennas for use in the cable TV industry.

The Torus antenna, developed and tested by Comsat Laboratories, can precisely focus on several satellites simultaneously compared with a conventional parabolic "dish" antenna which works with only a single satellite at a time. The Torus is protected by Comsat patents.

The agreement gives RSI an exclusive license to build and market Torus antennas ranging in size from 3 to 8.5 meters and non-exclusive rights in other sizes. In connection with sales of the Torus, RSI is also authorized to manufacture and sell a variety of Comsat-designed antenna feed systems.

Radiation Systems, located in Sterling, Virigina, has 20 years of experience in the design, manufacturing and marketing of high quality communications antennas for the military, air traffic control and the commercial satellite markets.

RSI estimates that a 4.5-meter Torus, the size most suitable for cable TV applications, will cost about $29,000. This price includes three receive-only feeds which will allow the Torus to work with three satellites at once. Depending on the spacing of communications satellites in orbit, the 4.5-meter Torus can work with a maximum of five to seven satellites simultaneously.

Because of its multiple satellite access capability, the Torus is significantly less expensive to build and more economical to operate in most cases than the two or more 5-meter single-beam dish antennas and the necessary real estate which otherwise would be required.

The Torus also offers reduced interference in congested frequency areas, high reliability, superior service and substantially lower maintenance costs. The feed system used with the Torus is designed to satisfy a variety of requirements, including wide bandwidths, high power handling capability, low insertion loss, and efficient illumination of the reflector.

RSI will construct the 4.5-meter Torus with eight uniquely-contoured panels manufactured of high-strength aluminum using RSI's AccuShape process. The panels are joined to a lightweight backup structure which is mounted on adjustable tubular legs. The antenna can be easily erected on a concrete foundation approximately 20 feet by 20 feet or slightly larger than the area needed for a single 5-meter dish antenna. RSI intends to manufacture and sell Torus antennas in a variety of sizes in both fixed-station and transportable versions. A 4.5-meter Torus can be seen at Radiation Systems in Sterling, Virginia.

## 10,000th circuit leased

*On February 19, Comsat received a request from AT&T for 12 circuits on the Intelsat Atlantic Primary Satellite for the country of Venezuela. That date marks another of Comsat's many milestones: on that day the Corporation leased its 10,000th circuit.*

Today's 10,000 circuits represent nearly two-thirds of all overseas communications in and out of the United States. The rest is carried by undersea cable. The 10,000 circuits are roughly equivalent to the satellite circuits of Great Britain, Canada, Japan and West Germany combined. This amount also represents almost one-fourth of all circuits now in use in the entire Intelsat system, which serves 134 countries.

Given the growth of such traffic over the last few years, experts predict that Comsat will lease its 20,000th circuit in four to five years and its 40,000th in the early 1990's.

Circuit leasing is handled by Comsat World Systems Division. The circuits are used for telephone, telex, facsimile and data services. International television service is also provided by Comsat World Systems and other authorized carriers.

One of the reasons for the dramatic growth in leased circuits is the continuing reduction in Comsat's rates. In 1965, one leased circuit cost Comsat's international record carrier customers $4,200 per month. Today, following several rate reductions, including the most recent of 11.8 percent on January 1, the cost of a leased circuit has dropped to $1,125—about one-quarter of the cost 15 years ago.

## ERT seminars scheduled

Environmental Research & Technology, Inc. (ERT), will conduct six environmental short courses during 1981, five of which represent major initiatives in helping to strengthen environmental planning and management skills among top-level policy makers and administrators from developing countries.

The seminars are held by the International Environmental Management Institute, ERT's professional educational arm. Alumni to date include 95 senior officials, including several government ministers, from 29 countries and six international organizations, such as The World Bank, Inter-American Development Bank, and African Development Bank.

The first seminar was held March 9-13 in Mexico City. These other seminars are scheduled:

- *Principles of Environmental Management in Developing Countries*, Concord, Massachusetts, 15-19 June.
- *Environmental Impact Assessment in Developing Countries*, Concord, Massachusetts, 22-26 June.
- *Principles of Environmental Education and Training*, Concord, Massachusetts, 22-26 June.
- *Seminar on Natural Resources and the Environment: 1981-2000*, Cambridge, Massachusetts, 20-24 July.
- *Air Pollution Meteorology*, offered jointly with the Harvard University School of Public Health, Boston, Massachusetts, 27-31 July.

These seminars are designed and undertaken as a private initiative by ERT, without governmental or foundation subsidy. Costs are recovered through tuition fees paid by participants and their sponsors. ERT provides scholarship assistance to individuals from developing countries unable to find full support. The faculty features scientific, technical and policy experts from the staff of ERT and invited faculty from such prominent organizations as The World Bank, United Nations Environment Program and Harvard University.

Evaluations of the program document its success. Among the comments from pleased alumni: "I have gained an insight into planning that will assist me in setting goals, objectives and programs for the following years. This has not really been done before, and it is essential. The framework for such a planning effort crystallized in my mind during the seminar. Also, a more international view was gained that puts the issues of my company into a larger perspective."

"The exchange of ideas among the participants was the most valuable

*Continued on page 37*

# COMSAT LABORATORIES
## International Center for Satellite Communications R&D

by *Dr. John V. Harrington, Senior Vice President, Research and Development and Director, Comsat Laboratories*

Comsat Laboratories is the research and development center of the Communications Satellite Corporation and its subsidiaries. An acknowledged leader in its field, Comsat Laboratories has made significant contributions to the advancement of satellite communications technology over the years. Our scientists and engineers perform research on systems concepts and architecture, devices, subsystems, technologies and techniques related to telecommunications, with strong emphasis on communications via satellite.

Comsat Laboratories is located on 210 acres of rolling countryside in Clarksburg, Maryland, about 35 miles northwest of Washington, D.C. Within its more than 254,000 square foot modern, functionally-designed building, we have some 518 persons working on the frontiers of communications technology. The staff includes about 200 scientists and engineers, with the remainder technicians and administrative and support personnel. More than three-fourths of the professional staff have advanced degrees, and approximately one-third have Ph.D.s. Their interests and abilities range across the many disciplines needed to solve the complex communications challenges of tomorrow.

Through its accomplishments, Comsat Laboratories has established itself as an international center for advanced research and development. Our extensive development programs in the last 10 years have led to the improved performance, greater capacity, and increased lifetime of communication satellites and ground systems as well as new transmission modes.

The Laboratories develops and establishes the feasibility of new earth station and spacecraft devices and components; investigates satellite network architecture and terrestrial interface issues; performs system transmission analysis simulations and propagation experiments; and develops system planning and analysis software, reliability models, and standards.

In addition, our efforts are directed toward improved voice, data, video, and graphics transmission services and efficient system design and implementation, as well as investigating and developing technology for innovative services through the application of communications satellites.

We are very proud of the important role that Comsat Laboratories has played in the success of the International Telecommunications Satellite Organization (Intelsat), the body that owns, maintains, and operates the global satellite system used by countries around the world. Under several contracts from Intelsat, the Laboratories conducts R&D programs directly related to the specific needs of Intelsat for technology development.

We provide scientific and technological expertise and laboratory support to the Corporation in its role as a major member of Intelsat and Inmarsat, and as a member and Manager of the United States Earth Station Owners Committee (ESOC); and to its wholly-owned subsidiary, Comsat General Corporation.

Our staff of scientists, engineers, and technicians has extensive experience in communications satellite research and development projects and programs for the Corporation, Intelsat, government agencies, private industry and international organizations. In addition to engineering and technical expertise, the staff has the management ability required to implement sophisticated communications networks.

To expand technical knowledge and understanding of the use of communications satellites internationally, the *Comsat Technical Review* (CTR), was established as a semiannual archival journal devoted exclusively to satellite communications. Since its inception in 1971, CTR has published more than 200 papers originated by members of Comsat's professional staff and has achieved worldwide recognition.

Just as the Corporation itself is developing new lines of business and new applications for its capabilities in satellite communications, so too is Comsat Laboratories emphasizing new technical programs and relevant new lines of research.

The frontiers of satellite communications are quite remote with many new services and systems still conceivable. It is the important and exciting objective of the Laboratories to ensure that those new applications and business possibilities are technically achievable.

# The LABS Achievements of 1980

*by Allan Galfund, Manager,*
*Technical Information, Comsat Laboratories*

The research and development program that would become **Comsat Laboratories** was initiated in 1966 when the Comsat engineering staff undertook studies to determine the course of future communications satellite technology development. The studies were followed a year later by the establishment of a Comsat R&D division to investigate advanced technology and an advisory board to recommend future R&D programs.

It soon became apparent that a permanent research and development laboratory was essential. An outside committee endorsed the concept. The facility would provide a home for scientists and engineers where new technologies could be pursued and applied to Corporate needs.

Ground was broken for the present **Comsat Laboratories** in January 1968, and the structure was completed in September 1969.

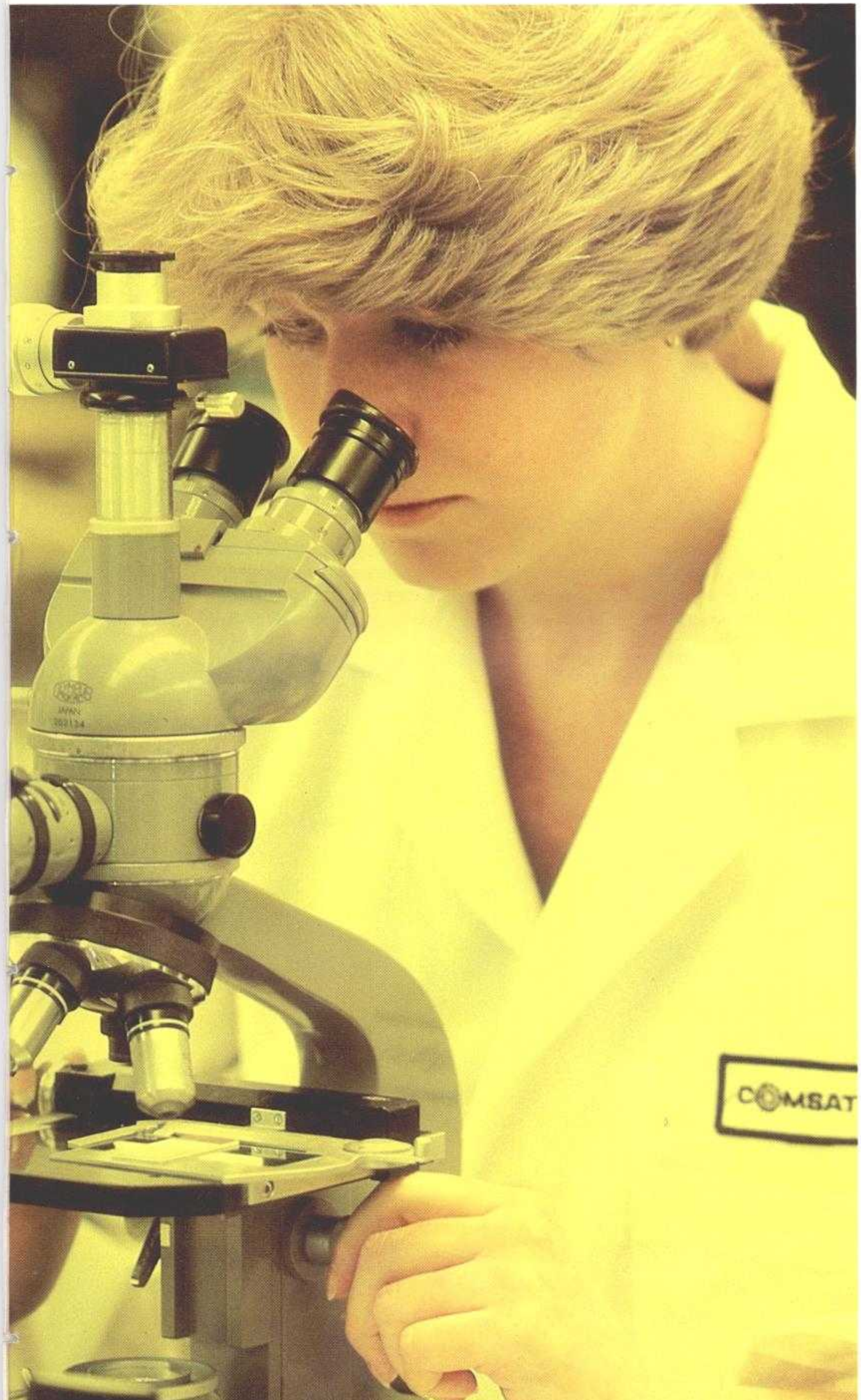
**Comsat Laboratories'** prime objective is to ensure United States leadership in satellite communications technology through **Comsat**'s role in **Intelsat** and **Inmarsat** and to continue to carry out research and development activities in support of other Corporate operations. Now into its second decade, **Comsat Laboratories** has many years of proven experience but retains the vigor and commitment of a young enterprise.

During the 1980 calendar year, "the **Labs**," under the direction of Dr. John V. Harrington, Senior Vice President, Research and Development, continued to contribute to the advancement of satellite communications technology. It carried on a broad range of research and development programs to advance communications satellite technology on a wide front, to augment capacity, increase service flexibility, and improve operating efficiency.

The Labs are developing methods for transmitting all types of communications—voice, video and data—in digital rather than analog form.

Some of the more significant **Comsat Laboratories** achievements during 1980 follow:

*Continued on page 8*




Comsat Laboratories employee Elizabeth R. McGee, Microcircuit Technician, inspects microwave circuit of new design in Microwave Integrated Circuit Photolithography Laboratory.

### Attitude Determination and Control System Simulator

The Intelsat V satellite is a complex and sophisticated communications spacecraft. Proper control of the satellite is vital to the successful operation of the communications system. With that in mind, an attitude determination and control system (ADCS) flight simulator for the Intelsat V satellite has been developed. The ADCS is used for a variety of purposes, including real-time training for engineers and technicians involved in Intelsat V satellite operations, establishing the relative risk in operating under different combinations of sensing and control conditions, investigating in-orbit anomalies, and providing back-up to analytical investigations.

Future efforts to increase the system's capability to operate over broader ranges of conditions and to provide more easily interpretable

### Low-Noise Amplifier

For the first time, Low-Noise Amplifiers (LNA) operating in the 11.7-12.2-gigahertz and the 10.7-11.7-gigahertz communications bands, have achieved a noise performance (110-120 K) comparable to that of temperature-stabilized parametric amplifiers. These fully engineered and practical low cost LNAs exhibit the lowest noise temperatures ever reported for thermoelectrically cooled 11-gigahertz and 12-gigahertz Metal Semiconductor Field Effect Transistor (MESFET) amplifiers. The compact, cooled LNAs have advantages of improved gain-stability-over-temperature, high reliability, wide bandwidth, simpler RF circuitry, and appreciably lower cost in comparison to conventional temperature-stabilized power amplifiers, yet have comparable noise temperature and power gain.

The cooled MESFET LNAs are expected to replace conventional parametric amplifiers in satellite

### Bearing Performance Analysis

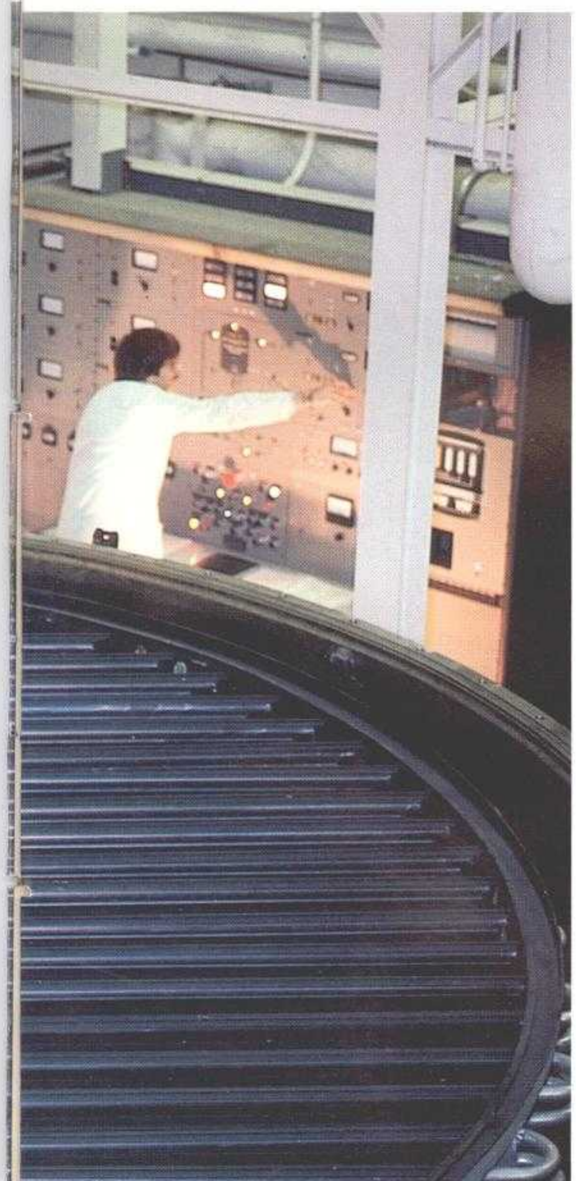
Modern communications satellites are expected to perform reliably for seven years or longer. One area in which

*Spacecraft battery pack with experimental heat pipe assembly is positioned for testing in the Labs' large thermal vacuum chamber.*

considerable uncertainty has existed in predicting long-term operation is that of rotating devices for which bearings are needed. (Intelsat V uses bearings in momentum wheels, gyros and solar array drives.) Bearing performance analysis techniques have been developed to sense and analyze the characteristics of bearings and to detect abnormalities and potential failures in ball bearings used in spacecraft devices. Those techniques are being applied to inspection and other quality control processes in the parts selection and assembly operations for satellites.

