Satellite Times®

A publication of Grove Enterprises

$3.50 US
$5.75 CAN

Volume 3, Number 3 January/February 1997

700 Years in Orbit

The incredible track record of Hughes' geosynchronous satellite busses

Satellite Times

Cover Story

***Cover Photo:** The launch of Telstar 303, a Hughes' HS-396 spacecraft, launched from the cargo bay of the space shuttle Discovery. This scene was photographed at 10:35 a.m. on September 1, 1984, during the STS-41D mission. (NASA)*

Seven Hundred Years in Orbit

By Philip Chien, Earth News

In the early days of the space program, satellites were built like custom racing cars. Today, it's more common to find most applications riding on a standardized satellite bus. *ST* staffer Philip Chien takes a look at the most popular satellite busses built by Hughes Space and Communications Group in the story starting on page 10.

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January/February 1996

From Voice to Vision

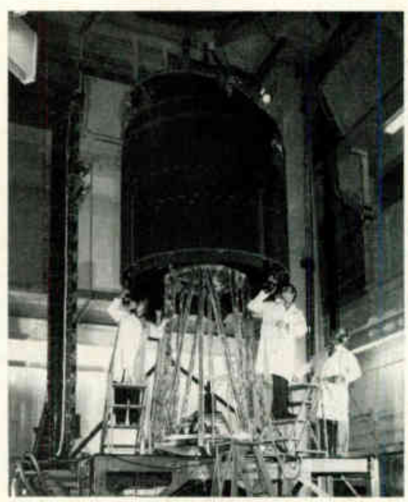
By Jeff Chanowitz

For the last fifty years, the Voice of America has built a reputation for providing accurate, balanced news and information via radio. Now the VOA has a new "face," thanks to satellite TV. Story on page 16.

"This is NPR from Space..."

By Bard-Alan Finlan

In 1996, TVRO dish owners discovered that the satellite transmissions of a pioneer in the field of SCPC program distribution, National Public Radio, had disappeared from their satellite radio dials. You can find out why starting on page 22.



DEPARTMENTS

Hubble's Best Is, Well, Profound ...

Hubble Space Telescope evokes a new sense of awe and wonder about the infinite richness of our universe in dramatic, unprecedented pictures of celestial objects. See the best of 1996 in a special color section starting on page 86.

ST

SATELLITE TIMES (ISSN: 1077-2278) is published bi-monthly by Grove Enterprises, Inc., Brasstown, North Carolina, USA.

Address: P.O. Box 98, 7540 Highway 64 West, Brasstown, NC 28902-0098
Telephone: (704) 837-9200
Fax: (704) 837-2216 (24 hours)
Web site: http://www.grove.net/hmpgst.html
Internet Address: steditor@grove.net

Subscription Rates: $19.95 in US and $28.50 in Canada. Call for air mail rates for other countries. For more information, please see page 94.

Postmaster:
Send address changes to *SatelliteTimes*, P.O. Box 98, Brasstown, NC 28902-0098.

Correspondence to columnists should be mailed c/o Satellite Times. Any request for a personal reply should be accompanied by an SASE.

DOWNLINK

By Larry Van Horn
Managing Editor
steditor@grove.net

ST *Gets a New Look!*

By the time you have gotten this far into this issue of *ST*, you have probably noticed some of the new look you will experience in this issue. There are many more changes that await you as you explore this issue. For the first time ever, we have full color available not only for editorial content, but advertisers as well.

All these movements required a change in printers. I would like to take this opportunity to welcome Tim Gregath and his staff of fine professionals at Quebecor Nashville to the *Satellite Times* production family. Tim and Quebecor team print many nationally-recognized magazines at their Nashville facility and *ST* is now proud to be among those elite publications.

Now it is time to hear from you. Joe Leikhim (Jleikhim@nettally.com) sent an E-mail letter regarding Bob Grove's recent open letter on the ham/scanner radio market. Here is what he had to say:

"I read with interest your open letter regarding the down turn in the ham radio/scanner market. I couldn't agree more. Here are a few of my observations:

1. The LEO threat to 2 meters and 70 cm.

"How many hams are willing to put any large investment into new equipment in these bands with that threat looming? I myself am queasy about the resale value of my IC-970 multimode rig if these bands are lost.

2. The demise of AO13.

"True, Phase 3D is waiting to be launched, but what happens if it fails (a distinct possibility)? What will replace P3D? What happened to simpler, lower cost payloads? AO10 is still working, albeit without batteries and controller. I think AMSAT has far too much riding on this one (P3D).

"The amateur radio industry cannot sit back and watch without taking action. The ECPA is one example. The law is a stupid one since it in effect protects no one and outlaws legitimate activity. You did not see the NRA sit back and do nothing about handgun legislation, right?

"ICOM, Kenwood, Yaesu and all of the others involved in promoting amateur radio and SWL hobbies have a lot to lose. The land mobile, PCS, and satellite folks are doing plenty that will destroy our hobbies. Plenty of money has been spent in Washington to "protect" their "interests." This spectrum gobble by big "M" and others is a ploy to put the entire spectrum into the hands of commercial interests who will try to exploit every last dollar until they learn that no spectrum deficiency really existed, and that they have gotten caught in the hype and are all going after the same limited market segment. By then, of course, it would be too late.

"The amateur radio industry must fight ($$$$LOBBY$$$) to protect their own interests. This includes a firm battle to protect the VHF, UHF, and SHF spectrum available for new and potential no-code licensees, the promotion ($$$again) of AMSAT and others to build a fleet of simple, reliable satellites to instill interest in the hobby. Face it, repeaters and packet are far less sexy to a consumer than cellular, PCS, and the internet. Amateur radio is expensive and these new diversions require virtually no up front investment.

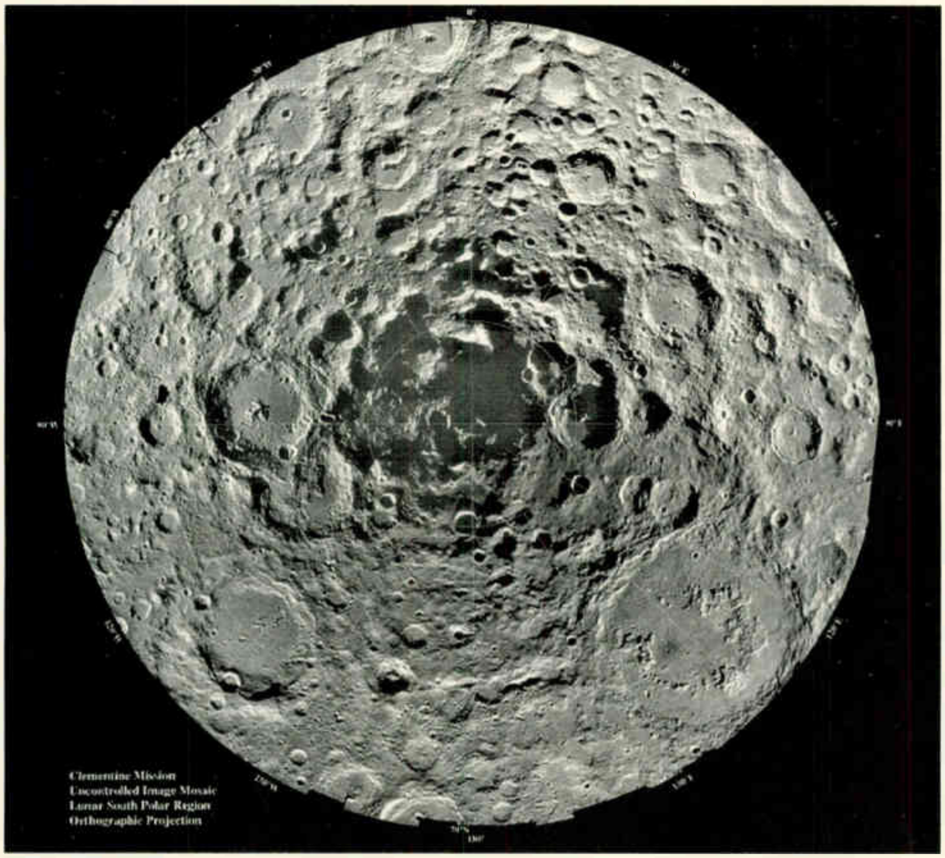
"And if we are to lose 2 meters or 70 cm, the LEO's or other commercial interests who benefit must be prepared to buy out the existing investment of amateur equipment in service. Just like the PCS relocation: PCS licensees must provide the microwave incumbents with a new system of equal performance. If LEOs agree to relocate hams to the band of their choice and pay the expenses related to such a relocation, then a fair and equitable exchange might be made. "Think of all the new ICOM, Yaesu, Kenwood equipment currently being sold! This won't continue if the FCC (Frequencies, Cash and Carry) keeps on giving away spectrum where amateurs once had status: 2.3 and 2.4 GHz, etc.