### Regenerative Receiver

To fully realize the advantages of digital satellite transmission and permit on-board processing, on-board data regeneration is required. A significant accomplishment achieved during 1980 was the development of a small (9.2" x 6.0" x 0.9") microwave integrated circuit (MIC) regeneration receiver. The receiver, which contains 12 microwave integrated circuits and six hybrid integrated circuits, converts a modulated radio frequency (RF) carrier to a baseband bit stream. Switching to baseband frequencies instead of microwave frequencies gives significantly more flexibility to data streams in a satellite-switched Time-Division Multiple-Access (SS-TDMA) system. Transmission economy is attained because with on-board data regeneration, only half the power is required for transmission or, if the same power is maintained, smaller earth terminal antennas are possible.



### Microwave Switch Matrix

Future high-capacity satellite systems will incorporate frequency-reuse. Multibeam antennas with compact feeds and sophisticated reconfigurable beam-forming networks to achieve multiple frequency reuse over geographical areas are under development. To interconnect the multibeams, Comsat Laboratories has developed a lightweight, low-power-consuming microwave switch matrix.

Present plans for the Intelsat VI call for two microwave switch matrices to be included in the satellite for satellite-switched Time-Division Multiple-Access (SS-TDMA) operation among six beams. The broadband 8 x 8 (eight-uplink, eight-downlink) microwave switch matrix, designed and fabricated using MIC techniques and tested at Comsat Labs, has provided a reference model for Intelsat VI and other future satellites. The implications of circuit complexities, device and material requirements, and SS-TDMA scheduling and synchronization problems have been investigated. As part of this project, a custom large-scale-integration (LSI) chip, which will be integrated within the microwave switch matrix to control its operation, is in the final stages of development.

### Coplanar Waveguide Technology

A new approach to microwave integrated circuit (MIC) technology is being developed. This approach, coplanar waveguide (CPW) technique, yields greater economy in fabrication and packaging over conventional MIC.

During 1980, many of the design techniques associated with coplanar waveguide microwave integrated circuits were tested in several useful circuits. As a consequence, Comsat Laboratories is now able to design and fabricate a wide range of complex microwave circuits and systems in a form much more compact and lower in cost than has been previously possible. Specific items completed to date include a 12-gigahertz down-converter for earth terminal use, a 12-gigahertz three-stage gallium arsenide field-effect transistor (GaAs FET) amplifier on a single 1/8th inch square substrate, and an L-Band intermediate frequency (IF) amplifier having 40 decibels gain.

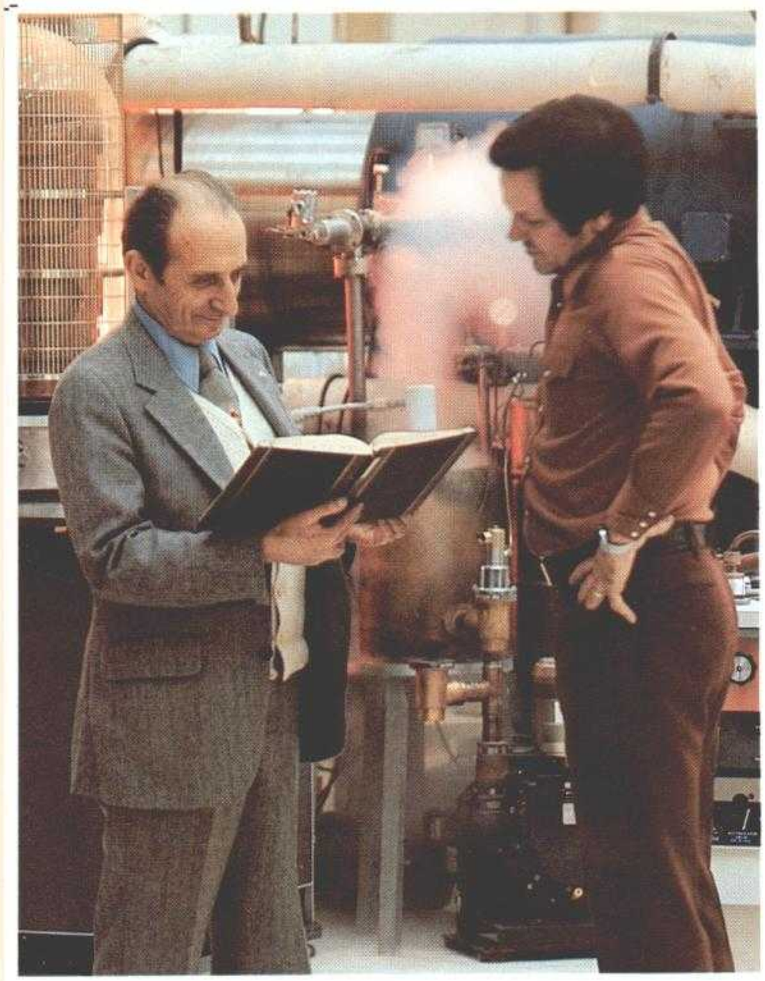
Potential applications for this technology include low cost earth terminal equipment and data collection platforms.

A 12-gigahertz microwave receiver has been successfully designed and tested. The entire receiver is realized on a single, compact CPW MIC substrate with a total area of 1.4 square inches. The single CPW substrate includes the functions of radio frequency (RF) mixer, demodulator, local oscillator (LO), and filter; all resistors as well as conductors are photolithographically defined in a single step.

### Monolithic Microwave Integrated Circuit Technology

Comsat Laboratories is developing the capability for making gallium arsenide monolithic microwave integrated circuits (MMICs). During 1980 the Labs designed and fabricated four different kinds of 4-gigahertz field effect transistors (FETs), including a dual gate FET, and metal-oxide-overlay capacitors. The capacitor dielectric layers can be made by a variety of processes including anodization of aluminum metal on the bottom plate. This has been done successfully and has provided very close control of dielectric thickness. Planned is the combining of 4-gigahertz FETs, capacitors, and other passive elements into MMICs to create products such as a switching element for a microwave switch matrix.

The possibility of producing complete microwave circuits, including active devices, by successive etching and activation of gallium arsenide substrates holds the promise of significant cost savings, greatly improved reliability, and large reduction in size. Such monolithic microwave integrated circuits will contribute to the successful design and long-term survival of complex, multibeam satellites. An effort started in 1980 to develop MMIC passive and active components. The first set of experimental single-gate and dual-gate gallium arsenide field effect transistors has been fabricated and DC-tested. Microwave testing of these devices will be performed soon and design modifications and improvements will follow. As presently planned, units to achieve a number of microwave functions such as amplifiers, a mixer, and switches will be developed.



*Dr. Pier L. Bargellini, left, Comsat Laboratories Senior Scientist, with Daniel D. Forrester, Senior Technical Specialist, Spacecraft Laboratory, in front of small vacuum chamber*

### RF System Monitor

A system monitor for SBS has been developed at the Laboratories and is being installed at the SBS earth station in Clarksburg, Maryland. This system will monitor the status and conditions of the satellite and of the Time-Division Multiple-Access-transmitting earth stations.

### 6-GHz High Power Channel Multiplexer

The development and fabrication of the 6-gigahertz high-power channel multiplexer for the Brewster, Washington Earth Station is the final step in implementing a study to improve operating cost and permit expansion of existing earth terminals. Such a multiplexer design based on the many years of microwave filter development is not available commercially.

The approach meets all Intelsat specifications, achieves maximum flexibility in permitting power and bandwidth expansion on a transponder-by-transponder basis. Earth station reliability is substantially enhanced by the replacement of very large, expensive, water-cooled 12-kilowatt traveling wave tube amplifiers (TWTAs) by smaller, less expensive, air-cooled 3 kilowatt TWTAs. Thus prime power requirements and operating costs can be significantly reduced.

### MIST
A new method of fabricating a high frequency gallium arsenide amplifying device has been invented. The device, a metal-insulator-semiconductor transistor (MIST), is formed by bombarding the insulating layer with high energy ions. By proper choice of the ion species and their energy and by controlling the number of implanted ions, it is possible to convert a controlled fractional thickness of the gallium arsenide into an insulating layer of high stability. Advantages of the fabrication technology are ease of preparation and high yield. Moreover, these transistors are unusually tolerant of high-energy ionizing radiation. This makes them highly suitable for use in satellite circuitry.

### Optical Communications
The utility of optical fiber communications systems as interfacility links at satellite communications earth terminals has been demonstrated. Work is continuing on a high efficiency, broadband repeater design with emphasis on applications to earth station diversity links.

A comprehensive study of the undersea optical fiber cable technology has been completed. The results of this study will be useful for the formulation and assessment of competitors' plans for transoceanic communications.

A basic optical processor has been designed and constructed which will form the basis for optical processing for a wide range of applications, including antennas, microwave networks, signal processors, spectrum analyzers, and others.

Optical switching elements have been constructed and tested for use in opto-electronic switch matrices. The opto-electronic design may have significant bandwidth and isolation advantages relative to alternatives for advanced satellite designs.

*Comsat Laboratories, research and development center for satellite communications in Clarksburg, Maryland. Photo by Allan Galfund.*

### Digital TV
Comsat Digital Television (CODIT-20), the latest of a series of digital TV equipment developed at Comsat Labs, provides broadcast quality transmission of digital television at a bit rate of only 20 megabits per second and will accept external transmission rates. Thus the transmission of three TV channels in the 36-megahertz bandwidth of an Intelsat transponder would be possible as would transmission of two TV channels over one 44.7-megabits per second pulse code modulation (PCM) multiplex channel. During 1980, the feasibility model of CODIT-20 was completed and evaluation tests were performed. The engineering model is scheduled for completion in 1981.

Progress has also been made in a video teleconferencing effort. Initial simulation of real-time sequences promises a practical system operating at 1.5 to 6.0 megabits per second.

### Supergroup Transmultiplexer
A new concept for the system design of a digital supergroup transmultiplexer (T-MUX) will result in simplifying hardware, lower cost, and improved reliability. The hardware implementation of the T-MUX, based on this new concept, is nearly complete and firmware development is in process. The engineering model is scheduled for completion and extensive testing in 1981.

The T-MUX is important to the introduction of Time-Division Multiple-Access in the Intelsat system, since it provides the required interface between frequency-division-multiplexed analog traffic received at the earth station and the time-division-multiplexed digital format required by the TDMA system.

### Advanced TDMA Development
Comsat Laboratories has developed an advanced Time-Division Multiple-Access terminal which employs a digital

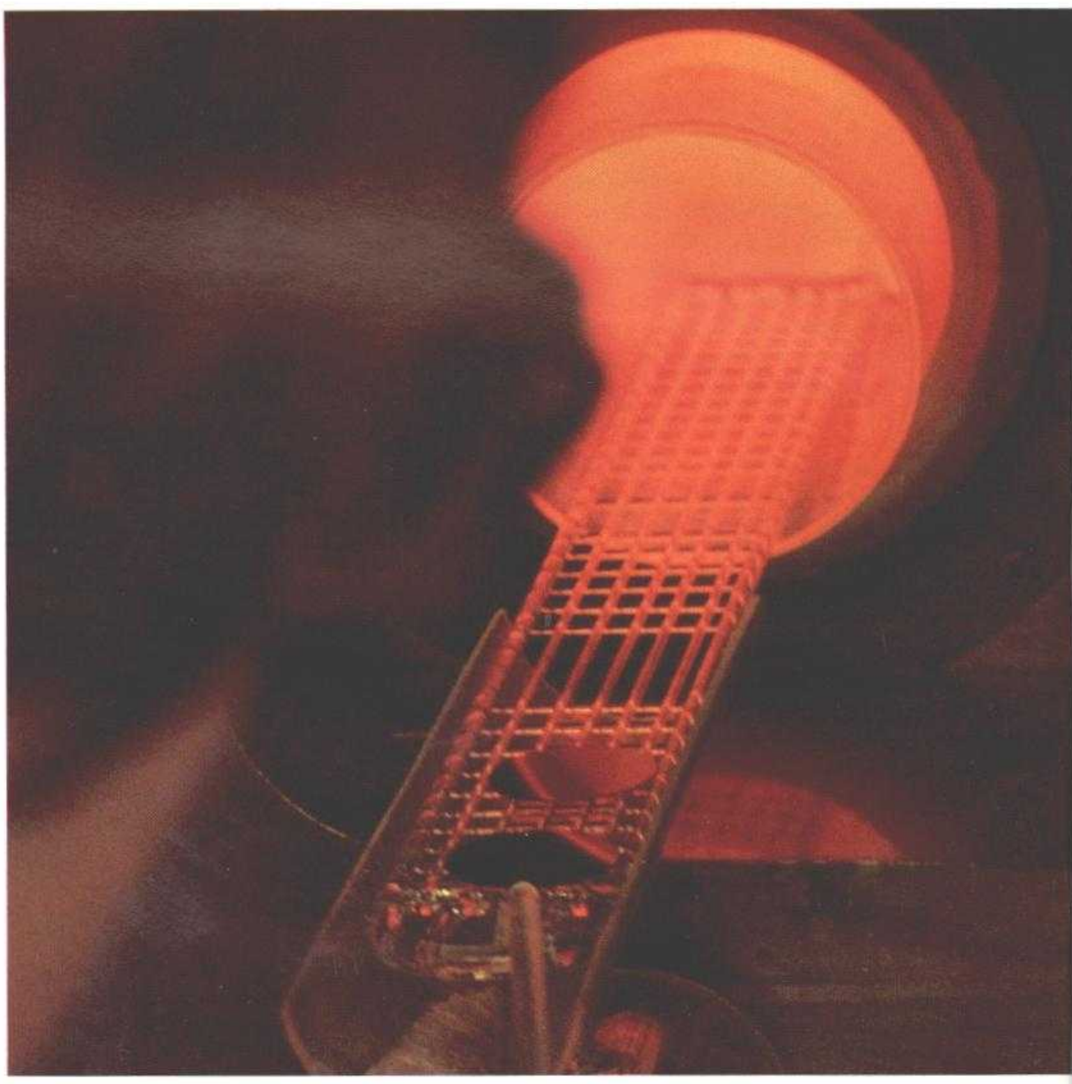
satellite transmission mode that can double the capacity of a satellite compared to what is possible with frequency-division multiplexed techniques. This improvement comes about because the capacity of a transponder is shared among multiple accesses in the time domain using a single carrier. Avoided is the intermodulation distortion which limits capacity of the Frequency-Division Multiple-Access techniques, and it also provides flexibility in reassigning circuits and greater economy in data transmission.

TDMA is inherently a digital transmission technique and hence is ideally suited to support digitized telephone transmission. Consequently, it is the best means for integrating terrestrial and satellite digital transmission systems. Through use of advanced source coding techniques, basic TDMA capacity can be quadrupled. (For more on **Comsat Labs'** TDMA achievements, see the article beginning on page 14 and also the article on SATNET beginning on page 26.)

## TDMA Test Bed Development

A Time-Division Multiple-Access test bed was developed to test and evaluate the TDMA transmission system under various operational conditions for noise, interference and nonlinearities. The test bed permits TDMA parameter assessments at a transmission rate of 120 megabits per second for real or simulated 6/4-gigahertz satellite links and is presently the only facility available for Intelsat V TDMA tests. The test bed includes a Labs-developed radio-frequency path simulator and a test set to measure modem performance and TDMA timing accuracy. The TDMA subsystems, which were developed by outside manufacturers, include two TDMA traffic terminals, a reference terminal, a separate modem, coding equipment for error detection and/or correction and space diversity equipment.

A synchronization unit controls the TDMA timing of the traffic terminals in terms of the satellite position computed by range triangulation from



*Silicon wafers enter diffusion/oxidation furnace as part of fabrication process for semiconductor devices. Place: Semiconductor Fabrication Clean Room, Comsat Laboratories.*

three stations. An acquisition and synchronization unit controls the TDMA timing of traffic terminals for a satellite when various up-links are periodically connected to separate down-links. In the laboratory these subsystems can be reconfigured in different ways to allow for a complete analysis of TDMA system performance.

### System Simulation for Intelsat

During 1980, substantial progress was made toward the completion of the Intelsat V satellite simulator. Eight of the ten travelling-wave-tube amplifiers allotted to the simulator have been incorporated in it and the remaining two are scheduled for integration in early 1981. Work has been initiated, using the completed portions of the simulator, on characterization of the performance of a 120 megabit per second quadrature phase shift keying TDMA modem through an Intelsat V transponder. In addition, a study has been undertaken on the dual path effects in the Intelsat V on the operation of the SPADE System Common Signaling Channel.

### CHAMP/CMS

The channel modeling program (CHAMP) has been developed by Comsat over the past years as a tool for analysis of signal degradation in a generalized communications satellite channel with emphasis on digital communications systems. The program simulates the effect of the various components of a channel, such as filters and amplifiers, on a signal and provides various measures of degradation as analysis functions.

A version of CHAMP has been written for use by analysts who wish to simulate a channel but who do not necessarily need to understand the mechanics of the program. Improvements were made in input format and input error message functions, and some function definitions were automated. The program was designed to run on an IBM 3032 computer using Conversational Monitoring System (CMS) capabilities, and has been optimized to be faster and less costly in terms of computer charges.

### Programmable Interface Processor

The Programmable Interface Processor (PIP) serves as a versatile front-end processor for a variety of satellite/computer communications applications. The PIP was developed to facilitate the implementation and testing of new networking concepts, protocols and interfaces either in the laboratory or through experimental satellite communications links. The hardware subsystems of the system have been designed, tested, and integrated with executive software into an operation multiprocessor system. The first version of the PIP multiprocess/multiprocessor operating system has now been replaced by the full-capability Version Two.

This completes the first two phases in the development program. The remaining development work consists of the development and integration of a system "Exerciser," the communications software, an applications emulator, and the final packaging.

### Forward Error Correction Codec Development

A set of forward error correction (FED) coding and decoding (codec) devices have been developed for a wide range of applications including high-data-rate Time-Division Multiple-Access digital speech interpolation, medium-data-rate Frequency-Division Multiple-Access/Time-Division Multiple-Access, and low-data-rate single channel per carrier (SCPC) systems. In particular, a rate 14/15 shortened Hamming code was developed, integrated, and tested with the system in order to enhance the performance of its alternate voice/data (AVD) channels. It was found that with this FEC codec, 9,600 bits per second data transmission over the SCPC AVD channels becomes feasible and practical.

### Coded Phase Modulation Technique

As part of the investigation of bandwidth and power efficient modulation techniques, a rate 2/3 coded octal phase shift keying (OPSK) system was proposed and evaluated for potential Time-Division Multiple-Access system applications. It was found that for a given radio frequency bandwidth and a given data rate, the proposed OPSK system can provide a potential power advantage of about 4 decibels over the quaternary PSK system at a bit error rate of 1 part in a million for the Intelsat V system environment. Also, a set of optimum rate 1/2 coded quaternary PSK modulation systems was proposed and evaluated for severely bandwidth-limited satellite channels with radio frequency bandwidth equal to or less than symbol rate.

# TDMA

## TECHNOLOGY WITH A FUTURE

*by Dr. S.J. Campanella, Director, Communications Processing Laboratory Comsat Laboratories*

*The articles beginning on this page and on page 26 describe work carried out either in whole or at least to a substantial extent at* **Comsat Laboratories** *in Clarksburg, Maryland. The similarity of Time-Division Multiple-Access (TDMA) as developed and perfected at* **Comsat Labs** *and SATNET (Satellite-based Atlantic Packet Network) is that both use time to discriminate among separate electronic messages. Both, in other words, are systems that involve tuning in time. A common method for discriminating among electronic messages in a network has been to put each on a separate frequency. This is known as Frequency-Division Multiple-Access (FDMA). The advantage of systems that are tuned in time over systems that are tuned in frequency is that time-tuned approaches require significantly less communications capacity than do frequency-tuned ones. The major difference between the two approaches discussed in this issue of* **Comsat Magazine,** *TDMA and SATNET, is that the former, as the following article points out, has now been shown to be commercially viable for satellite communications and will soon be used in the Intelsat system while SATNET continues to be an experimental effort. Editor's Note.*

Recently an advanced TDMA system designed to achieve low-cost implementation of TDMA terminals, to demonstrate a flexible traffic burst assignment and control architecture and to accomplish interfacing to a variety of analog and digital terrestrial links was tested in the Pacific Ocean region of the Intelsat system. The equipment was developed at **Comsat Labs** under the Comsat Global Research & Development program and the Pacific Ocean field trial was conducted with the cooperation of International Communications Services of Comsat World Systems Division and **Intelsat**.

TDMA accomplishes multiple access satellite communications by transmitting traffic bursts or packets in a periodic time frame called the TDMA frame, on a carrier having a frequency common to all participating stations. The traffic bursts carry time division multiplexed voice, data and image channels which can be selected by any or all network terminals. Information is carried by digital modulation means.

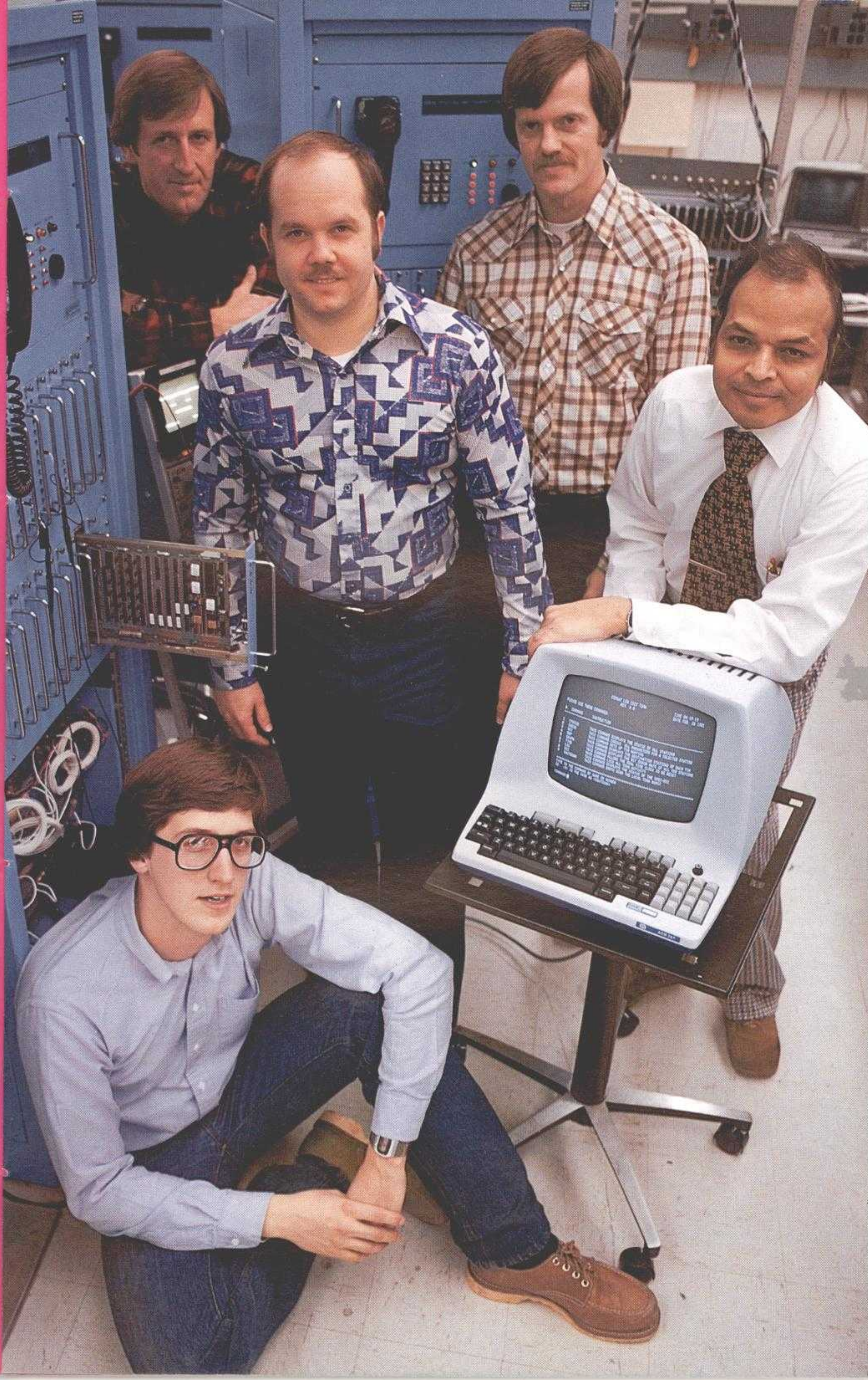
The TDMA terminal equipment is based on microprocessor-implemented Central TDMA terminal Equipment (CTTE) which controls TDMA traffic burst locations in the frame. The drawing on page 16 illustrates how TDMA traffic bursts appear in a TDMA frame. Each TDMA frame begins with a reference burst. In some system designs there may be more than one reference burst for reasons of reliability. The reference burst is followed by the traffic bursts which are identified by their position in the frame relative to the reference burst. Thus to "tune" to Station A the receiver simply looks in the time slot that begins at time "TA" following the reference burst. Each traffic burst begins with a preamble used to synchronize earth station reception equipment to the burst and to carry order-wire and control information needed for network operation.

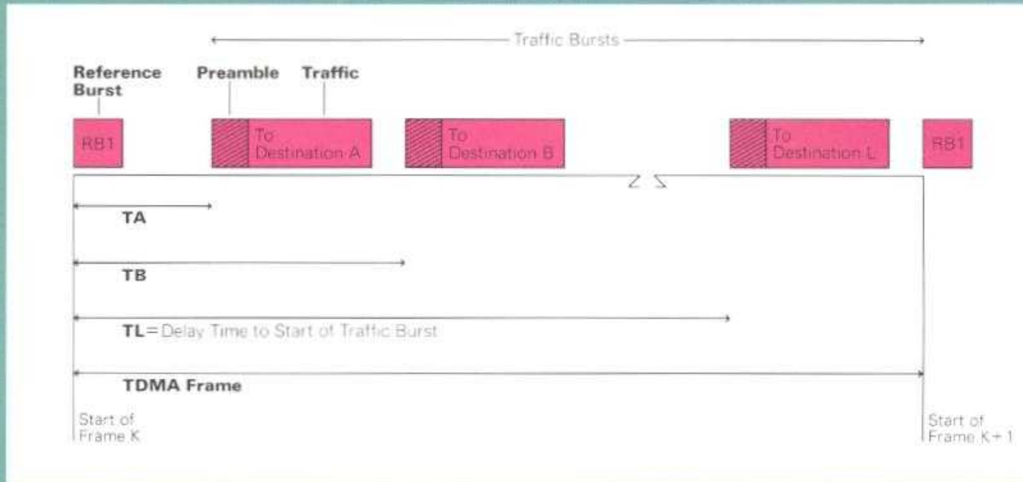
Information is carried by a digital modulation method which uses the signalling technique shown on page 17. The information is expressed in terms of the phases of a carrier. This may be compared to the position of the hour-hand on a clock. The reference phase is 12 o'clock and this is defined as 0 degrees. When the hand points to 3 o'clock, the phase is 90 degrees; 6 o'clock, 180 degrees; and 9 o'clock, 270 degrees. The drawing also shows the time representation of these four phases. The information is carried in short bursts of signal called a symbol which has one of the phases, depending on the information carried. These symbols are transmitted at a high periodic rate to achieve the necessary information flow.

*Advanced Time-Division Multiple-Access Terminal with some of the people in Communication Processing Laboratory, Comsat Laboratories, who helped develop it: from left, Peter Hoover (seated), Richard Jones, Richard Lindstrom, Robert Ridings, and Shanti Gupta.*



*Continued on page 16*



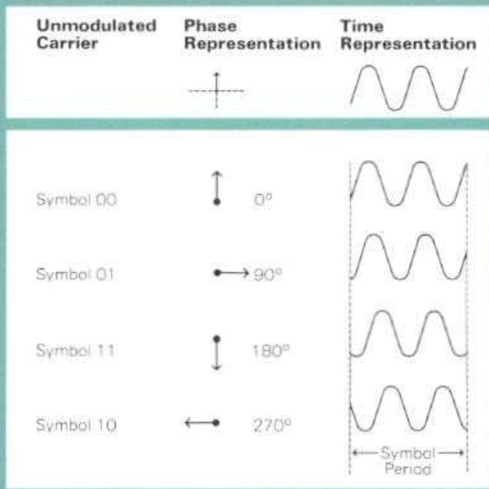



Information is expressed in terms of a choice of a zero (0) or a one (1) called a bit. If bits are taken in pairs, each pair has four combinations: 00, 01, 10 and 11, and these can be identified by the four phases of a symbol. Thus, the bit combination 00 is represented by transmitting a symbol that is in phase with the unmodulated carrier. The other three possible bit combinations are represented by additional 90 degrees phase shifts of the transmitted carrier relative to the unmodulated carrier. In a typical Intelsat IV-A transponder which provides 36 megahertz of useful bandwidth, a symbol rate of 30 megasymbols per second can be carried providing a bit rate of 60 megabits per second. In the Intelsat V, transponders having a useful bandwidth of 72 megahertz are available and these are able to support symbol rates of 60 megasymbols per second and hence bit rates of 120 megabits per second.

The traffic carried by the TDMA system is in digital form. Analog traffic must be converted to digital form to be transmitted over the system. Typical digital telephone system practice in both the United States and in Europe uses a bit rate of 64 kilobits per second to carry individual voice channels. Thus with a bit rate of 60 megabits per second, which is possible with 36 megahertz of useful transponder bandwidth, the maximum achievable traffic is 937 voice channels. For 120 megabits per second operation, this is doubled to 1,875 voice channels. However, capacity is lost due to the need to provide time for reference bursts and preambles and, in addition, to allow for guard time between the bursts so that uncertainties in burst position-keeping do not cause the bursts to overlap. When these losses are accounted for, approximately 5 percent of the traffic-carrying capacity is lost. Thus the capacity for a 60 megabits per second TDMA system is reduced to approximately 890 channels and for a 120 megabits per second system to 1,730 channels.

If individual 64 kilobits per second voice channels are carried full time on the satellite, then the capacities noted previously would be realized. However, because the talk spurts of talkers engaged in conversation only occupy a channel 40 percent of the time at peak busy hour, it is possible to interpolate a multiplicity of conversations onto individual channels and thereby achieve a traffic multiplication advantage of between 2 to 1 and 2.5 to 1. This increases the traffic-carrying capacity of a TDMA system from 1,790 to 2,225 channels for 60 megabits per second operation and 3,480 to 4,325 channels for 120 megabits per second operation. These numbers are based on two reference bursts per frame and 10 traffic bursts per frame.

The advanced TDMA terminal utilizes an architecture which has microprocessor-controlled common equipment at its heart. It controls the process of acquisition and synchronization of the TDMA frame for locating the instance of traffic-burst transmission and reception. The acquisition process refers to the initial localization of a traffic burst relative to the reference burst. During the acquisition process the traffic station transmits only the preamble of its traffic burst and locates it in the proper location relative to the reference burst by a feedback process. Only the preamble is used because uncertainty in initial burst positioning may cause a burst to depart a relatively large




amount from its assigned position. Synchronization refers to the continuous maintenance of an accurate burst location relative to the reference burst.