"If the LEO's don't buy up all of this incumbent equipment, it will find its way to flea markets, Caribbean islands, and South America, where it will find new life dispatching taxi cabs. The LEO's would not be happy with that prospect, would they?"

Thanks, Joe, for joining me on the *Downlink* page in your space magazine of record, *Satellite Times*. I would like to hear from you, if you have a comment on *ST* send E-mail to: **steditor@grove.net** or address your mail comments to: Downlink-Managing Editor; Satellite Times; P.O. Box 98, Brasstown, NC 28902. ST

Satellite Monitor

By Wayne Mishler, KG5BI
E-mail: mishler@ipa.net



Water Found On The Moon. The Pentagon announced on December 3, 1996, that data acquired by the Clementine spacecraft indicates that there is ice in the bottom of a crater on the Moon. Located on the Moon's South pole it was discovered with radar data.

Moon water: ticket to lunar colonization, agriculture, industry

The probable discovery of water on the moon by the NASA satellite *Clementine*, if true, could turn the moon into a colonial space port.

A water source combined with solar electrical power could lead to colonization of the moon or a lunar base for space exploration. Near the crater at the moon's south pole where *Clementine* made the discovery, mountain peaks jut into perpetual sunshine. They would make good sites for continuous solar power generation. "A source of energy so near a source of water has many potential applications," says one *Clementine* scientist.

It also raises the possibility of a rush by rival nations to claim water rights. Some are already putting a dollar value on the discovery. Lunar ice could be worth as much as $9 trillion in life support, agriculture, and industry at a future lunar base, one scientist predicts.

Scientists explain that this is not pure water, but ice mixed with dirt. But, if the satellite's data is correct, there is enough ice to be melted and cleaned to support life in a colony.

The probability of finding water on the moon comes as no surprise to the science community. Geologists for years have suggested that we might find water at the lunar poles. They say there may be water in several craters, deposited by comets impacting the lunar surface.

If you have access to the world wide web on the internet, check out the URL: **http://www.nrl.navy.mil/clementine/clementine.html**, for more information.

Advanced satellite center opens

A satellite center described by Lockheed Martin Missiles & Space as the "world's largest, most innovative and efficient" satellite manufacturing plant opened November 19 in ceremonies at Sunnyvale, Calif., to satisfy increasing demands in the space-based telecommunications industry.

The $65 million center will produce spacecraft for Lockheed Martin Telecommunications to handle mobile telephone networks, electronic data and fax transfer, direct-to-home television, and broadband communications.

Spacecraft operations are being transferred from a Lockheed plant in East Windsor, N.J., to the 158,000-square-foot Sunnyvale facility 18 months ahead of schedule.

"Heritage companies that built the first satellites at the dawn of the space age are now a single team producing systems that will revolutionize the telecommunications industry," says Lockheed chairman Dan Tellep. "The Commercial Satellite Center will allow us to reduce costs while giving customers a quantum leap in communications services at a reasonable price."

The new facility has a "clean room" the size of two football fields where there can be no more than 100,000 particles per cubic meter of air larger than .5 microns—80 times smaller than the diameter of a human hair.

Resembling an automotive production line, the center has the capacity to produce eight satellites a year. Construction time for each satellite will be reduced from the industry standard of 24 months to 18 months during the initial phase of operation. Eventually the time it takes to build a satellite in the center will be reduced to one year.

The facility was designed for production of the A2100 commercial satellite. "The modular design of the A2100 allows it to be configured to customers' specific needs, changing components as required and avoiding the cost and risk of new design developments," says Mike Henshaw, president of Lockheed Martin Missiles & Space.

"The design uses 20 percent fewer parts than earlier satellites, resulting in lower cost and faster cycle time," he adds.

The building has a 50-foot-high major assembly area, including integration and test, staging and support areas. It includes an 11,664-cubic-foot thermal vacuum chamber that simulates temperatures and pressures in space which can be 76 billion times less than on Earth. A 64,000-cubic-foot acoustic test cell duplicates audio frequencies and noise levels up to 165 decibels to simulate the vibration of large booster rockets at launch.

The center's Sine Vibration Test Facility can produce 45,000 pounds of thrust to check for resonant vibration similar to that encountered at lift off.

The plant already has a backlog. "We recently launched three satellites from three continents on three different launch vehicles—all within one week. They are on station and performing well," says Russ McFall, president of Lockheed Martin Telecommunications.

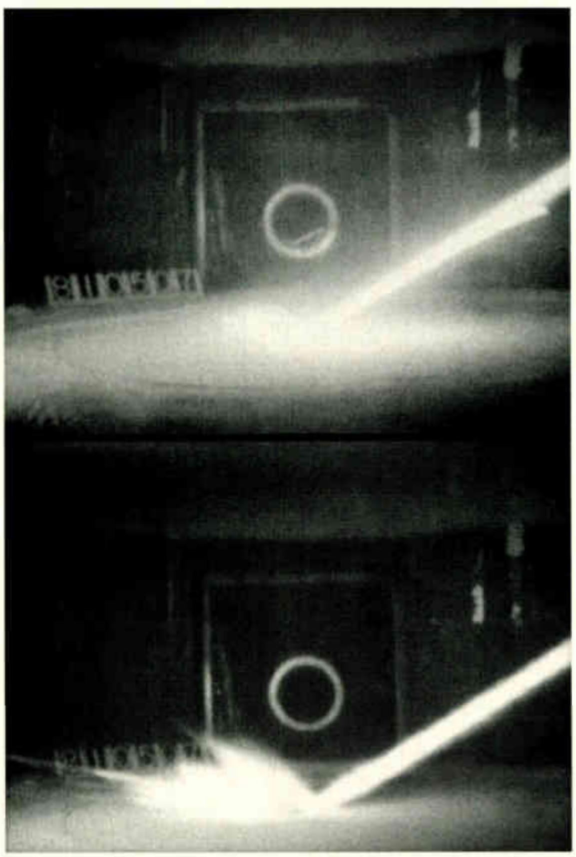
The day the Earth shook

It was a blow that shook the Earth to its core. An asteroid bigger than Mount Everest ripped into the Yucatan peninsula of Mexico from the southeast at an oblique angle of about 20 to 30 degrees. A wall of white-hot fire ricocheted northwest, like napalm, incinerating plants and animals to extinction in its path across North America. The explosion then mushroomed skyward and engulfed the planet, destroying entire species around the globe.

That's a snapshot of the catastrophe that wiped out dinosaurs on Earth 65 million years ago, according to a new study just released by Brown University of Providence, R.I.

This new theory differs from previous hypotheses that global destruction was caused by an asteroid raising dust that blotted out the sun, which would probably have distributed damage uniformly around the globe. The global fossil record shows the damage was unevenly distributed. Some areas in North America were more severely damaged. Others had less destruction. Some were spared altogether.

The Brown University study supports the fossil record of destruction. The damage was especially severe because the asteroid struck at an oblique angle, spreading waves of ground-hugging, vaporous fireballs onward over a much larger area than if it had collided at 90 degrees with Earth. The wall of fire carried with it a two-mile-deep layer of vaporized rock and debris sheared off of the Yucatan.



This high-speed sequence shows an object striking a surface at an oblique angle, sending vapor and material downrange. Scientists say the asteroid that wiped out the dinosaurs 65-million-years ago hit the Yucatan from the southeast at a similar angle, propelling vaporized rock and other material into North America and eventually worldwide. (Brown University)

"It was like a nuclear explosion taken north on a jet-powered sleigh," says Peter Schultz, professor of geologic sciences at Brown University. "This was indeed the day the Earth shook."

The key evidence supporting this glancing-blow theory is an impact crater discovered deep beneath the Gulf of Mexico at the northern tip of the Yucatan peninsula. The oblong crater is 185 miles wide. Its shape, as revealed by magnetic and gravity sensors, is characteristic of an oblique angle of approach.

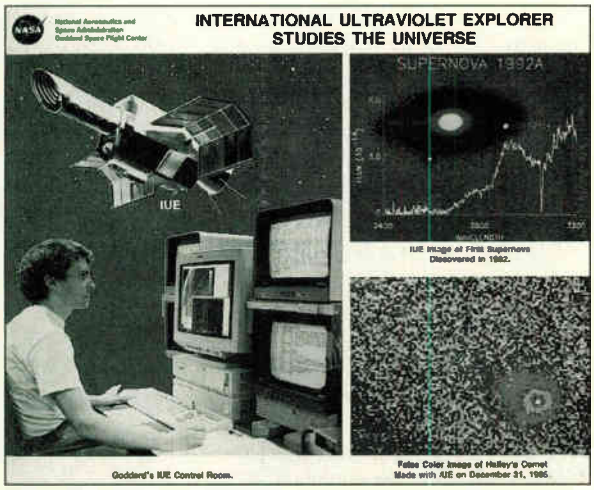
Researchers say the horseshoe-shaped crater matches the structure of similar craters on the moon and Venus that were created when objects struck them at oblique angles.

Spacecraft leaves legacy for future generations

On Jupiter there are flickering lights in the sky similar to the Aurora Borealis on Earth, with one notable difference. They are visible only by ultraviolet light. They flicker in response variations in the solar wind striking Jupiter's atmosphere. This aurora activity seemed to be repressed after the fragments of the comet Shoemaker-Levy 9 slammed into Jupiter in a spectacular series of explosions. Scientists believe comet dust was the cause. They have been watching the skies of Jupiter through the eyes of several spacecraft, including the *International Ultraviolet Explorer* (IUE) which, like a wounded soldier, managed to limp onward to complete its final observations of Jupiter on September 30.

In March of this year, the spacecraft was ailing, with only one of its six gyros still functioning, which limited the scope of its original mission. By skillful control and spacecraft engineering it went on harvesting new data, including prolonged observations of the comet Hyakutake. The craft's concluding campaigns targeted several active galaxies and stellar winds as well as Jupiter.

"I am sad but also privileged to be the



last observer with IUE," says Renee Prange of Orsay, France, who was in charge of the Jupiter program. "At the end it provided us with 800 observations of Jupiter, so it was still doing important work at the leading edge of planetary astronomy and space research."

IUE was intended to last for three years from its launch by NASA, the UK, and the European Space Agency on January 26, 1978. But the 700-kilogram spacecraft surprised everyone by continuing on to supply astronomers with ultraviolet spectroscopic information available from no other spacecraft until the launch of the Hubble Space Telescope in 1990.

After the termination of *IUE*'s space operations this September, the mission continues on the ground of reprocessing all the raw data transmitted from the spacecraft over the years. This will create the *IUE* archive of ultraviolet spectra, from which future generations of astronomers will continue to cull information on nearly 10,000 objects in the sky.

Conference to showcase global telecommunications solutions

A new conference debuting early next year will profile the rapidly changing market for cable and television distribution services in Canada.

Canada Link '97 is scheduled for February 24-27 at the Waterfront Hotel and Vancouver Trade and Convention Center. It will be co-located with Inter Comm '97, the premier Canadian-based telecommunications event that draws more than 8000 delegates and visitors from 60 nations.

"Canada Link is a logical step in the development of the Link worldwide multichannel TV conference series," says Carl Berndtson, managing director of Link Events which is organizing the schedule of events.

"There is a flurry of activity going on within the country, driven by several factors: favorable regulatory developments governing foreign investment, and a nationwide commitment to improving telecommunications infrastructures, and service delivery through competition," he adds.

Gordon Hutchison, president of Ottawa-based Evert Communications Ltd. and chairman of Canada Link points out the need for discussion. "With digital DBS services, wireless cable, and telephone companies moving into the cable TV market, the need to foster investment is great," he explains.

"Our daily interaction with key players in the Canadian communications industry indicates the need for an event that focuses on the new market dynamics not constrained by a particular point of view or agenda. the co-location with Inter Comm '97 should provide an exciting venue for this conference."

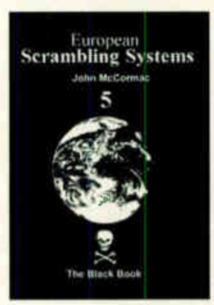
Canada Link '97 is co-sponsored by *Canadian Communications Report*, a newsletter published by Ottawa-based Evert Communications Ltd.

For more information on the conference, contact Gerard Herrador, Rosenberg, Tex., telephone (713) 342-2488 or email info@linkevents.com.

World Radio Network appoints director of corporate affairs

World Radio Network (WRN), which broadcasts to much of the world via satellite, has appointed Simon Spanswick as its director of corporate affairs, a new position with responsibility for marketing, public relations, and sponsorship development.

Formed in 1992, WRN provides continuous English language programming from 25 broadcasters in 20 countries to



Simon Spanswick

continental Europe and North America by *Astra* and *Galaxy* satellites. The firm recently introduced services to Africa, South Asia, and Asia-Pacific.

WRN has pioneered audio on the Internet, and all programs carried on WRN satellite and cable services can be accessed through the World Wide Web.

Spanswick comes to WRN with a decade of experience with the British Broadcasting Corporation (BBC) and previous experience as a freelance broadcaster. While with the BBC he presented *Waveguide*, the weekly communications program on BBC World Service. Prior to that, during preparations for the 1992 World Administrative Radio Conference, he worked in World Service Engineering. He also worked in World Service Press, Publicity, and Marketing.

"Simon's combinations of skills and experience, both as a broadcaster and in corporate affairs, will be of immense value to WRN," says Karl Miosga, WRN managing director. "He joins us at a time when we are launching new services for our contributing broadcasters, and expanding into new markets across the world."

Spanswick is also coordinator of Digital Radio Worldwide, the consortium of international broadcasters, including eleven prominent international radio stations, implementing satellite-delivered digital radio to replace shortwave broadcasting.

"Working for the BBC has been enormously satisfying, particularly since I have been able to combine a role behind-the-scenes with one at the sharp edge of broadcasting in front of the microphone," Spanswick says. "But now at a time of great change and opportunity brought about by new delivery methods and the increasing pace of digital development, it seems the right point to help develop one of the most successful independent organizations in the international broadcasting industry."

U.S. DirecTV broadcasts illegal in Canada

The *Canadian Press* newspaper is advising local residents not to buy equipment for receiving DirecTV broadcasts.

That service, says the Press, is not licensed in Canada by the Canadian Radio-television and Telecommunications Commission. Consumer advocates warn that DirecTV would cut off programming for Canadian customers. A local vendor says he will sell hardware packages capable of receiving that service for about $1,000.