When a TDMA terminal operates in a global or regional beam system where it can directly view the location of its traffic burst relative to the reference burst, the TDMA terminal can directly apply the feedback needed to correct its own traffic burst position to accomplish synchronization. However, in a multi-beam system in which a TDMA terminal may not be able to directly view the location of its traffic burst relative to the reference burst, it becomes necessary for burst position control to be accomplished by feedback control from a cooperating station located in the receiving beam. This cooperating station is able to see both the traffic burst and the reference burst and sends correction information back to the controlled station.

In the Intelsat V system, the method of cooperative feedback control is to be accomplished by the reference station in the receive beam region. The microprocessor-controlled equipment contained in the **Comsat Labs** advanced TDMA design is able to perform either method of burst position control described previously.

The microprocessor-controlled common equipment also routes voice, data and image traffic to and from various Terrestrial Interface Modules (TIMs) using a high-speed data bus. Address and control information are provided on two data bus control lines to route the transmission bursts to the proper TIMs. In addition, the microprocessor-controlled common equipment also places the station's traffic bursts at their assigned location in the TDMA frame and provides for voice order wire and other operational information communications needed by the system. Burst location information can be entered by manual keyboard or automatic means. Burst locations can be changed from one frame to the next to respond to traffic burst assignment changes.

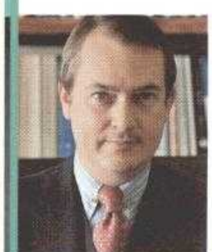
The advanced TDMA terminals used in the Pacific Ocean test were operated at a bit rate of 60 megabits per second using 36 megahertz bandwidth transponders on an Intelsat IV-A satellite. The frame period was adjusted to 750 microseconds. The terminal will operate at frame rates ranging from as short as 125 microseconds to as long as 20 milliseconds. The test demonstrated voice TIMs operating at both 1.544 megabits per second for T-carrier digital service and 2.048 megabits per second for CEPT digital service. A digital speech interpolation TIM operating at a 2 to 1 multiplication factor and carrying up to 240 simultaneous voice channels was demonstrated. Order wires among the traffic stations may be carried over delta-modulated channels contained in the burst preamble. A terminal monitor/control unit, provided with extensive software, accomplished status displays, channel routing and capacity updating and maintenance monitoring.

Advanced TDMA terminals were located at thee earth stations: Paumalu in Hawaii operated by **Comsat**, Hong Kong in the Orient operated by British Cable and Wireless, and Ibaraki in Japan operated by KDD.

The field test provided an opportunity to subjectively assess the quality of the voice circuits with and without the digital speech and interpolation techniques. The voice services were found to be of good to excellent quality in both cases. In addition, the performance of voice band data modems over the TDMA circuits with and without digital speech interpolation was also evaluated at bit rates up to 9,600 bits per second. The operation was found to be very satisfactory, providing the same quality of service expected on conventional terrestrial digital circuits operating at 64 kilobits per second. The test also successfully involved use of a trans-multiplexer, a new technology used for direct conversion of analog frequency division multiplexed groups and super-groups to the digital format needed for TDMA transmission.

# COMMENTARY

by Dr. Delbert D. Smith
Senior Vice President, Corporate Affairs,
Communications Satellite Corporation



Growth in the demand for satellite communications services has increased dramatically during the sixteen years since the first commercial communications satellite, Early Bird, was launched. For example, **Comsat**'s leased international satellite communications circuits have increased exponentially from 60 in 1965 to 10,000 at present; and it is estimated that such traffic will increase to 20,000 circuits in the mid 1980s and to 40,000 circuits in the early 1990s.

This phenomenal traffic growth indicates an increasing recognition of the significant benefits which can be achieved through satellite communications. Yet this growth also poses the problem of accommodating higher demands for service despite limitations in the amounts of geostationary orbit and radio frequency spectrum resources which are available for satellite communications.

Given these limits, the satellite communications industry must continually explore alternative technological means of increasing service capacity. Such exploration is the mandate of **Comsat Laboratories**, an institution which has demonstrated considerable leadership in satellite communications research and development. **Comsat Laboratories** has pioneered in the development of methods to improve and increase satellite capacity and efficiency, some of which have been incorporated into operational satellite systems.

One area of achievement for **Comsat Laboratories** is that of "frequency reuse," which involves the concept of segregating microwave beams so that the full bandwidth within each beam can be used without interference with other beams of the same frequency. Such segregation is accomplished through polarization or beam isolation.

Frequency reuse techniques have been included in satellites designed for **Intelsat**. For example, the Intelsat IV-A series of satellites employ frequency reuse by utilization of directional antennas. The Intelsat V series of satellites incorporates both polarization and beam isolation to quadruple the capacity of the 4/6 GHz bands.

Another area of achievement is the development of Time-Division Multiple-Access (TDMA) technology. Time-division technology involves separating an electronic message stream into individual units and then intermixing the units with those from other message streams moving through a network. At the receiving end the units are recombined to produce the original message. The net result is a more efficient use of the transmission network since natural pauses within a particular message, which are wasteful in terms of the constant flow of signals through a network, are filled with other messages. The multiple access technology allows separate ground stations to synchronize their transmission and reception of electronic message units with regard to a given satellite. Thus, TDMA maximizes the capacity of a network.

TDMA will be used for operational international satellite communications for the first time with the Intelsat V series of satellites. In addition, TDMA is a significant technological feature of the Satellite Business Systems (**SBS**) domestic satellite communications network.

These accomplishments are important steps towards increasing satellite communications capacity within the limits of orbital and spectrum resources. The advent of the space shuttle will foster other technological means principally through its capability to launch very large payloads at lower cost, which will further expand capacity to accommodate future traffic growth. We are indeed fortunate to have **Comsat Laboratories**, which can be considered a "national resource" in terms of talent and expertise, working to fulfill its mandate of seeking ways to expand satellite communications capacity for the future.

# World Systems Division

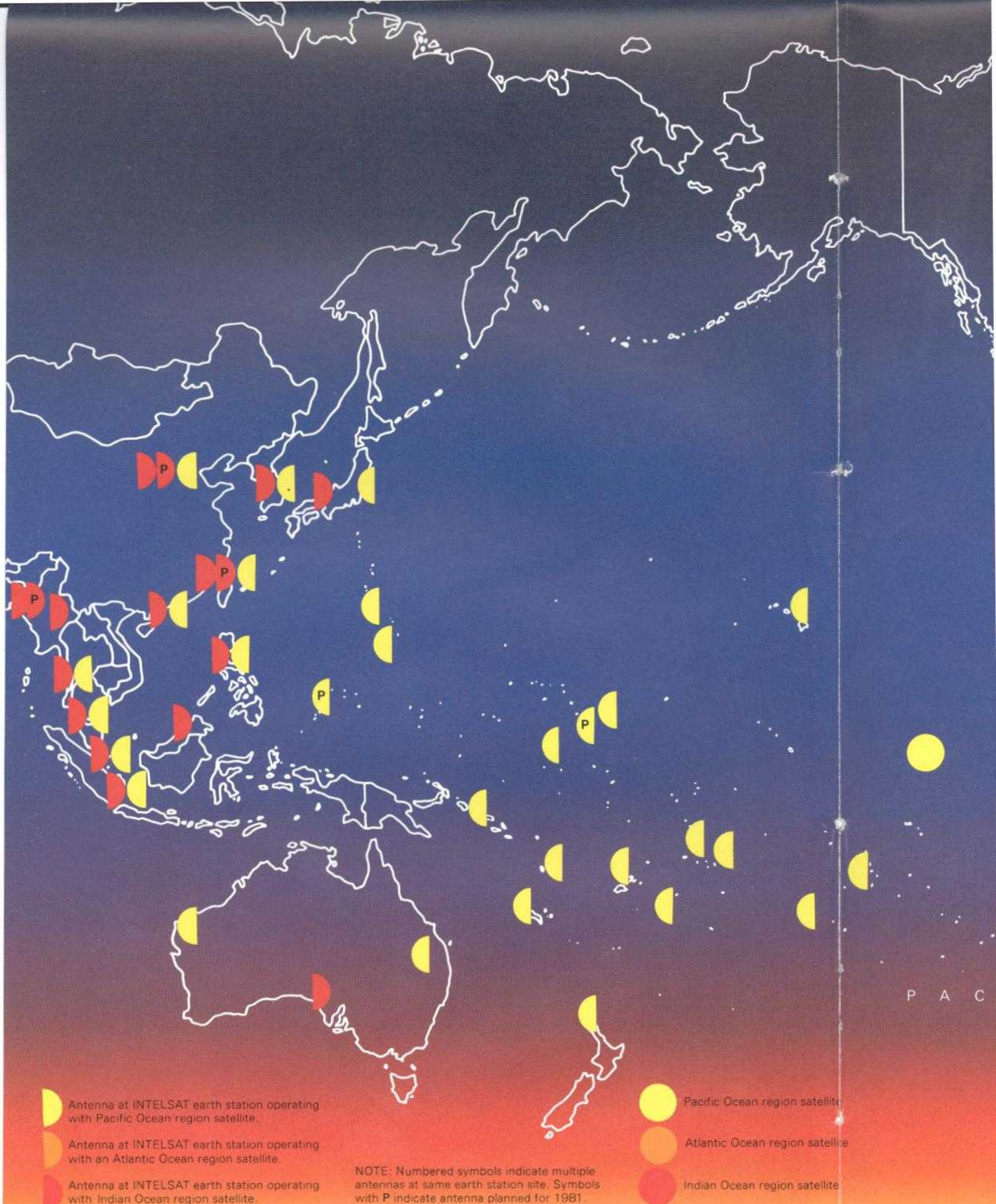
COMMUNICATIONS SATELLITE CORPORATION

**Comsat,** through its World Systems Division, furnishes communication satellite services to international carriers for service to the public, primarily between the United States and foreign points.

To provide these services, **Comsat** uses eight U.S. earth stations and the satellites of the International Telecommunications Satellite Organization (**Intelsat**), in which it holds an ownership interest of about 25 percent. **Comsat** is the U.S. representative to **Intelsat**, which now comprises 105 member nations.

The Intelsat satellites in geosynchronous orbit 22,240 miles above the equator, and the hundreds of earth stations around the world operating with them, form a global network for the transmission and reception of telephone, teletypewriter, data, facsimile and television communications. Either directly, or through terrestrial connections with countries having earth stations, more than 135 countries use Intelsat system services full time.

On the following pages we are pleased to present the 1981 map of the Intelsat global satellite communications system.

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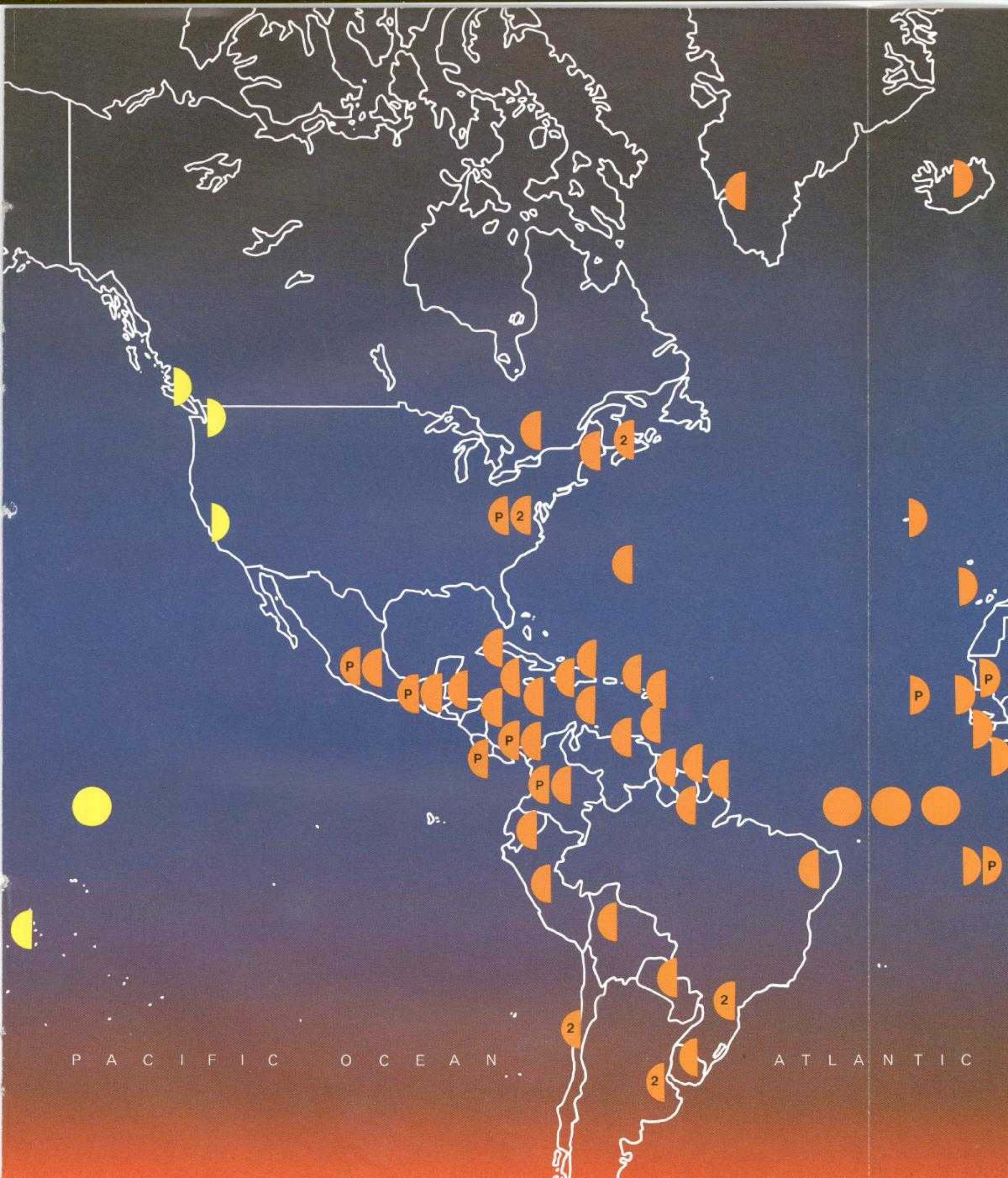


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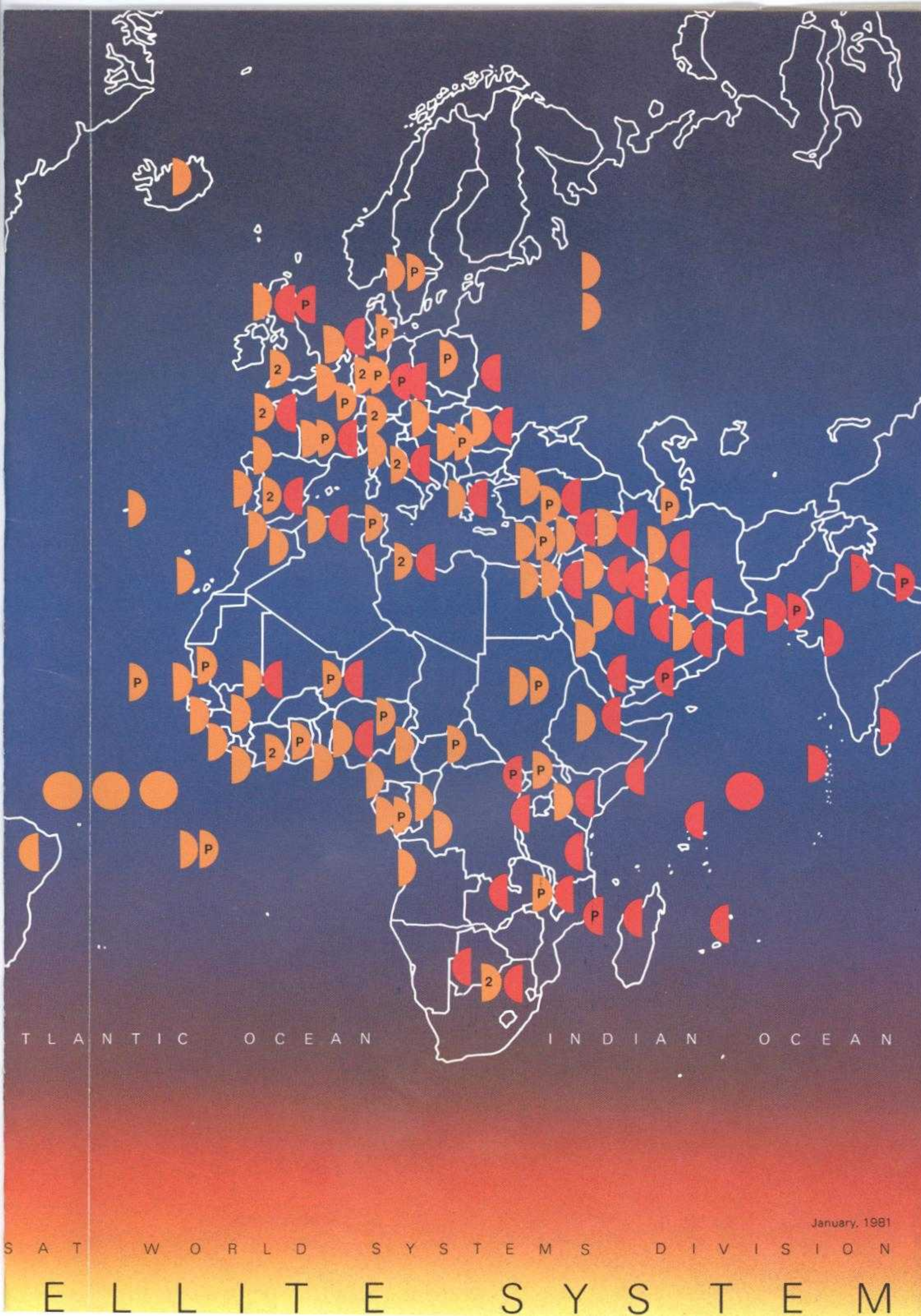


# Worl

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## INTELSAT Earth Stations in International Service

Earth stations listed below were operating as of December 31, 1980. Where there is more than one antenna at an earth station, the numerical designation stands for the specific antenna providing service for the region.