"Consumers ought to be careful about buying an expensive piece of equipment only to find that somebody flipped the off switch," says Canada's Industry Minister John Manley.

And, finally...

They just don't make grandkids the way they used to. There I was, minding my own business, sitting on a couch at my daughter's house, recovering from Thanksgiving dinner, when my 4-year-old grandson, Jason, plopped himself on my lap and started a conversation that ended with me reaching for an antacid and doubting my existence.

"Grampa?"

"Yeah?"

"Whatcha gettin' me for Christmas?" He tilted a fluffy head and batted big eyes at me.

"What you want?"

"Don't get him started," warned mommy (my daughter.)

"Nonsense," I said. "This is what grandparents are for."

"A mouse," Jason said.

"Oh, you mean like Mickey Mouse?" I asked.

"No Grampa, not one of those. You know. The kind that comes with a computer."

"Now you've done it," mommy said.

"Not to worry," I said. "I know about these things. Now, Jason, tell grampa why you want a mouse and a computer."

"Well computers have fun things in them. You can play games and learn stuff."

"Like what?"

Wrong question. From there the conversation turned to Einstein's theory of relativity and to a new mathematical theorum (at least I'd never heard of it before) stating that the point in real time at which we exist absolutely is infinitely small. Did I mention that Jason is four?

Hey, the rationale holds water. The future doesn't exist in real time, you know. Neither does the past. The only thing that exists is now. You can never again take the same breath you took a second ago. Nor can you travel even one second into the future; you have to wait until the future comes to you. Therefore you can only exist in the "now." But just try to measure a "now." How long is it? A minute? A second? A tenth of a second. A millionth of a second?

In this context, finding the place where you truly exist in real time is like trying to pinpoint the square root of two or calculate how many times you can walk halfway to the wall. You could spend the rest of your "nows" doing it, regardless of how infinitely small they are.

I'm predicting this discovery will lead us into an era of time travel. It could also lead me into trouble. Mommy doesn't approve of me involving her wholesome baby boy in what she calls "far-fetched yarns." Hey, I understand. Parents are narrow minded, you know, always worried about setting good examples by telling the truth. Fortunately for mankind, grandparents have risen above that.

Okay, so maybe I helped just a teensy bit with the math. But it was a joint effort. And my grandson and I just might be onto something here. I'm assured (by a source mommy won't let me reveal) that Santa Claus has known about this time-thing for eons. It's the secret, my source says, of how reindeer fly Santa around the world in the twinkle of an eye. ST

Sources:

Brown University of Providence R.I.; Canada Link; *Canadian Press*, courtesy of Mr. Ed Wickstrom; European Space Agency; Lockheed Martin; World Radio Network

SAT TRACKER ©

Full-featured, state-of-the-art, computerized operation of Yaesu and Emoto rotators has never been easier or less expensive... The SATTRACKER© is here!

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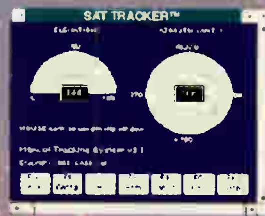
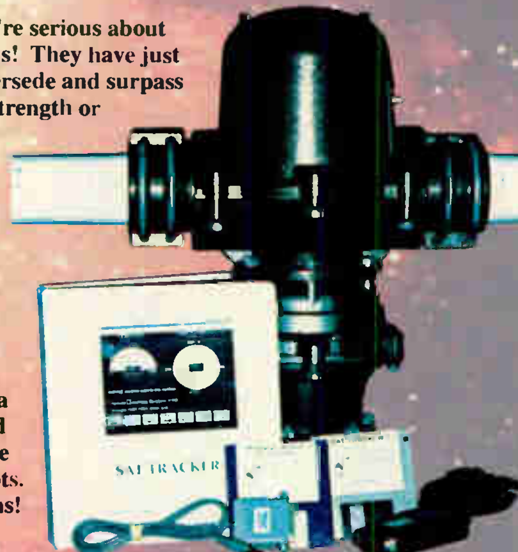
- Parallel interface for maximum data tansfer and timely control
- Completely laptop compatible for portable operation
- Requires no slots, serial ports or power from your PC
- Fully compatible w/ "Instant Track™", "Real Track™" and other software interface specs
- Runs in the background as a TSR (Terminate and Stay Resident) program
- DOS and WINDOWS™ 3.1 compatible
- Complete user and programmer documentation available



The SAT TRACKER© is a combination of hardware and software which allows you to accurately track all types of satellites or celestial objects from Horizon to Horizon. The system will even assist in accurately tracking rapidly moving low orbit satellites such as the military "LEO" Satellites or Amateur radios' "MICROSAT" Satellites. The SAT TRACKER© can be used in multitude of applications, besides satellite tracking, which require real time computer control of antenna systems.

EMOTO - EV800X & EV800DX

Good News for all you amateur satellite, moonbounce and microwave dish operators. You're serious about your modes of communications and Emoto is serious about meeting your AZ-EL rotator needs! They have just released the long awaited EV800DX and EV800X AZ-ELs. The beefed-up units actually supersede and surpass Emoto's already legendary EV700D5X. The new "EMOTATORS" simply have no equal for strength or accuracy! Emoto's secret is its new unified, single body construction elevation section head along with a newly developed running mechanism. The EV800DX should hold almost anything still! The EV800DX version offers a high-tech digital controller with unmatched, almost zero backlash, +/-1° accuracy for both elevation and horizontal rotation, which is very important for the precise aiming of your dishes and satellite arrays! Remote terminals on the rear panel of both the EV800DX and EV800X are included as standard. These allow for automatic computer control using your compatible computer and commercial or user-written software. By the way, as an added convenience, after rotator and array installation, all calibration adjustments may be done in the shack, at the control box. No need to go outside, climb the tower and tweak the dish or antennas in to exact position. If needed, the EV800DX may be separated into its two component parts. For example, the elevation head at the top of a mast and the horizontal section from within the tower, if you should feel this application would be helpful in your installation. Of course, all units include, as standard, the extras you've come to expect from Emoto: complete mounting hardware, all connectors and weather proofing boots. When you erect a large AZ-EL antenna system, the very last thing you need is rotator problems! With Emoto, the bottom line is rugged, long term reliability, user-friendly operation and cost effectiveness. With the new EV800DX AZ-EL and EV800X elevation rotators here at long last, we can tell you they were certainly worth the wait! Check with your favorite dealer today or call us for the authorized dealer nearest you!



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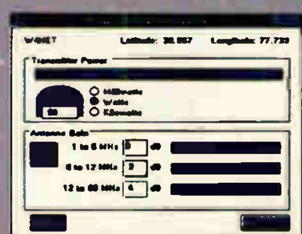

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Seven Hundred Years in Orbit

The Hughes HS 394 was a satellite designed for a wide range of applications, including direct broadcasting.

The Incredible Track Record of Hughes' Geosynchronous Satellite Busses

By Philip Chien, Earth News

In the early days of the space program, satellites were built like custom racing cars. Every satellite was individually built to the mission's exact specifications. While this made the most use of the launch vehicle's capability, it increased the cost of the satellites.

Today, it's more common to find most applications riding on a standardized satellite bus. The same computer, propulsion system, solar arrays, power systems, attitude control sensors and thrusters, telemetry system, and other components are reused on each model with few modifications. Only the communications payload is customized to each customer's specific requirements. This offers flexibility while minimizing costs. The same satellite bus which, in one application is a video relay satellite, can be a much higher power direct broadcast satellite for another customer, and a mobile communications satellite for a third.

On July 26, 1963, Syncom became the world's first synchronous communications satellite. Exactly 30 years later, 120 of Syncom's descendants were active and circling the equator, 50 of them carrying the Hughes name.