### Atlantic Ocean Region

Algeria: Lakhdaria 3
Angola: Cacuaco 1 and 2
Argentina: Balcarce 1 and 2
Austria: Aflenz
Bahrain: Ras Abu Jarjur 1
Barbados: Barbados
Belgium: Lessive
Belize: Belmopan
Bolivia: Tiwanacu
Brazil: Natal, Tangua 1 and 2
Cameroon: Zamengoe
Canada: Des Laurentides, Mill Village 1 and 2
Cayman Islands: Grand Cayman
Chile: Longovilo 1 and 2
Colombia: Choconta
Congo: Mougouni
Cuba: Caribe
Cyprus: Makarios
Denmark:
  Greenland: Godthaab
Dominican Republic: Cambita
Ecuador: Quito
Egypt: Maadi
El Salvador: Izalco
Ethiopia: Sululta
France: Bercenay-en-Othe 1, Pleumeur-Bodou 1 and 2
  Guiana: Trou-Biran
  Martinique: Trois Ilets
Gabon: N'koltang
Gambia: Banjul
Germany: Raisting 2 and 3
Greece: Thermopylae 2
Guatemala: Quetzel
Guinea: Wonkifong
Guyana: Georgetown
Haiti: J-C Duvalier
Iceland: Skyggnir
Iran: Asadabad 1
Iraq: Dujail 2
Israel: Emeq Ha'ela 1 and 3
Italy: Fucino 1 and 3, Lario
Ivory Coast: Abidjan 1 and 2
Jamaica: Prospect Pen
Jordan: Baqa 2
Kenya: Longonot 2
Kuwait: Umm Al-Aish 2
Liberia: Sinkor
Libya: Tripoli 1 and 2
Mali: Sullymanbougou 1
Mexico: Tulancingo
Morocco: Sehouls
Mozambique: Boane
Netherlands: Burum 1
  Netherlands Antilles: Vredenberg 1 and 2
Nicaragua: Managua
Nigeria: Lanlate 2
Panama: Utibe
Paraguay: Aregua
Peru: Lurin
Portugal: Sintra
  Azores: Ponta Delgada
Romania: Cheia 1
Sao Tome e Principe: Sao Marcal
Saudi Arabia: Riyadh 4, Taif
Senegal: Gandoul
Sierra Leone: Wilberforce
South Africa: Pretoria 1 and 3
Soviet Union: Dubna, Moscow
Spain: Buitrago 1 and 3
  Grand Canary: Aguimes
Sudan: Umm Haraz
Surinam: Partes, Santo Boma
Sweden: Tanum*
Switzerland: Leuk 1 and 2
Togo: Cacavelli
Trinidad and Tobago: Matura Point
Turkey: Ankara
United Arab Emirates: Abu Dhabi
United Kingdom: Gibraltar, Goonhilly 2 and 3, Madley 2
  Ascension Island: Ascension
  Bermuda: Devonshire
United States: Andover, Etam 1 and 2
Upper Volta: Somgande
Uruguay: Manga
Venezuela: Camatagua 1 and 2
Yugoslavia: Jugoslavija
Zaire: N'sele

*Tanum earth station is a joint undertaking of Denmark, Finland, Norway and Sweden.

### Indian Ocean Region

Algeria: Lakhdaria 1
Australia: Ceduna 1 and 2
Bahrain: Ras Abu Jarjur 2
Bangladesh: Betbunia
Botswana: Kgale
Brunei: Telisai
Burma: Rangoon
Burundi: Bujumbura
China: Beijing 1
China: Taipei 2
Djibouti: Ambouli
France: Bercenay-en-Othe 2, Pleumeur-Bodou 4
Germany: Raisting 1
Greece: Thermopylae 1
India: Ahmed, Vikram
Indonesia: Djatiluhur 2
Iran: Asadabad 2
Iraq: Dujail 1
Italy: Fucino 2
Japan: Yamaguchi
Jordan: Baqa 1
Kenya: Longonot 1
Korea: Kum San 2
Kuwait: Umm Al-Aish 1
Lebanon: Arbaniyeh
Libya: Tripoli 3
Madagascar: Philibert Tsiranana
Malawi: Kanjedza
Malaysia: Melaka
Maldives: Maldives
Mali: Sullymanbougou 2
Mauritius: Cassis
Netherlands: Burum 2
Niger: Niamey
Nigeria: Lanlate 1
Oman: Al Hajar
Pakistan: Deh Mandro
Philippines: Pinugay 2
Qatar: Doha
Romania: Cheia 2
Saudi Arabia: Riyadh 1
Seychelles: Bon Espoir
Singapore: Sentosa 1
Somalia: Kaaraan
South Africa: Pretoria 2
Soviet Union: Lvov
Spain: Buitrago 2
Sri Lanka: Padukka
Syria: Sednaya
Tanzania: Mwenge
Thailand: Si Racha 2
United Arab Emirates: Dubai, Ras Al-Khaimah
United Kingdom: Madley 1, Hong Kong 2
Yeman Arab Republic: Sanaa
Zambia: Mwembeshi

### Pacific Ocean Region

Australia: Carnarvon 2, Moree
Canada: Lake Cowichan
China: Beijing 3, Shanghai
China: Taipei 1
Cook Islands: Avarua
Fiji Islands: Suva
France
  French Polynesia: Papenoo
  New Caledonia: L'Ile Nou
Indonesia: Djatiluhur 1
Japan: Ibaraki
Kiribati: Christmas Island
Korea: Kum San 1
Malaysia: Kuantan
Nauru Island: Nauru
New Zealand: Warkworth
Philippines: Pinugay 1
Singapore: Sentosa 2
Solomon Islands: Honiara
Thailand: Si Racha 1
Tonga: Nuku'Alofa
United Kingdom: Hong Kong 1
United States: Brewster, Jamesburg, Paumalu
  American Samoa: Pago Pago
  Guam: Pulantat
  Northern Mariana Islands: Susupe
Vanuatu: Porto Vita
Western Samoa: Afiamulu

# GROWTH

*by **Len Koch**, Public Information Specialist, Office of Corporate Affairs*

The story of the Intelsat global satellite system in 1980 was one of vigorous growth. At the end of 1980, Comsat was leasing 9,808 full-time half-circuits to its Intelsat customers, an increase of 2,188 from 1979 and the largest single-year increase in the history of the Corporation. The total number of half-circuits leased in the Intelsat system in 1980 was 40,615, a 25 percent increase from the 1979 total of 32,414. The number of communications pathways also increased significantly, from 757 on December 31, 1979, to 839 on December 31, 1980.

The sheer size of the Intelsat system is revealed on the map on the preceding pages. (Symbols on the map stand for earth stations in the system, and each symbol points to the satellites with which it operates.) A comparison of this map with previous maps of the Intelsat system produced by the Comsat Office of Corporate Affairs also reveals the significant growth of the system.

**New Earth Stations**

Fifteen new earth stations were added to the Intelsat system in 1980. In the Pacific Ocean region, Intelsat service was inaugurated through the Cook Islands, Kiribati, Malaysia, Northern Marianas (Saipan) and Western Samoa earth stations. New stations serving the Atlantic Ocean region are located in Cyprus, Iceland, Guinea, Guatemala, Sao Tome, the Cayman Islands, and Dubna in the U.S.S.R. New earth stations in the Indian Ocean region are located in Botswana, Burundi, and Djibouti.

As of December 31, 1980, a total of 134 countries or territories possessed operational earth stations. Of this total, 89 were members of Intelsat, 29 were non-members, and 16 were other territories. Nineteen countries or territories which previously did not have earth station facilities are planning to construct them. Eight of these are Intelsat members, seven are non-members, and four are other territories. Intelsat also gained a new member country, Guinea.

Comsat inaugurated Intelsat service at its new earth station in the Northern Marianas in November 1980. With the addition of the Saipan station, Comsat now has an ownership interest in eight earth stations that are part of the Intelsat system. The other seven stations are located in Maine, West Virginia, Washington, California, Hawaii, American Samoa, and Guam. Comsat manages all these stations with the exception of Guam.

**Operational and Planned Antennas**

At the end of 1979, the Intelsat system comprised 271 antennas at 222 earth stations in 124 countries. By the end of 1980, there were 325 operational antennas at 263 earth stations in 134 countries. Of these, 150 antennas were Standard A antennas (97 to 105 feet in diameter), 47 were Standard B antennas (33 to 39 feet in diameter) and 128 were non-standard antennas. Several of the new Standard C antennas (55 to 62 feet in diameter) are scheduled to be placed in service during 1981.

As of December 31, 1980, there were 86 Standard A, 23 Standard B and 61 non-standard antennas in the Atlantic Ocean region. In the Pacific region, there were 19 Standard A, 10 Standard B, and 13 non-standard antennas in operation. And in the Indian Ocean region, 45 Standard A, 14 Standard B, and 54 non-standard antennas were operational.

Planned antenna activations for the Atlantic Ocean region include 43 Standard A, 11 Standard B, and seven of the new Standard C antennas. For the Indian Ocean region, 17 Standard A, seven Standard B, and six non-standard antennas are planned. Three Standard A, six Standard B, and 40 non-standard antennas are planned for the Pacific region.

Rapid growth in the Intelsat system is expected to continue in 1981 with the addition of Intelsat V satellites and new earth stations and antennas.

# Launch Completes Comstar System

*Launch of the fourth Comstar satellite on board an Atlas Centaur spacecraft the evening of February 21 as seen from the viewing area in Cape Canaveral, Florida. Photo by James T. McKenna.*

*by Debra Benham, Marketing Services Specialist,*
*Comsat General Corporation*

The last Comstar communications satellite to be launched by NASA for Comsat General made its way through the evening sky Saturday, February 21 at 6:23 p.m. EST. Traveling aboard an Atlas Centaur launch vehicle, the Comstar D-4 joins three other Comstar satellites and completes the first satellite system to provide domestic telephone communications in the United States.

Forty-eight hours after the launch, the apogee kick motor was successfully fired on command from the Comsat Launch Control Center at Comsat Headquarters in Washington, D.C., sending the D-4 into a gradual drift toward its geosynchronous position. Following in-orbit performance testing, Comstar D-4's home, 22,240 miles above the equator, will be 127 degrees West Longitude. Its mission will be to provide communications capacity in place of Comstar D-1. D-1 and D-2, originally located respectively at 128 degrees West Longitude and 95 degrees West Longitude, will operate as one satellite once the D-4 becomes operational. This will extend their original seven-year life expectancy by reducing their power load and conserving their batteries. D-1 and D-2 were launched respectively in May and July of 1976 while D-3 was launched in June 1978.

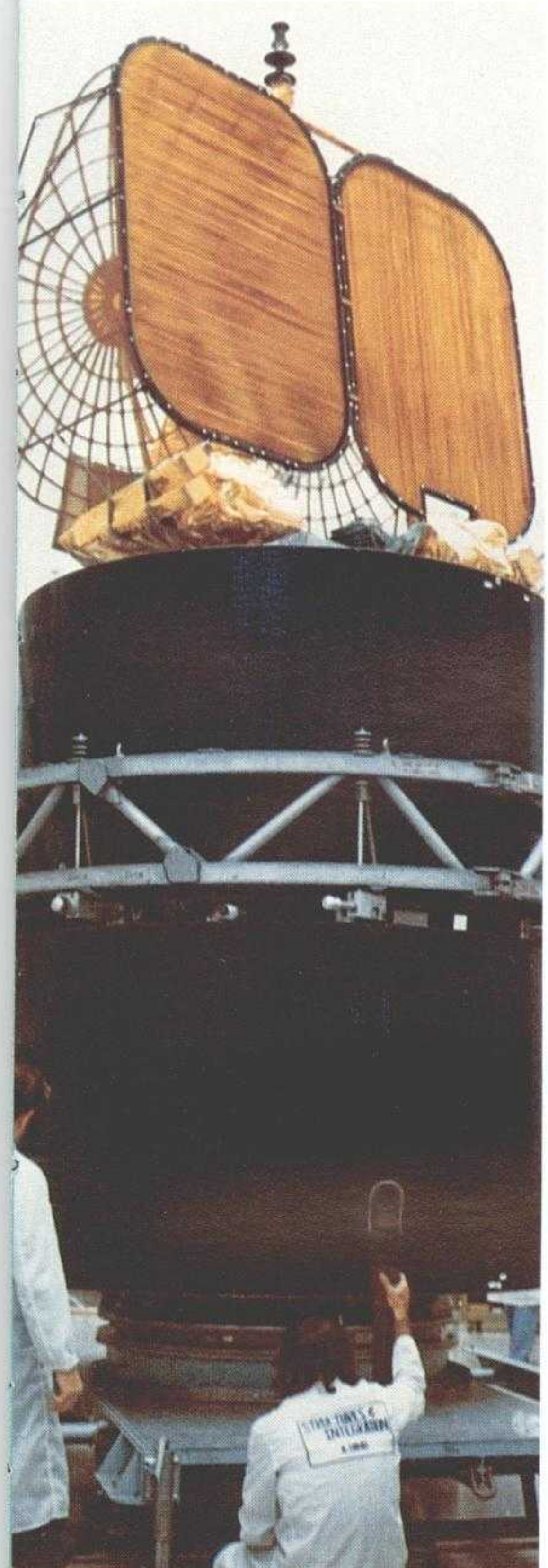
Built by the Hughes Aircraft Company for Comsat General, each Comstar satellite stands 20 feet high and 8 feet in diameter, with a launch weight of 3,348 pounds. An array of approximately 14,000 solar cells mounted on the body of the satellite provides approximately 610 watts of direct current in-orbit power. During the launch and solar eclipse seasons that occur twice a year, power is drawn from nickel-cadmium batteries.

Comsat General leases the entire capacity of the Comstar System to American Telephone and Telegraph (AT&T). AT&T uses some of this capacity and subleases the rest to GTE Satellite Corporation (GSAT), a subsidiary of General Telephone and Electronics Corporation. Comsat General serves as Systems Manager for the Comstar system, and is responsible for the in-orbit "health" of the four satellites and the successful functioning of the space segment of the system. This includes the design and construction of the Comstar satellites, procurement of the launch vehicles, and operation of tracking, telemetry and command (TT&C) earth stations.

**Earth Station Facilities**

TT&C earth stations are located in Southbury, Connecticut, and Santa Paula, California, and are used by Comsat General to monitor and control the satellites. Command, station keeping, satellite switching and telemetry data are collected by these earth stations and forwarded to Comsat General's System Control Center (SCC). The SCC is responsible for the in-orbit control of the satellites and is located at Comsat General Headquarters in Washington, D.C. Once tracking data has been received by the SCC, it is processed and displayed for further analyses. Station keeping and antenna pointing commands to the satellites are then routed from the SCC through the TT&C earth stations. To date, the health of the satellites has been excellent, providing over 2.4 million hours of uninterrupted transponder service for long-distance communications.