In a little over three decades, Hughes Spacecraft and Communications has certainly become the leader in the commercial satellite industry. Its HS-376, HS-393, and HS-601 models have been sold by the score. These platforms have over 700 years of cumulative on-orbit experience, with that number increasing by four years every calendar month.

A Reliable Workhorse

Hughes' HS-376 model featured an identical satellite bus (structure, batteries, propulsion system, solar cells, computer, etc.) with communications payloads and antennas customized to the customer's requirements. A HS-376 bus for one customer might feature 24 C-Band transponders to serve the entire United States, but another customer might want higher power spot beams to serve specific regions, or multiple frequency bands.

The HS-376 model was optimized to use the Delta 3920 launch vehicle's capabilities, with full compatibility with the space shuttle, too. If a customer had selected a space shuttle launch, but there were delays, the satellite could easily be transferred to a Delta.

The HS-376 is spin stabilized, with a counter-rotating communications platform. The bottom of the satellite includes most of the electronics, the cylindrical solar panels, a Thiokol Star 30 solid rocket propellant apogee kick motor, and monomethyl hydrazine propulsion system. The top 'despun' section (actually spinning at the same rate in the opposite direction) includes the communications payload and antennas. The advantage of a dual-spin satellite is that the communications antennas always face the Earth, while the spinning section has very few thermal control requirements and very low propellant consumption. The primary disadvantage to a spinner is that only half of the solar cells are facing the Sun at any given moment.

The HS-376 is shipped from the factory to the launch site as separate sections. The hazardous materials such as the batteries and fuel arrive separately. At a payload processing facility near the launch pad the batteries are installed and the spacecraft is put together. It's spin balanced on a machine quite similar to the way an automobile tire is balanced.

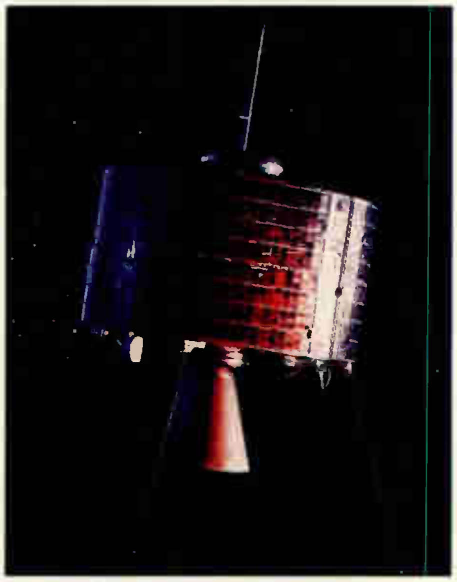
After fueling it's taken out to the launch pad and mated to the launch vehicle.

On November 15, 1980, the first Hughes-376 communications satellite, *SBS-1* [International Designator 1980 91A] was launched, using a Delta 3920 launch vehicle. The first space shuttle launch of a HS-376 was the STS-5 mission in November 1982 which launched two HS-376 models, *SBS-3* [1982 110B] and *Anik C3* [1982 110C].

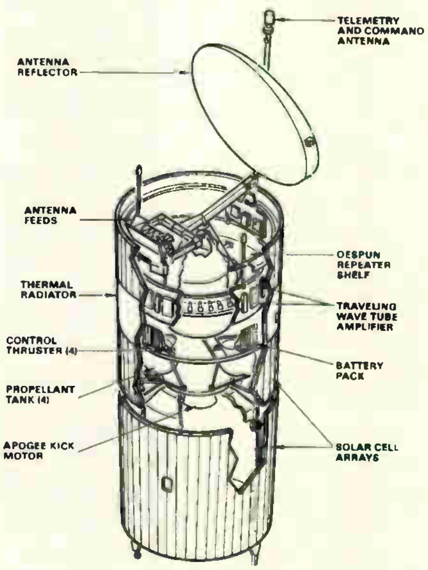
The HS-376 turned out to be incredibly successful. Forty-eight spacecraft have been built so far, including special lightweight and widebody customized versions. Industry consultants have often talked about the end of the HS-376's usefulness, due to newer, more powerful designs, but the HS-376 still continues to sell. *Thor IIA*, a Norwegian domestic communications satellite, is scheduled for launch in February.

An interesting story lies behind the fact that although 48 models have been

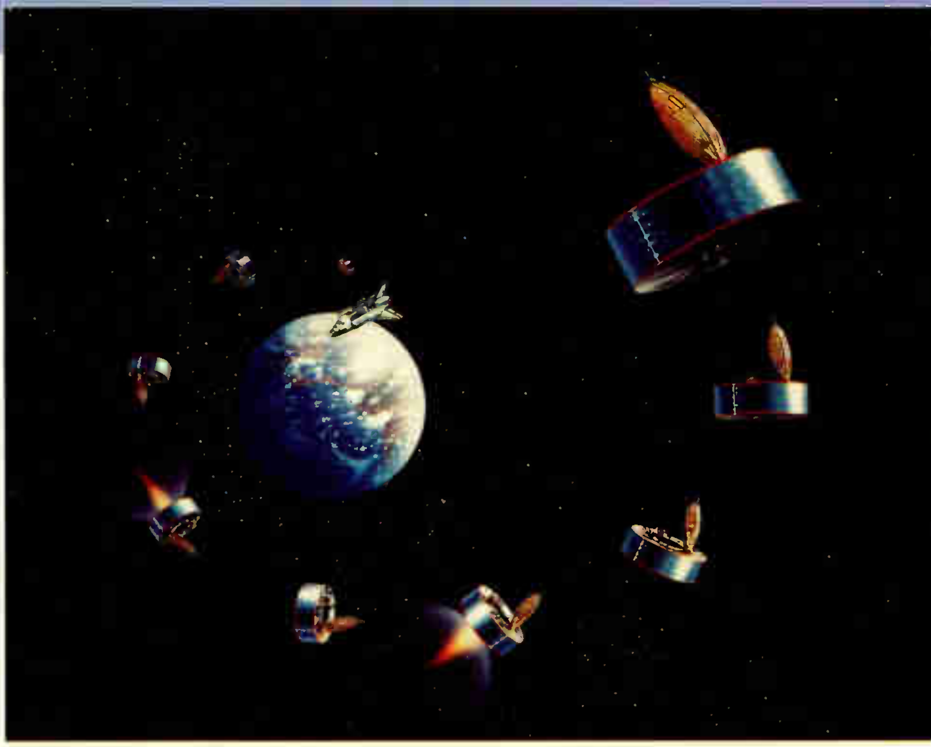
The venerable HS 376 model, shown in exploded view view below.



The Hughes Syncom II, the world's first successful synchronous orbit commsat.



HS 376
SPACECRAFT CONFIGURATION



The HS 399 communications satellite makes its way into geostationary orbit after being deployed by the Space Shuttle.

built; there have been 50 HS-376 launches! In February 1984 two HS-376 satellites were launched from the shuttle—*Westar VI* [1984 11B] and *Palapa B2* [1984 11D]. Failures in their PAM upper stages caused the spacecraft to be stranded in low earth orbit. NASA agreed to try to retrieve the satellites on an shuttle mission with the agreement that the spacecraft would be reflown on a future commercial shuttle flight. The two satellites were successfully captured and returened to Earth during the STS-51A shuttle mission in November 1984.

The five astronauts had to sign a customs form, since they had "imported" the hardware in to the United States. The crew was honored by the Lloyds of London Insurance group with the ringing of a special bell which only occurs when a successful salvage operation has saved the insurance company money.

Eventually, the *Palapa B2* was sold back to the government of Indonesia—but through a third party. Astrologers had recommended that it was "unlucky" to purchase a used satellite, but the sale through an intermediary made it acceptable!

Western Union had sold off its spacecraft assets, so the *Westar VI* satellite was eventually sold to Asiasat. After NASA chose not to fly commercial satellites from the shuttle anymore, the satellite owners were permitted to obtain commercial launches on expendable boosters.

By coincidence, the two satellites which had been launched together and retrieved together were launched within a week of each other—but from launch pads halfway around the world! *Asiasat 1* [1990 30A] was launched on a Great Wall Industries Long March 3 on April 7, 1990. *Palapa B2R* [1990 34A] was launched on April 13th on a Delta rocket. Nobody asked the Indonesians how they felt about the luck involved in relaunching their satellite on Friday the 13th! In orbit the two satellites once again rejoined each other, stationed only 13 degrees apart in the geosynchronous belt.

Alternative Busses

Hughes HS-393 model did not sell as well. It was a larger growth model, optimized to use the shuttle's performance and pricing policy, although it retained compatibility with expendable launch vehicles. Only three HS-393 models were sold, *SBS-6* [1990 91B], *JCSAT 1* [1989 20A] and *JCSAT 2* [1990 1B]. It turns out that all three were in-house sales since SBS was a division of Hughes Communications and JCSAT was a commercial Japanese-Hughes venture.

Still, the HS-393 at least made it off the ground. Two other Hughes models, the HS-399 and HS-394, remained paper studies. The HS-399 was an extremely short, wide satellite, designed to take up one fourteenth of the length of a shuttle's cargo bay—the minimum cost for a shuttle-launched payload. The intended customers for the HS-399 model were developing countries and newly started satellite communications companies who couldn't afford to go with more sophisticated satellites.

On the other end was the HS-394 model, a combination of the best features of a spinning satellite and a non-spinning satellite. The central core of the satellite would spin for stabilization, but the satellite would also feature two extendible solar wings to increase the amount of available power. After the *Challenger* accident, NASA got out of the commercial launch services business, and the market for the HS-399 and HS-394 models disappeared.

The HS-601 Success Story

Hughes chose to go with three-axis, stabilized satellites for its next design, the HS-601. It was a radical departure for the company. From the very first, Hughes had built spin-stabilized satellites, with the sole exception of the *Lunar Surveyor* spacecraft. Futhermore, the marketplace had many competing three-axis stabilized designs, and it took a while before the HS-601 found its niche.

The HS-601 is roughly cube-shaped, designed to fit within an Atlas or Ariane fairing. It includes a liquid bipropellant apogee engine. The same propellant supply which is used to circularize the spacecraft at geosynchronous altitude is also used for the satellite's station-keeping propellant. While a liquid apogee engine is more expensive than a solid rocket motor, it's more flexible. If the launch vehicle can place the spacecraft in a better-than-planned transfer orbit, the propellant saved can be used to extend the satellite's lifetime. Alternately, if there is a problem during the launch and the satellite reaches an incorrect orbit, there may be enough propellant to reach a usable orbit, even if it results in a lower than planned lifetime.

The north and south sides of the spacecraft have extendible solar wings and customers can order a larger wing if more power is required. The east and west sides of the satellite hold the large communications antennas. On some specialized models additional antennas can be mounted directly on to the satellite's Earth-facing side. Internal gyroscopes are used to stabilize the spacecraft augmented by thrusters.

One extremely interesting feature of

the HS-601 shows how well thought out the design is. The satellite in its shipping carton fits in a standard Boeing 747F cargo aircraft—with an inch to spare.

The first HS-601 customer was the government of Australia, which purchased two Aussat B (later renamed Optus) satellites. Australia insisted that the satellites be launched using Chinese Long March launch vehicles, and Hughes complied. The Long March 2E model was chosen, with Hughes providing U.S. built Star 63 upper stages. *Optus B1* [1992 54A] was launched on August 14, 1992 from China and successfully placed in service. *Optus B2*, however, failed to reach orbit when the launch vehicle's fairing disintegrated 60 seconds into the mission. Hughes and Chinese officials blamed each other for the accident, and refused to release their separate failure investigation reports to the insurance or aerospace industry.

Hughes's second customer was a more straightforward deal: the U.S. Navy decided to purchase one HS-601 as the UHF follow-on (UFO) satellite, with an option for up to nine additional satellites. Eventually, the Navy decided to purchase two additional UFO series, and seven EHF series with additional extra high frequency (EHF) transponders.

The contract called for in-orbit delivery, and Hughes selected the Atlas I for the UFO series, and Atlas II for the EHF series. *UFO 1* [1993 15A] was launched on March 25, 1993 on AC-74, an Atlas I. A problem with the Atlas first stage resulted in an incorrect orbit, so the Navy never took title to the spacecraft. It was used for engineering tests before it was abandoned in orbit. Later UFO and EHF series were much more successful in achieving orbit and entering operation.

Meanwhile, Hughes' Galaxy communications division decided to purchase three HS-601 spacecraft—*Galaxy 4*, *Galaxy 7*, and a ground spare *Galaxy 8*. These were dual-payload satellites with 24 C-band transponders and 32 Ku-band transponders intended primarily for domestic television distribution. *Galaxy 7* [1992 72A] was launched on October 27, 1992, on an Ariane 4 launch vehicle, followed by *Galaxy 4* [1993 39A] on June 24, 1993, on another Ariane 4.

Since both spacecraft were functioning well, *Galaxy 8* was a surplus spacecraft until Hughes Galaxy decided to refurbish it as the *Galaxy 3R* (Galaxy Latin America) spacecraft. *Galaxy 3R* [1995 69A] was launched on December 14, 1995 on an Atlas IIA launch vehicle.

Galaxy 3R actually has three sets of antennas for its C- and Ku-band transponders. One set of antennas is compsoed of standard C-band antennas optimized for U.S. service. The other two sets are Ku-band antennas, with one set optimized for the U.S., and the other set aimed at all of Latin America from Mexico to mid-Chile and Argentina. At launch the Ku-band resources of the satellite were dedicated to Galaxy Latin America to start direct broadcast transmissions to homes in both the Spanish and Portuguese speaking portions of Central and South America.

After Galaxy Latin America's own dedicated satellite is launched. *Galaxy 3R* will be reconfigured to use its Ku-band beams for domestic service.

A version of the HS 601 body stabilized satellite.

Another major HS-601 customer is the tiny European country of Luxembourg. It owns six Astra satellites, all stationed at 19.2 degrees East. They offer hundreds of channels of entertainment in many different languages.

Some unusual HS-601 applications include: MSAT, TDRS follow-on, DirecTV, and ICO.

MSAT features Canadian-built communications payloads on standard HS-601 busses. The payloads operate in the L-band at frequencies assigned to mobile communications. The antennas are extremely large, to permit very small mobile antennas for the customers. Two MSAT spacecraft were built, one owned by AMSC (American Mobile Satellite Communications) and one for Telesat Canada. *MSAT 1* [1995 19A] was launched on April 5, 1995, on an Atlas II launch vehicle. *MSAT 2* [1996 22A] was launched on April 20, 1996, on an Ariane 4.

Hughes' HS-601 also was a hefty procurement bid with NASA. NASA's current Tracking Data and Relay Satellites (TDRS) are based on a two-decade old TRW design. After a long struggle to obtain funding NASA chose to purchase the replacement TDRS as incremental spacecraft instead of more advanced designs. The arrangement called for a commercial satellite procurement with NASA providing expendable launch vehicles.

Hughes proposed versions of the HS-601 which won the TDRS follow-on procurement. The new satellites will offer backwards compatibility with the existing TDRS system with S and Ku-band communications, and will also feature new Ka-band transponders for additional future capacity.

DirecTV is Hughes's entry in the U.S. *pizza pan* satellite receiver market. *DBS-1* [1993 78A], partially owned by USSB, was launched on November 17, 1993, on an Ariane 4 launch vehicle. *DBS-2* [1994 47A] was launched on August 3, 1994, on an Atlas IIA. *DBS-3* [1995 29A] was launched on June 10, 1995, on an Ariane 4.