Each satellite possesses the capacity to relay 18,000 simultaneous telephone calls including use for Wide Area Telephone Service (WATS) and U.S. government private line communications. The Comstar system is the first domestic satellite system to provide long-distance telephone circuits for public use. A total of 24 transponders per satellite are capable of receiving and sending either analog or digital signals, which allows each satellite to accommodate combinations of TV and frequency-division multiplexed and time-division multiplexed signals. A flexible switching design, which can be operated by ground control, allows the 24 transponders to be allocated among the satellite coverage areas (48 contiguous United States, Alaska, Hawaii and Puerto Rico) according to existing



Comstar satellite at Hughes Aircraft Company plant. Each Comstar has capacity for 18,000 circuits and includes 24 transponders.

communications requirements. The ability to accommodate signal and switching combinations provides the Comstar System with the greatest operating flexibility of any domestic satellite system.

One of the unique capabilities of the system is the use of cross-polarization isolation. Essentially, cross-polarization doubles the communications capacity of a satellite. The process permits horizontally and vertically polarized beams to travel together at the same frequency and be separately received by the antenna system of the satellite. The Comstar satellites are equipped with specially designed filter screens that isolate the cross-polarized signals and allow the system to accommodate twice as much information transfer through efficient bandwidth re-use.

As a pioneer for future satellite communications systems, each Comstar carries experimental beacons at frequencies of 19 and 28 gigahertz. Designed by **Comsat Laboratories**, these beacons permit the collection of data at these very high frequencies that may be used in the design of future satellite systems requiring wide bandwidths. The beacons provide measurement data on the effects that atmospheric conditions, such as rain, have on the 19 and 28 gigahertz frequencies.

For the past five years, Comstar has served this nation's communications needs well by providing reliable, high-quality telephone communications via satellite. There is every indication that the demand for telephone communications will continue to grow throughout the coming years. Undoubtedly, the Comstar System will serve as a mainstay of future satellite communications systems designed to meet these growing needs.

# SAT

*Experimental system intermixes voice, computer*

*by Stephen A. Saft, Editor, Comsat Magazine*

An experimental satellite-based communications network that is a form of Time-Division Multiple-Access (TDMA), called SATNET, could show the way to more efficient use of communications satellite capacity in the future for many applications.

Normally, several satellite channels would be needed to service the needs of a communications network. SATNET, an experimental network supported by funds from the Defense Advanced Research Projects Agency (DARPA), an agency of the Department of Defense, uses just one satellite channel. On that channel, SATNET, an acronym for Satellite-based Atlantic Packet Network, intermixes live voice, computer data and facsimile transmissions from several network terminals.

Transmissions are in digital format in SATNET, and they are sent in the form of bundles or packets, each one of which is only part of a message but which are put together into complete messages far faster than the human mind can detect at the receiving end.

In addition to intermixing message types among several earth terminals on just one channel, SATNET has demonstrated these other accomplishments:

- Earth terminals working at different data rates—specifically, at 64 kilobits per second and 16 kilobits per second—can be linked together in the same network.
- Control of a packet-switched network need not be centralized, but can be distributed among the terminals in the network.

Participating organizations in the SATNET project are: the University College in London, England; the Royal Signals and Radar Establishment in Malvern, England; the Norwegian Defense Research Establishment in Kjeller, Norway; Bolt, Beranek and Newman in Cambridge, Massachusetts; the University of Southern California at Los Angeles, California; Linkabit Corporation in San Diego, California; and **Comsat**—at its headquarters building at L'Enfant Plaza in Washington, D. C., and at its **Laboratories** in Clarksburg, Maryland.

In addition, through landline links, terminals in the ARPANET and PR (Packet Radio) NETs are also tied into SATNET.

To operate, SATNET uses an SCPC (single-channel-per-carrier) channel of the Intelsat IV-A Atlantic Primary Satellite. The antennas providing the satellite links for the network are the Standard A types at the Etam, West Virginia, Goonhilly, United Kingdom, and Tanum, Sweden, earth stations and the Torus antenna at **Comsat Labs** in Clarksburg, equivalent to a Standard B type antenna. The network terminal at **Comsat**'s downtown Washington headquarters is linked by landlines to the network terminal in suburban Clarksburg, which in turn is linked to the Torus antenna. The network terminal at **Comsat** headquarters and **Laboratories** operate at 16 kilobits per second. The terminals linked to the Standard A antennas operate at 64 kilobits per second.

In charge of the earth terminal at **Comsat** headquarters is Dr. David L. Mills, Senior Research Scientist with the Transmission System Laboratory at **Comsat Labs**, but on permanent assignment at Comsat headquarters. He is assisted by Dr. Hoi Y. Chong and Mike O'Connor. At the Labs, the project is headed by Joachim (Kim) Kaiser and includes Stanley Rothschild and James Thomas.

Basic to SATNET is equipment that performs three key functions:

- conversion of all messages into digital format,
- the breaking down of all digitized messages into bundles or packets,
- the scheduling or slotting of packets so that they do not get lost but can be put back together at the receiving end.

*data and facsimile transmissions on a single channel.*

The transmission of computer data in digital format involves no conversion procedure. Computer data is already in digital form, a series of ones and zeros. In the case of live speech and facsimile transmissions, the message must be converted into digital form and then reconverted back into its "real life" mode at the receiving end.

One of the key components in the system is the Satellite Interface Message Processor (Satellite IMP), which handles both the packeting of messages and the sequence in which the packets are distributed. Supplied by Bolt, Beranek and Newman of Cambridge, Massachusetts, each Satellite IMP is a Honeywell 316 computer with special, dedicated software. There are a total of four in the network.

The job of getting electronic packets on and off the radio frequency (RF) equipment at the earth stations is handled by the four Packet Satellite Project (PSP) Terminals in the system. These were designed and assembled at Comsat Labs.

Another important component in the system is the Linear Predictive Vocoder, which provides live speech from the digital packetized message stream. Lincoln Laboratories developed the Vocoder used in the network. In addition, Linkabit Corporation supplied the modems and other equipment.

To keep the system synchronized, each Satellite IMP in SATNET is programmed to issue a signal burst 30 to 40 milliseconds in length to every other terminal in its own separate time slot every 1.3 seconds. In fact, each Satellite IMP issues a total of 66,000 such bursts during every 24-hour period. As Larry Palmer, who formerly headed the SATNET effort at the Labs, describes it, through the signal burst method, each terminal is saying, "Hello, I'm here and am ready to send and receive when needed."

A history of the bursts sent and received in the entire network is recorded and carefully scrutinized by another of the principal architects of SATNET, Bolt, Beranek and Newman, to determine how well the network is functioning. The system can experience transmission anomalies causing packets to be missed and thus lost, Larry Palmer explains.

The packeting of messages occurs in the Satellite IMP. The sender of the message has first of all coded into his message an indication of priority. For example, speech, because it must be "live" or "real time," receives first priority and will be held in "storage" by the Satellite IMP the shortest amount of time possible. Both computer data and facsimile data messages can be held longer. Using an algorithm programmed into it, the Satellite IMP will then break the message into packets no longer than 2,000 bits in length or, in the case of speech, 200 milliseconds long. The Satellite IMP then directs the transmission of the packets at pre-assigned time slots.

Digitized and packetized messages, intermixing of message types on the same channel: is this the wave of the future in satellite communications? The answer is an emphatic yes, at least for some applications. Says Dale McNeill, SATNET project leader at Bolt, Beranek and Newman, "By showing the way to sharing single satellite channels for multiple message formats, SATNET points the way to the kind of highly efficient use of satellite capacity that will be necessary in the future."

Dr. David Mills, in charge of the SATNET installation at Comsat headquarters, states, "We've proven that hybrid transmission systems involving speech and various kinds of data are practical. We can make it work. Now, under DARPA sponsorship, we will be moving toward a wideband system using a domestic satellite, and we will be moving toward the integration of facsimile and speech into existing electronic message systems."

# *Comsat Service Bureau,* Television Link to the World.

*An inauguration, the hostage release, a Super Bowl—bureau performs extremely well during busy time.*

*by George A. Lawler, Vice President, Marketing, International Communications Services*

January 20, 1981 will probably be remembered in the telecommunications industry as the day when professional communicators were really put to the test—particularly, and not surprisingly, the people in the Comsat Service Bureau, where those involved with international satellite television had their facilities and talents stretched to the limit.

The Comsat Service Bureau in Washington, D.C. is the central controlling point for the scheduling of all international satellite television transmissions which originate in, terminate in, or transit the United States. As the U.S. representative to Intelsat, a 105 nation organization which owns the satellites, Comsat coordinates overseas requests for service with Intelsat, U.S. customers, and U.S. carriers, and with overseas telecommunications entities. Additionally, arrangements must be made by the customer to get the signals from U.S. broadcasters, through domestic landlines, to the Comsat earth stations at Etam, Andover or Jamesburg, up to satellites hovering 22,300 miles over the Equator, and down to distant earth stations. The distant administration then must arrange for overseas landline connections to the receiving broadcasters for distribution to millions of viewers.

Of course, when telecasts are scheduled to be received by American broadcasters from overseas, the process is just the reverse. This is no small task. The bureau and its adjacent communications center are staffed around the clock by capable, professional communicators. Verbal and written orders pour into the center constantly. At any given moment, Comsat may be involved with providing as many as eight simultaneous telecasts via Atlantic and Pacific Intelsat satellites.

For weeks prior to January 20, the Service Bureau had been formulating plans to provide viewers around the world with live TV pictures of the inauguration of the 40th President of the United States. Meetings with the foreign broadcasters and U.S. carriers began the day after the National Elections, November 4, 1980. Telex and phone orders were coming in daily and at a steadily increasing rate. In addition to those for the inauguration, orders were being received for live coverage of the Super-Bowl football game scheduled five days later on January 25 as well as for daily programs.

The United States network pool (ABC, CBS, NBC, and others) had appointed CBS as host broadcaster for foreign television entities for the inauguration. Close coordination with the CBS pool producer was established and maintained. It was CBS's job to provide studio and local facilities for overseas transmissions. Correspondents, technicians and coordinators for the European Broadcasting Union and its individual members, and representatives of numerous Asian, South and Central American, African, Middle-Eastern, Pacific Ocean Area and Caribbean nations converged on Washington to get the story across the oceans of the world to their viewers.

At the Service Bureau, staff members had rolled up their sleeves to handle the heavy volume of paperwork required to process the sea of orders involving three U.S. earth stations, four

international satellites and eight TV channels. The trick to this chore is to attempt to provide each country all the television service it desires. Occasionally, this involves making connections in Europe or in the Pacific area for "double-hop" programs.

A "double-hop" transmission requirement occurs in three types of situations. To reach countries whose earth stations can only "see" the Indian Ocean satellite, which is not visible from the United States, is one type of situation. In this case, it is necessary to transmit the signal from the United States via an Atlantic or Pacific Ocean satellite to an earth station in Europe or in the Pacific area which can relay the signal to the Indian Ocean satellite.

When a direct, single-hop transmission cannot be scheduled over the normal routing to an Atlantic or Pacific area country due to prior commitment of requested time to another country operating on the same path, a double-hop also would be required. For instance, Japan might place an order for a program at a specific time. The normal routing for U.S./Japan TV traffic would be from the Comsat earth station at Jamesburg, California to the Pacific Ocean satellite, Intelsat IV F-8. There are two TV channels in IV F-9, but if they have already been booked by other entities, then it is possible to send the signal through the "backdoor route" via an Atlantic satellite to Europe for relay to the Indian Ocean satellite and on to Japan.

A third use of "double-hop" occurs when the television "picture" standards of the receive country are different than the line standards of the transmit country, and when neither country has an available standards convertor. Conversion from one country's standard to the other's is required to put a usable signal on the air. In this situation, it is necessary to transmit the signal to a country which has an available standards convertor for relay. The Comsat Service Bureau determines the standard being transmitted, the standard required on the receive end, and, if conversion is required, where best to get it accomplished. Then they may intelligently map out a routing which will satisfy the order.

The Service Bureau, and indeed, all of its counterparts in other countries, as well as in Intelsat, accepts orders on a "first-come, first-served" basis. No nation or broadcaster has priority over another for satellite time. No service may be pre-empted in order to accommodate another regardless of the relative "importance" of any event. However, arrangements may be made and often are, between entities for one broadcaster to relinquish time to another, but only with the explicit and confirmed permission of the customer who has originally booked the time in question. Indeed, changes and cancellations of orders are a recognized requirement in providing good service to the user. During the period January 15 through 21, while processing 264 orders which actually totalled 225 hours and 42 minutes of satellite time, the Service Bureau handled 186 orders which were either cancelled or modified.

As we approached inauguration, and as the volume of orders steadily increased, rumors were rampant as to the imminent release of the U.S. hostages from Iran. Then, just when it seemed as though every TV channel had been utilized to its capacity for inaugural transmissions, the 52 U.S. hostages were released at the very moment when President Reagan was taking the oath of office.

Fortunately, the U.S. TV networks had prepared for this event with the establishment of network "pool" teams in Algeria (ABC) and in Frankfurt, Germany (NBC). The pool producers at these locations had already established a rapport with the national broad-

*Continued next page*

casters and communications administrations in those countries and had, in fact, already transmitted a number of stories in preparation for the big news. The transmissions from Algeria would require transmission via Italy due to the standards conversion requirement mentioned earlier, or due to the fact that Algeria only operates with one of the Atlantic satellites, and the time, having been already booked on that path, had to be ordered over another path available via an Italian earth station.

The Comsat Service Bureau, which normally books 10 to 15 transmissions a day, handled 43 totaling 78½ hours in the period from 4 a.m. January 20 through 4 a.m. January 21. Then, once Inauguration Day events had passed, the TV industry increased its demands for service in connection with the hostage release, their flight to Algeria, Frankfurt, and Ireland, the arrival at West Point, and the dramatic reunions with families and friends.

Reactions of the hostages' families, government officials, hometown friends and co-workers, the man-on-the-street, medical, psychological and financial experts were filling the satellite paths. From January 21 through January 25 (Super-Bowl Sunday), Comsat coordinated 130 telecasts, an average of 26 daily, about double our normal production. While most of these were hostage-related, the regular news and sports coverage continued unabated, including live Super-Bowl transmissions to Venezuela, Germany, Italy, Spain, the United Kingdom, Bermuda, Japan, Korea, the Philippines, Guam, and American Samoa.

In the days following, more heavy coverage of the hostages' return to Washington, D.C., the ticker-tape parade up Broadway in New York City, and the hometown receptions was supplemented by coverage of the Islamic Summit Conference and the visit of the president of South Korea to Washington. Additional news concerned the development in the Administration in Washington including the ongoing Senate hearings in connection with Cabinet appointees. By the end of the month, things were beginning to return almost to normal.

During a normal month in 1980, the Service Bureau handled slightly less than 300 hours of television. (Of course, February was extraordinarily heavy with the Lake Placid Winter Olympics, and November was quite busy in connection with the National Elections.) In January, 1981, our volume ballooned to over 500 hours of transmission.

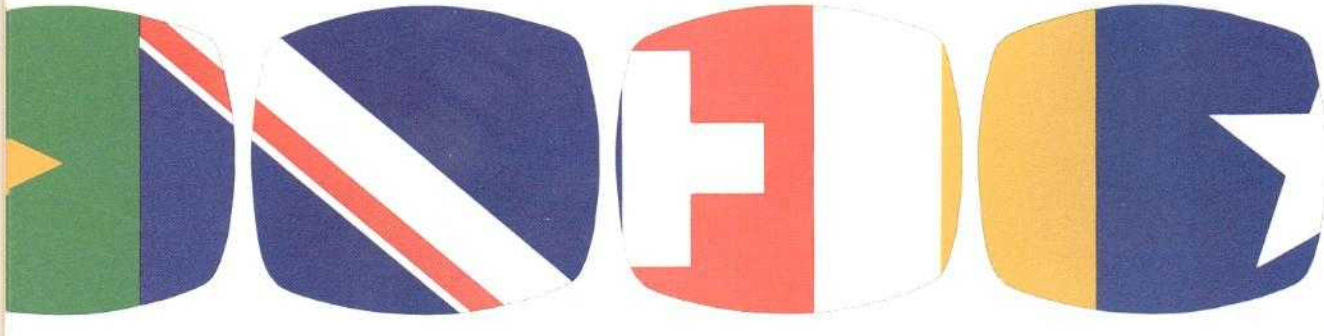
The dedication and expertise of the people who staff the Comsat Service Bureau have been lauded by our customers both here and abroad. I think it was best expressed in a letter to us from Mr. Doug Nelson, Broadcast Control Manager for the News Division of NBC-TV, New York, an excerpt of which follows. He recently wrote to us on behalf of the U.S. Network pool:

"This note is long overdue. In December, I mentioned to you that the Service Bureau deserved special commendation for their performance in handling our many requests. Today, after the hostage crisis has finally been resolved, I would like to reemphasize that statement and make an additional comment.