Each satellite has sixteen 120 watt transponders—much higher power than the typical 45-60 watt Ku-band transponders used on conventional broadcast satellites. The high power transponders—special frequency assignments and widely spaced satellites to avoid interference—permit the small 18-inch dishes to be used with adequate signals except during rainy conditions. Digital, but lossy, compression techniques permit the three satellites to offer over a hundred channels of programming.

Low Orbit=High Power

Inmarsat's ICO Global Communications will become the first non-military customer to use a Hughes bus in a non-geosynchronous orbit. In 1995 it gave Hughes a $1.3 billion contract for twelve satellites. The satellites will operate in circular 10,400 kilometer orbits, well below the 35,888 kilometer geosynchronous altitude.

These satellites will use S- and C-band communications and support 4,500 simultaneous phone calls from small cellphone-style receivers. The first launch is anticipated in 1998; commercial service will begin in 1999 when at least six satellites are in operation. The satellites will have nominal lifetimes of 12 years. Due to the unusual orbit, the spacecraft will require extendable thermal radiators and high power gallium arsenide solar cells.

The HS-601HP (high power) version was introduced in 1995. It features gallium arsenide solar cells, advanced battery technology, and a xenon ion propulsion system (XIPS). It can carry communications payloads twice as powerful as the standard HS-601 model. The Xenon arcjets provide very small amounts of thrust—but at an extremely high velocity. They're actually powered more by electricity, which is easy to generate in space by solar cells, than by fuel, which is a limited consumable which can't be refilled.

While arcjets provide much less thrust, they're more efficient in the long run, similar to the way an economy car may be able to get to a destination faster than a sports car because the sports car has to make more stops to refill its gas tank for its much hungrier engine.

The first HS-601HP model will be the *Galaxy 8-I* dedicated Galaxy Latin America satellite, scheduled for launch in September 1997 on an Atlas IIAS launch vehicle.

Hughes's latest offering is its HS-702 model. It will feature over 10,000 watts of power, the capability of carrying up to 90 high power transponders, and a predicted orbital lifetime of 15 years. So far the only sale has been one in-house sale to the Hughes Communications division, but Hughes Aircraft is betting that the HS-702 models will fill many of the geosynchronous orbit slots in the early 21st century.

Lockheed Martin Astrospace, Space Systems/Loral, and Matra Marconi also build satellite busses. We'll look at their models in a future issue of *Satellite Times*.

The excellent service record of Hughes satellites speaks volumes about the quality of the company's employees.

Understanding the International Designation System

Each satellite has an unique international designator. The first four digits are the calendar year for the launch—expressed in universal time (e.g. a launch at 8 p.m. Eastern Time on December 31 counts as the first launch of the next year because it's already after midnight Universal Time). The next two or three digits indicate the numeric order for the launch vehicle for that year. The last letter(s) are assigned in alphabetical order to each piece tracked from that launch. The letter "A" is assigned to the primary payload, and B through the number of letters required to catalog the remaining pieces from that launch. "I" and "O" are not used to avoid confusion.

If a satellite is launched by the space shuttle then the shuttle is designated the "A" object, and the first satellite is the "B" object. For expendable launch vehicles "A" is the primary payload and "B" is the second payload, or upper stage. Multiple letters are used if necessary.

For example 1993 33A would indicate the primary payload on the 33rd launch of 1993. 1993 33B would be the upper stage, or second payload, if there was one on that particular flight.

World Radio History

from Voice to Vision

Above, you are in the VOA's new Studio 47, scene of the network's Farsi program, "Roundtable to You," adapted from a popular radio call-in show.

The Voice of America in Asia now has a "face," too, thanks to satellite TV

Below, an employee answers the phone and records the questions on the international call-in line in preparation for the "Roundtable" telecast.

By Jeff Chanowitz

For the last fifty years, the Voice of America (VOA) has built a reputation for providing accurate, balanced news and information via radio. The intended audience has ranged from the Communist dictatorships of Eastern Europe during existence of the Iron Curtain to the currently repressive military juntas of Myanmar and Nigeria. With the global proliferation of satellite dishes, even within authoritarian regimes, the VOA has inaugurated a new television/satellite service that will provide news and information in six languages to a worldiwde audience.

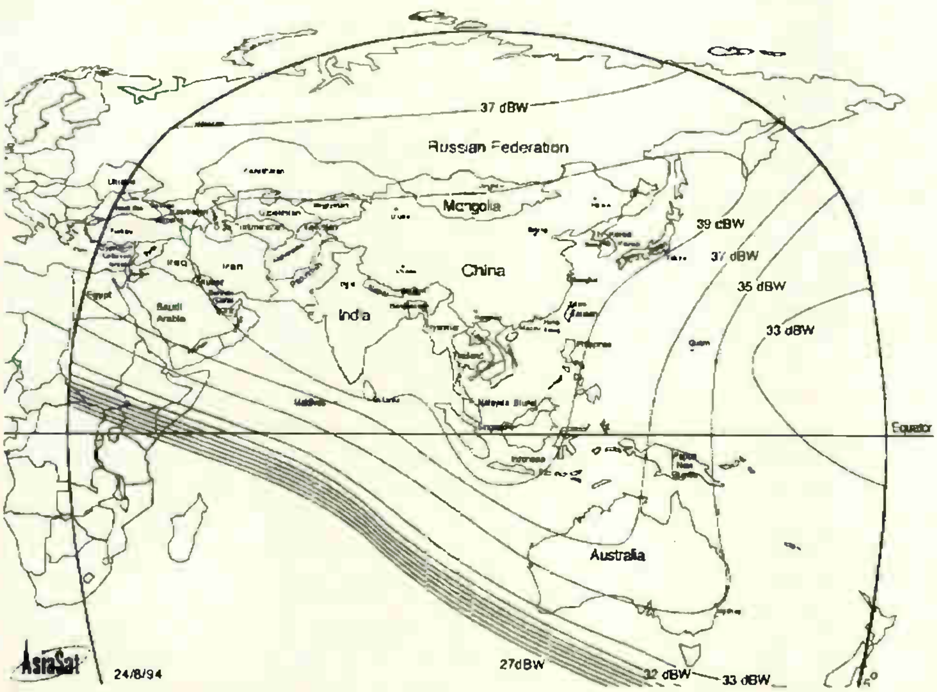
On October 25, 1996, the VOA, which is the United States government's international broadcast service, formally inaugurated VOA TV. The new service will provide simulcasts of existing and newly created radio programming as well as programming made specifically for TV viewers. With the C-Span TV networks as the new service model, Geoffrey Cowan, who served as the VOA director until November of 1996, described the new service mission as offering "attractive, low budget radio-television programs to the world in a number of languages."

The new control room of Studio 47 located in the basement of the VOA studios in Wahstington, D.C.

Emergence of VOA TV

Like many other U.S. government broadcasting initiatives, the emergence of VOA TV sprang from a foreign policy crisis. In September 1994, when President Clinton linked the People Republic of China most favorable trade status with the United States to China human rights policies, the U.S. decided to implement various measures to foster human rights in China. The VOA became a part of this new policy initiative. Cowan commented, "The President authorized that the VOA's program *China Forum* be placed on satellite (which is almost impossible to jam or scramble) via AsiaSat." He added, "We did not know how many people would be watching, but it was there if viewers in China wanted to see it."

With viewer reaction having been described as quite "impressive," Cowan decided to launch a new satellite TV service. However, during the current period of government downsizing and tight federal budgets, obtaining the hundred of millions of dollars needed to fund a full scale television service was virtually impossible. As a result, Cowan decided to launch a low-cost service that would utilize existing VOA radio programs so that they could be televised. When questioned if people would watch televised radio programs, Cowan cited the success of the *Larry King Show*, which he indicated is "essentially a



Footprint of the AsiaSat communications satellite, which broadcasts VOA television programs.

radio program designed for TV," and added that "seeing the rebroadcasts of our radio service on Haitian television—which has an audience share of over 60% of the country—convinced me that this type of programming could succeed."