"NBC had the responsibility for the U.S. Television Pool in Frankfurt for the release of the hostages. In that capacity we had to provide facilities and transmission times for each of the three television networks. As you well know, the television networks are not always predictable in their demands for service. The pool frequently received requests at the last minute, requiring considerable extra effort by the Service Bureau.

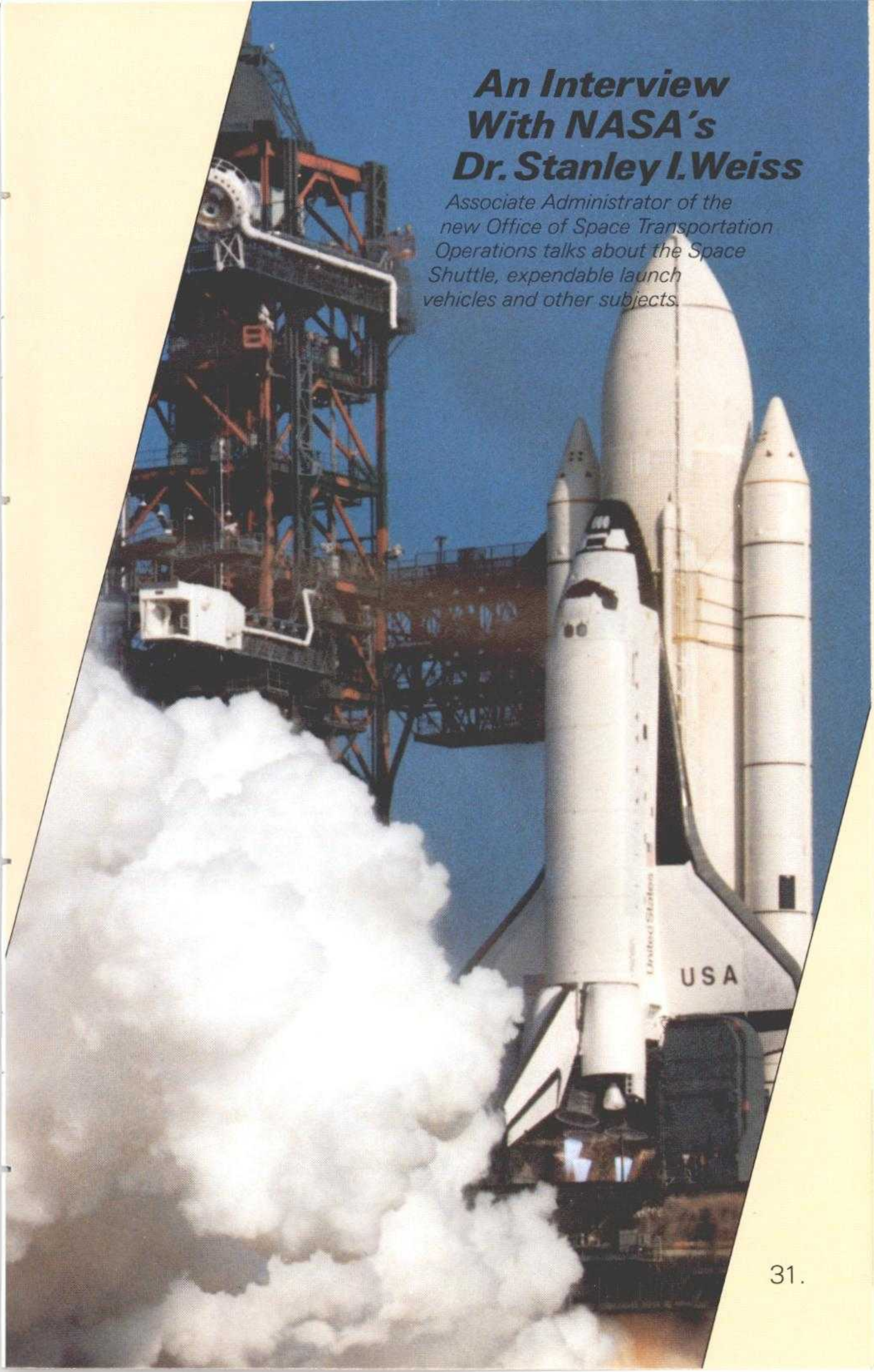
"Their cooperation and performance were superb!

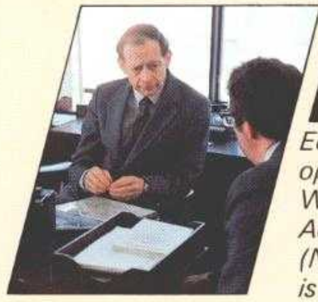
"It is a real pleasure to deal with such professionals."



# An Interview With NASA's Dr. Stanley I. Weiss

*Associate Administrator of the new Office of Space Transportation Operations talks about the Space Shuttle, expendable launch vehicles and other subjects.*





*In late February, Stephen A. Saft, Editor of **Comsat Magazine**, had an opportunity to interview Dr. Stanley I. Weiss, an official of the National Aeronautics and Space Administration (NASA) in Washington, D.C. Dr. Weiss is Associate Administrator of the new Office of Space Transportation Operations and thus is responsible for scheduling, manifesting, pricing and launch service agreements for the Space Shuttle and NASA's expendable launch vehicles and, in addition, for NASA's development and procurement activities related to the European Spacelab.*

*In the article that follows, an edited version of a tape-recorded conversation with Saft, Dr. Weiss discusses the shuttle and many other topics of interest to readers of **Comsat Magazine**.*

*Q: A potential commercial user of the shuttle would come to your department. Is that correct?*
Weiss: That's right. We're the sales office, the marketing function and the business management activity for the operation.

*Q. You are involved with the expendable launch vehicles as well as the shuttle. How do you see your mix of activities changing through the 1980s?*
Weiss: We have, as a result of really vastly increased requirements in the communications satellite field, seen a much greater need for our expendable launch vehicles than had been anticipated, most importantly, because the shuttle has slipped a couple of years. In the two-year period between 1980 and 1982, when we had originally hoped to have the shuttle operational, the requirements for launching commercial and foreign communications satellites haven't stopped, and we've had to fill the gap with expendable launch vehicles. We will continue providing launch capability with expendable vehicles at least through 1985. And, as a matter of fact, the peak year is probably 1983, when while we will have two shuttles that have the potential of providing support, we will really just be bringing the second one on-line. In 1983, we will be launching on the order of a dozen Deltas and Atlas Centaurs, largely for communications satellites.

*Q: What is the cost to launch a commercial satellite and how does this vary from expendable vehicle to shuttle?*
**Weiss:** Right now the user of the Delta class launch vehicle is paying just under $25 million. Had this launch been available on the shuttle at this time, the customer would be paying somewhere in the order of about a third of that, but when you add in all the services and the like, it would probably reach approximately half with the particular fare structure that was set up at the onset of shuttle development. We'll be going to an averaged full cost recovery for the shuttle operations in 1986. And at that time we look for a modestly increased price to the user because we will be required to defray the full operating cost, which today's price doesn't do.

*Q: We're talking about defraying only the operating cost of the shuttle, not the development cost. Is that correct?*
**Weiss:** The intent is to consider the development cost as an investment in a national asset. There's a strong similarity with uranium enrichment plants, which today furnish enriched uranium for utility power plants using a facility that was developed many, many, years ago for the AEC as a national investment.

*Q: How have you determined the shuttle cargo price?*
**Weiss:** We set the basis for determining the price as an average price per launch based on the costs anticipated over a 12-year period. In other words you take the average over that period. Within that average-per-full-shuttle launch, we allocate the cost on the basis of the volume and weight that each particular payload uses of the payload bay based on about a 70 percent load factor. That means that what we try to manifest with each commercial satellite is about a third of the bay or a third of the capacity. In other words, each user would pay a third of the operating launch cost.

*Q: Your booking situation for the shuttle is what?*
**Weiss:** Through 1985, we have booked to full capacity with about 30 percent of that being commercial and foreign, a little over 30 percent being NASA and Spacelab, and the other—just under a third—being Department of Defense launches. We also have a fairly good-sized group of expendable launch vehicles, something in the order of 40 expendables over that period of time. And while we say "a full booking," we do have the capability of exchanging payloads. We have some empty missions set aside for re-flight opportunities. Hence, there is a little bit of flexibility built into the system right now.

*Q: Even up to 1985?*
**Weiss:** Even up through 1985. Real flexibility.

*Q: Then I am right in assuming from what you just said that the shuttle will carry three commercial satellites at a time and launch them?*
**Weiss:** That's the way we have currently designed the manifest. In addition we feel we may be able to handle more once we get experience. For example, in terms of weight and volume constraints, four Delta-size payloads could be carried in the shuttle payload bay.

*Q: How important is the communications satellite industry to NASA and to the success of the shuttle?*
**Weiss:** We have some 19 communications satellite payloads from U.S. commercial users scheduled for the shuttle as well as 24 scheduled on expendables. In addition, foreign users account for an even dozen that are firmly scheduled and some 17 more planned. So you can see we count on these payloads as a very large portion of the manifest. And since they pay for full-cost-recovery of the operation, they are a very important element of the program.

*Continued next page*

*Q: How will the fact of the shuttle's existence and its successful use change the communications satellite industry, as you see it, in terms of the way we design satellites, the way we manufacture them, and the way we operate them?*

**Weiss**: I can see changes that are a result of a number of considerations which can be influenced by the shuttle. For instance, given the number of satellites we're being asked to launch, we clearly are moving in the direction where there is the danger of interference patterns. The capability of launching a lot of satellites at reasonable cost encourages expansion of the communications satellite industry but at the same time encourages crowding of the geosynchronous orbit. In the need to narrow the antenna patterns and the like and reduce interference, the industry could move toward higher frequency transmission. In addition because of the lift capacity of the shuttle, the industry could move in the direction of many more channels on a larger carrier using a variety of communications techniques.

A shuttle-oriented communications satellite industry might see the usefulness of very large space platforms that would serve as central communication transmitters and relay systems. Also, because of the lower cost of launches, a lot of organizations will begin to think in terms of how communications satellites can serve their needs. When we get that sort of proliferation, that expands the imagination also in terms of utilization. We are starting to see that now, but I think we haven't yet plumbed the extent to which our imaginations are going to take us.

*Q: As you know, we at* **Comsat** *now have our Launch Control Center. When let us say an Intelsat satellite is brought up into low orbit by the shuttle and is released from the cargo hold, when would our operation take over and yours cease?*

**Weiss**: Well, of course, part of the answer depends on what sort of services you buy from NASA. Once an Intelsat satellite is released, it could be controlled from a mission control center run by you folks.

*Q: Do you foresee the time or might we assume there could come a time when a* ***Comsat*** *employee or an* ***Intelsat*** *employee or an* ***SBS*** *employee, etc., might be on board the shuttle and be serving the role of mission specialist?*

**Weiss**: More accurately, I could see someone like that serving the role of payload specialist. You have this person on board because of his or her special understanding of the specific payload. The mission specialist, on the other hand, must be a NASA employee or a military engineer or astronaut. The mission specialist receives a lot of training comparable to that of a full fledged astronaut. The payload specialist is specifically associated with that payload and receives a minimal of astronaut-related training. If we're carrying three or possibly even four communications satellites belonging to three or four different organizations, we would find it difficult to carry a payload specialist for each.

*Q: I would be interested in anything you would care to say about the need for more shuttles than have been presently authorized—a fifth shuttle, possibly a sixth or even more.*

**Weiss**: I am a firm believer that once we get this system flying that we're going to find many more uses for the shuttle than we currently can think of. Given the mission model that we have right now, I anticipate that we would want a fifth vehicle at a minimum as a backup. You know there are going to be performance improvements that we'll want to consider. We don't have scheduled in any substantial overhaul time. I am sure that overhaul will become a necessity at some point. We really have in many ways been very optimistic about the utilization of the four vehicles that we are now scheduled to fly. So, at a minimum for flexibility sake, I see the necessity for a fifth vehicle. Then if we really develop the business, if we exploit the expectations of space utilization fully, I see a sixth vehicle possibly even a seventh as justified. Of course there is going to be a point after we've flown the shuttle enough, that we may come to see the need for a next generation shuttle. Any decision about a second-generation vehicle will govern how many of the current family we need.

*Q: You are planning upon an improved version at this time?*
**Weiss**: No, we don't have any funds going toward it now, but we have given the subject some thought.

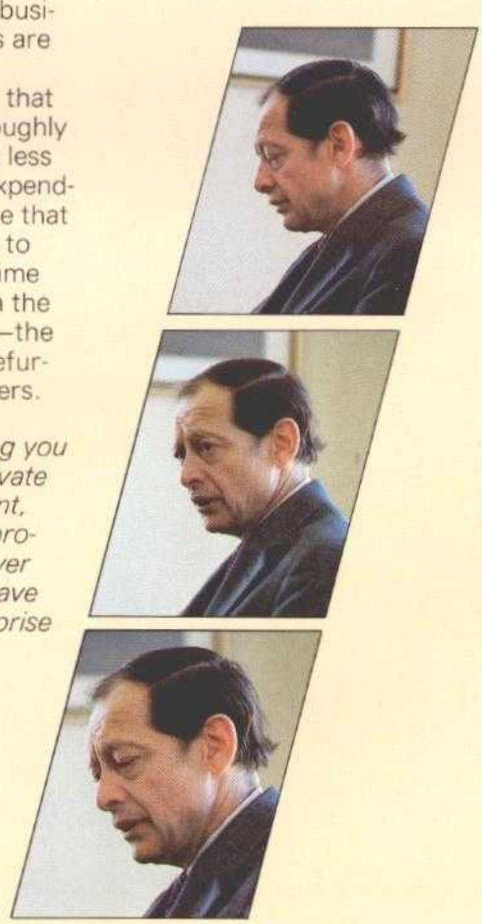
*Q: What about this question of turn-around time? Just a moment ago, you talked about overhaul but it seems to me that utilization of each vehicle will also be a product of turn-around, of how long it takes for inspection and minor repairs, clean-up and refueling. How does the turn-around picture look at the present time?*
**Weiss**: For the most part, our information is speculative, but we are starting to get some experience from this first orbiter. We expect to get down in the 200-hour range. Our manifest is based on approximately 280-hour turn-around right now, and we would expect that while our first few flights are up in the 300-500 hour time frame, that this will come down pretty rapidly. Now we'd like to see it down below 200 hours, and that's going to be one of our goals.

If you ask what are our objectives in this office aside from running a business and making sure that vehicles are there to carry user loads and that logistics work out, I would answer that it is to assure that costs stay thoroughly competitive, meaning substantially less than the costs for the use of the expendable launch vehicle. One way to see that shuttle costs are low as possible is to reduce turn-around time. At the same time, we must control the costs on the expendable portion of the system—the external tank—and the costs for refurbishment of the solid rocket boosters.

*Q: I would be interested in anything you might say on the subject of the private or the eventual private management, in whole or in part, of the shuttle program. Do you think the time will ever come when it will make sense to have this type of activity as a free enterprise private sector activity?*
**Weiss**: I have that sort of thinking in the options I look toward downstream, and we're developing long-range plans which apply that as an option. I don't know whether it will come to pass, simply because the utilization right now still looks to be about 60 percent government payloads and 30 percent to 40 percent commercial or foreign. So whether we go to something like a **Comsat** Corporation for operating this or not is still pretty difficult to define.

*Q: Some use of your research activities on board Spacelab will be devoted to space manufacturing. Are you at all optimistic that this could lead to commercial space manufacturing?*
**Weiss**: Yes, I am very encouraged that some specialized manufacturing can be developed—for materials, for pharmaceuticals, and for very large in-space structures. Large in-space structures could be developed for use as commercial satellite platforms or commercial manufacturing platforms. We have had several proposals that would seek to do these things as a private sector activity. I would have to say that I am very optimistic about this.

*Continued next page*



*Q: In what other ways do you think the shuttle could significantly change our way of life? We talked about communications satellites, and now we have talked about space manufacturing. Are there other ways?*
**Weiss**: Many proposals, some seemingly fanciful, have been looked at, like disposal of nuclear waste, like special illumination techniques. In addition, there is the space solar satellite concept.

*Q: You mean by "illumination techniques" that dark areas on earth would be lit by satellite?*
**Weiss**: Yes, satellites could be used to illuminate areas up north in prolonged darkness during the winter. That type of thing has been looked at from a long-range viewpoint. I personally think that we will be able to develop structures sizeable enough in space that we can start to move beyond our local earth orbit with some pretty reasonable vehicles that could be the basis for taking people well out into the solar system and doing very daring exploration with them.

*Q: You raised the point about solar powered satellites, and I did want to ask you a couple of questions about them. How hopeful are you that we can move in this direction? Are there solar power experiments that are planned in conjunction with the shuttle?*
**Weiss**: We really have not had any encouragement in this area. We're maintaining some technological development, that, you know, would leave us in a jump-off position, but we're hardly exploiting that sort of potential in any of the programs we have going in NASA. Several technological problems must be resolved before developmental work can begin on the solar power satellite concept. How do we transmit the energy? How do we recover enough power out of a solar collector system that is transmittable? What receiving techniques do we use? And after we've worked all this out, do we obtain a system that has an economic payoff? I guess I'm not numbered amongst those who see anything like this happening in this century.

*Q: I'm wondering where we put the communications satellites of the future when we devote a large part of the geosynchronous orbit to huge solar power satellites.*
**Weiss**: I mentioned very large platforms. They could be one of the answers, and they might prove to be a thoroughly commercial venture. A corporation would own the platforms and would rent space for antennas and transponders. This sounds to me like a pretty interesting commercial venture.

*Q: Through your office, NASA finds itself in the selling business.*
**Weiss**: Absolutely.

*Q: I wonder, is this a role that you've been able to move to comfortably or have there been some difficulties? How do you think NASA is doing as salesman for the shuttle program?*
**Weiss**: It has been easy because, in the demand and supply equation, demand is greater than supply at the moment, and that's why we're still using expendable vehicles. I think that sometime downstream we'll find that satellites themselves will have such a long life on-orbit that replacement will not be a basis for running a lot of launches. Should that happen, we in NASA will be looking for generating business that will put us more into a selling mode. We do have competitors. I mean Ariane. Presumably the Soviets, if they wanted, could generate a competitive posture. This means that we had better make sure we treat the users of today like customers of tomorrow if we want to have a future.

*Continued from page 4*

experience. It was very interesting to see where other countries are in terms of environmental protection and to hear their attitudes toward solutions which are a function of their society and values."

"The seminar has shown that environment has no boundaries. It has brought together almost all the disciplines concerned with the environment, from earth sciences to satellite communications, and countries of all political affiliations."

## Comsat General Integrated Systems organization made known

The organizational structure of Comsat General Integrated Systems, Inc. (CGIS), has been announced by Michael S. Alpert, Vice President, Communications & Information Products, Comsat General Corporation. Formerly known as the Integrated Design and Manufacturing Systems Division (IDMS), CGIS offers computer-aided design (CAD), computer-aided manufacturing (CAM) and computer-aided test (CAT) services. It is located in Palo Alto, California.

Wayne Brown, formerly Director of the IDMS Division, has been elected President of CGIS. Also elected to new positions are Jarin Feldstein, Vice President of Operations, and Barry Goss, Vice President of Product Development. Both previously held senior positions with IDMS. In addition, David Rager has been elected Vice President of Marketing and Dr. Alex Beavers, Vice President of Finance and Administration. Mr. Rager was formerly Vice President of Marketing for Scientific Calculations, Inc., a firm engaged in the CAD/CAM business. Dr. Beavers was formerly a Principal in the Management and Information Systems Division of Booz, Allen & Hamilton. Finally, Mark Frey, formerly a Senior Adviser in Comsat General's Planning & New Ventures Division, has been appointed Director, Business Development for this new corporation.

According to Vice President Alpert, "CGIS is developing CAD, CAM, and CAT systems for microwave and digital product lines. These systems eliminate repetitive drafting and can solve tricky layout problems, maintain data records, and permit immediate computerized evaluation of a design. CAD/CAM/CAT is expected to help a variety of high technology industries reduce costs and increase productivity in the design and manufacturing process."

In order to enhance Comsat's capability to develop and market CAD/CAM/CAT systems, Comsat General has recently acquired two computer software firms, Compact Engineering of Palo Alto, California and Comprehensive Computing Systems and Services (CCSS) of Austin, Texas. Compact Engineering was organized in 1976 by Les Besser. Mr. Besser has been elected Senior Vice President of CGIS and is in charge of the Microwave Division. Compact's family of software is currently used by more than 300 organizations worldwide. Mr. Alpert noted that Compact's most sophisticated product, SUPER-COMPACT™, has just been released. Providing circuit analysis, optimization, and network synthesis, it is expected to become the industry standard for both discrete and integrated microwave circuit design, Mr. Alpert stated.

CCSS, organized in 1972 by Dr. Stephen A. Szygenda, has developed a digital logic simulation and test generation system called CC-TEGAS. Dr. Szygenda has been elected Senior Vice President of CGIS and is in charge of the Digital Division. As part of his new efforts, Dr. Szygenda will expand the capabilities of CCSS' current software to include more of the digital CAD/CAM functions. This development will eventually lead to a total integrated digital CAD/CAM system. CCSS software, marketed under the name CC-TEGAS, is currently used by more than 130 companies in the United States, Europe, and Japan.

"The acquisition of CCSS and our earlier acquisition of Compact Engineering provide a solid foundation for CGIS' entry into the CAD/CAM/CAT industry," Mr. Alpert stated. "Building on our early experience with CAD/CAM/CAT technology in satellite design and with the capability brought to us by these acquisitions, Comsat General Integrated Systems has the opportunity to become a leader in the digital and microwave segments of this rapidly growing industry."

# FOR THE RECORD

*Excerpts of what officers of Comsat and subsidiaries said at recent speaking engagements*

*"Satellite Communications for Military and Civilian Purposes" by Dr. John L. McLucas, President, Comsat World Systems Division, at the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, February 11, 1981.*

*Dr. John L. McLucas, President*
*Comsat World Systems Division*

**Satellites and the Military**

Advances in satellite communications have opened up new vistas, new capabilities. Satellites facilitate communications with tactical mobile units, for example. Yet there is also the problem of a satellite's vulnerability to jamming or selective destruction by the enemy. How can this threat be overcome? Do you try to design the super satellite equipped with an array of gadgetry that makes it as immune as possible to enemy attack? That simply starts a kind of costly competition for superiority that could go on forever. Every time the satellite is made more invulnerable, the weapon designed to knock it out is made more powerful or flexible.

The alternative is to spread out your potential target. Instead of focusing on building the invulnerable satellite, you proliferate the communications resources at your disposal so that the enemy has no single clear-cut target. But this requires a great deal of coordination to set up. Space and terrestrial facilities must be standardized and networks must be potentially interchangeable. Let us assume that an enemy attack obliterates everything but a handful of satellites and earth stations. Provision should have been made for them to talk to each other in an emergency situation or then your strategy is useless. Without interconnectivity, the proliferation of facilities will never operate as a deterrent. You must also assume that all of our nation's communications facilities—whether in space or on the ground, whether military or civilian—form one vast set of resources that can be linked quickly and efficiently in an emergency. Everything must be viewed as a whole, even though it may have been put together piecemeal.

Obviously, such a defense strategy presents a serious challenge for implementation. The process of ensuring the degree of coordination needed is staggering, yet it may be the best course available to us. Only if our communications resources are vast so that an enemy sees no clear way of knocking out our communications capability, do we stand a chance of deterring enemy action . . .

**Concerns: Spectrum, Orbital Space**

The concerns regarding spectrum and orbital space become so serious that planning of orbital positions is now being advocated by many nations. The developing countries, in particular, have expressed the fear that by the time they establish the need and technology to use satellite frequencies all usable resources will be gone.

Significant developments have also occurred in technologies applicable to earth stations and ground terminals. Digital processors, for example, now enhance the quality of voice signals and increase the capacity to handle data and video transmissions.

Still another trend is the development, over successive generations, of both commercial and experimental satellite systems, of beaming techniques that can concentrate a satellite's radiated power to smaller and less expensive ground stations. The ability to use small antennas—from ten meters in diameter down to one meter or less—opens up satellite communications for more diverse and specialized uses. Not the least of these uses is the creation of sophisticated networks for handling data, video and facsimile transmissions as well as for voice communications.

Satellite Business Systems, for example, is providing switched digital traffic streams via satellite that will allow its business customers to obtain a complete spectrum of voice, data, facsimile and teleconferencing services on a regular or demand basis. Small antennas located at the customer's various facilities will be interconnected directly through the satellite. The SBS system is scheduled to become operational within a few weeks, and SBS is just one of many companies poised to offer such advanced business communications services.

The first U.S. direct broadcasting satellite system is also on the horizon. Comsat has filed with the Federal Communications System an application for a satellite system to provide subscription television service directly to small antennas on the rooftops of subscribers' homes.

Our society thus is entering an entirely new period in its history. The communications revolution has the potential to enhance our lives in a multitude of ways. And it may well be that the ultimate outcome of this revolution will lie not in what it produces, but in what it does to us as human beings. The great change may not only be in how we communicate, but in our very concept of what it means to communicate.

It is imperative, therefore, as we move toward becoming an ever more information-rich society, that we make the transition in an enlightened fashion. The changes to come undoubtedly will generate new social pressures and uncertainties. It would be unfortunate if these problems were to thwart us from realizing the full benefits our technology can produce. On the other hand, we must guard against blindly pursuing technology wherever it leads, unmindful of the social, economic and human costs.

*"A National Program for Geostationary Platforms" by Dr. Burton I. Edelson, Senior Vice President, Comsat General Corporation, at the Awards Luncheon, American Institute of Aeronautics and Astronautics (AIAA) Conference on Large Space Platforms, San Diego, California, February 3, 1981.*

*Dr. Burton I. Edelson*
*Senior Vice President*
*Comsat General Corporation*

**Geostationary Platforms**

I strongly believe that a commitment by the President of the United States to back and support NASA in the years ahead is essential. Particularly, I believe that a major new, high-visibility project for NASA is needed. The project should be carefully selected. It should be one that is technically challenging, but practical. It should capture the imagination, but serve a useful purpose. My candidate for such a project is a network of geostationary platforms.

I recommend that NASA undertake, as a major goal during this decade, attaining a dominant presence and operational capability in geostationary orbit. The U.S. government and industries will be able to use that capability even into the next century to reap economic benefits directly from geostationary orbit missions, and to serve as an operating base for control of other more extended space missions.

The development of satellite communications over the last two decades, a subject with which I am familiar, has underscored the enormous importance of that thin, invisible track running through a celestial arc, exactly over the equator, 35,800 kilometers (22,300 miles) up. Today there are well over 100 satellites in geostationary orbit. There are dozens of separate communications satellite systems in operation or planning at this time. These systems are for international, regional, domestic, military and experimental purposes. In addition to communications, there are other missions well served by the geostationary orbit. These include remote sensing of the earth for meteorological and earth resource purposes, tracking, data relay, and data processing. There are important scientific missions which could be conducted in geostationary orbit, and of course, it has significant military importance as well.

A number of studies have indicated the advantages of large multi-mission platforms in geostationary orbit in providing communications, switching and processing, and the other missions I just mentioned. Several platforms could be interconnected by microwave, or perhaps laser links. A small number of large platforms, perhaps ten or so, could effectively and efficiently replace a hundred or more small single-purpose satellites.

There is already a definite trend toward platforms, even without a national commitment. The Intelsat V and TDRS Satellites might be considered small platforms. NASA Marshall has an excellent design program for larger platforms underway. Interestingly, an argument has been raised as to whether, to optimize orbit capacity, a large platform or a cluster of smaller satellites might better serve. "Clusters," of course, represent the same concept as "platforms," linking payloads with radio links rather than with structures. Clusters might well be a temporary solution until the shuttle is operational, but in the long run, platforms will surely have a cost advantage. Studies have shown that large multi-purpose platforms may provide service in geostationary orbit at one-half or less the cost of multiple small single-purpose satellites.

I can name quite a few advantages for a geostationary platform program. First, it would be a meaningful national commitment. Second, it would involve the use of our unique capabilities and resources. Specifically, it would capitalize on the space shuttle. Third, geostationary platforms would be highly visible (figuratively!) to the rest of the world. Fourth, it would be an obviously useful program with economic and commercial benefits. The cost effectiveness of platforms would create new missions and new business.

In addition to the direct benefits, a geostationary platform program would provide an excellent opportunity to develop related technologies and capabilities. Paramount among these is the ability to assemble, erect and operate large space structures. At first, in the mid-80's, a creditable geostationary platform might be put in orbit with one shuttle launch—say 5,000 kg (12,000 pounds). Then, a larger one would require several orbiters with rendezvous, assembly and test in low earth orbit with manned assistance, then raising the assembled elements to geostationary orbit as a unit. Eventually, surely in the 90's, large platforms (20-30,000 kg) will be modified, repaired and serviced—either by man or machine in geostationary orbit.

We must have high performance upper stages for the shuttle to perform these missions efficiently. The Centaur stage, which I understand was just approved by NASA for integration into the shuttle, will provide an initial useful capability.

A manned operating base in low earth orbit would be of great assistance in assembling, checking and servicing platforms on their way to geostationary orbit. Incidentally, an interesting and attractive point suggested by Klaus Heiss recently is that a program such as this would provide an outstanding opportunity for the development of robotics technology—an area of enormous need and potential—one that contributes directly to that all-important goal of productivity.

All of these factors serve to demonstrate that a geostationary platform program would be useful, prestigious, technically challenging, and, when successful, economically rewarding to the nation. A commitment to undertake this program could pay great dividends to the United States, our space program, our economy, and our world stature.

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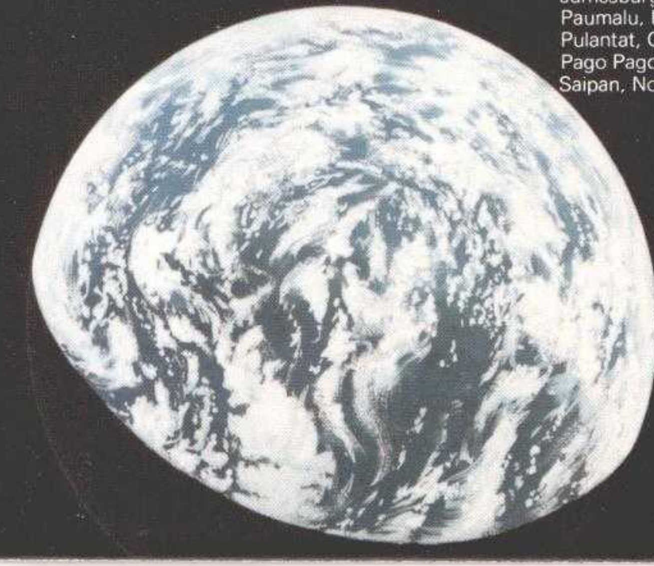
Pago Pago, America Samoa
Saipan, Northern Mariana Islands



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#### Earth Stations

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Southbury, Connecticut
Fucino, Italy (MARISAT TTC&M)

Communications Satellite
Corporation


6
The major achievements in 1980 of Comsat Laboratories, research and development center for satellite communications, are described.

14
Time-Division Multiple-Access (TDMA) carries more messages per unit of satellite capacity than the conventional FDMA approach.

19
By any standard, the Intelsat global satellite communications system would be termed "extremely large." The latest map of the system gives a good idea of its size.

23
Successful launch of the D-4 satellite completes the Comstar system, the first domestic satellite system to provide long-distance telephone circuits for public use.

26
SATNET, an experimental satellite-oriented communications system, can work with different data rates and distributes system control among the terminals in the network.

28
The Comsat Service Bureau, the United States' television link to the world, per-performed extremely well during the news-filled inauguration, hostage-release, Super Bowl period.

31
NASA's Dr. Stanley I. Weiss talks about the Space Shuttle, expendable launch vehicles and other space subjects.


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