By reallocating a million dollars in last year's budget—the VOA built studio 47 in its basement and covered the start up costs for the service. VOA has now joined the ranks of such international broadcasters as the BBC (United Kingdom) and Deutsche Welle (Germany) in providing viewers living in authoritarian regimes a chance *see* the programs to which they had been listening.

TVRO Ownership

Who and how many people will be viewing DBS programming is hard to gauge as ownership of satellite dishes is banned in many countries, which levy huge fines on owners caught with satellite dishes in their possession. In China, despite the 1990 ban on satellite dishes and costs ranging from 3,000 to 150,000 Yuan ($350 to $17,000)—which are huge sums by Chinese standards—the dishes are gaining in popularity.

The Economist magazine recently reported a typical case of satellite ownership in China. One owner was a worker at a state collective. This man, known as Mr. Yang, had gone in together with his state owned work unit to buy a dish for $2,300; he used the dish to provide a satellite television service to his residential complex for the small cost of 12 yuan per month for each household.

In Iran, the regime has established strict Islamic codes that censor the press and bar western culture from the media. The government has also banned satellite dishes and has established fines of $1,000 for ownership of TVROs—again, huge sums by Iranian standards. Despite this ban and a recent crackdown orchestrated by the government against TVRO owners, it is estimated that a third of the country's urban populace has access to satellite TV. As Cowan joked, "We know people have a dish in their houses in Iran, because they watch MTV."

For the most part, satellite dish ownership in these authoritarian counties is limited to the urban areas, due their high cost. Informal estimates obtained from the VOA indicate that there are about 500,000 TVROs in China and over a million in Iran.

The Programming

In order to attract the larger number of Iranian viewers, the VOA has placed the Farsi service's program *Roundtable With You* on satellite. The international call-in program, which formally inaugurated VOA TV when it aired on October 25, featured lyrist Ardalan Sarfaz and pop vocalist Mahasti. Both are Iranians who have been living in exile for the past 17 years.

The show was heavily promoted in Iranian publications in London and Los Angeles and on the VOA's radio programs, and many of the program's callers indicated that they were watching the program via satellite. One caller to the international call-in line remarked about "the good looks" of the shows host, while another complained that it was very hard to angle his dish toward the AsiaSat satellite in order to receive the program.

Many callers who were listening to the broadcast on radio wanted to know the satellite coordinates to receive the program on their dishes. Admittdely, the satellite broadcasts have just started, but with 40% of the callers to the first two *Roundtable to You* broadcasts indicating that they were watching via satellite, VOA TV seems to be off to a popular start.

At present, VOA TV produces five hours of weekly programming. The Arabic service's *The Weekly Forum* is simulcast from 1900 to 2000 UTC on the Atlantic Ocean Region (AOR) Intelsat 601 at 332.5° East longitude on transponder 21 (3742.5 MHz), and the Indian Ocean Region (IOR) Intelsat 703 at 66° East longitude on transponder 33.

The English service's *Talk To America* airs from 1800 to 1900 UTC on the AOR/IOR satellites and the Pacific Ocean Region (POR) Intelsat 511 at 180° West longitude on transponder 14 (3.976 GHz).

The Farsi service's *Roundtable To You* airs from 1900 to 2000 UTC, and the Mandarin service's *China Forum* airs on Mondays from 1400 to 1600 UTC on AsiaSat 2 located at 100.5° East longitude on transponder 2B (3.680 GHz).

VOA's Russian service's *Viewpoint*, which airs on Thursdays, will be carried on Fridays via the three Intelsat birds. There will also be a selection from the Thai service's news programming in the near future.

The Future

Describing it as the "next generation in international broadcasting," during his last speech as director, Cowan stressed the service's new commitment to direct broadcast satellite technology. Cowan also laid out an impressive goal of providing 24-hours of satellite broadcasting on AsiaSat—a satellite with a footprint that reaches 72% of the world population, and stated that his goal was "to bring to the region, without censors, all the favorite programs we have on radio."

While the funding for such expansion plans are tentative, at best, the introduction of VOA TV will provide TVRO owners—whether located in authoritarian regimes or in the United States—an opportunity to see America's voice to the world in action. ST

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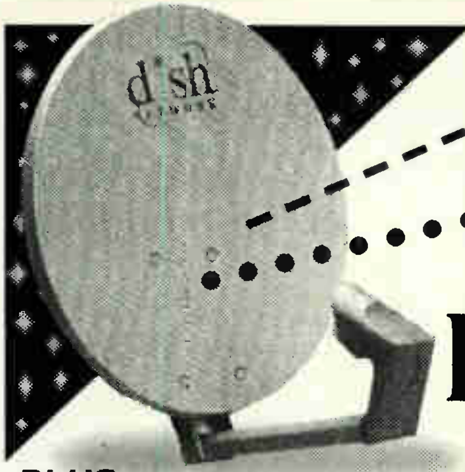

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"This is NPR from Space ..."

By Bard-Alan Finlan

Actually, National Public Radio already broadcasts to the U.S. via satellite ... but only a few of us can hear.

IN THE EARLY PART OF 1996, home listeners to single channel per carrier (SCPC) satellite radio broadcasts discovered that satellite transmissions of a pioneer in the field of SCPC program distribution, National Public Radio, had disappeared from their satellite radio dials.

Perplexed and disappointed listeners who inquired about the matter to NPR, however, soon learned the fate of these transmissions: NPR had begun a process of converting them from an analog to a digital format, with no provisions in place for satellite home listeners to receive them. To understand why this transition has taken place, it is necessary to review the background of public radio and its developmental efforts in satellite program distribution.

A Lesson in History

Public radio in the United States traces its origin back to 1945, when the Federal Communications Commission finalized the FM broadcasting spectrum to our present 88-108 MHz. At that time 20% of this spectrum space (the frequencies between 88-92 MHz) was reserved for noncommercial educational radio stations. During these formative years, broadcasting minimal effective radiated power requirements for noncommercial stations ranged to a low of only 10 Watts, and community and educational radio stations (i.e., those associated and/or funded by colleges and universities or other educational institutions) began to spring up all over the nation. Today, there are upwards of some 650 public radio stations active in this country.

Often operating with small budgets, developing public radio stations sought a common thread between themselves to pursue funding and obtain quality programming.

In 1952, with financing from the Ford Foundation, the Educational Television and Radio Center was formed. This organization was intended by its designers to be a national exchange for providing programming, services, ideas and information to educational broadcasters. It soon became apparent, however, that local and private funds were not adequate to support the developing public radio and television consortium and, by 1962, federal funding had had its beginnings.

Over the years, variously titled support and funding groups were formed. Among these were the National Association of Educational Broadcasters and the Carnegie Commission on Educational Television. In 1964, the Carnegie Commission recommended to Congress that a private, not-for-profit body be established with funding from the federal government for the purpose of administering government funds and encouraging the growth of public broadcasting.

These efforts by the Carnegie Commission led to the Public Broadcasting Act of 1967, wherein Congress authorized the creation of the Corporation for Public Broadcasting (CPB). CPB's charge was to distribute federal funding and make available quality programming, obtained from diverse sources, to all citizens. It was also required to encourage the growth and development of nonbroadcast telecommunications technologies and establish an interconnection system for the delivery of programming services.

Congress, however, forbade CPB from administering and operating the interconnection system itself, so CPB had to engender cooperation from local public broadcasting stations to establish such a system. CPB's efforts led to the formation in the late 1960's of the Public Broadcasting Service (PBS) for television and National Public Radio (NPR) for radio. Both entities were created as non-profit organizations owned by their respective public television and radio stations.

Other organizations were later formed, including American Public Radio (APR)—which was later to become Public Radio International or PRI), but they were not to develop independent interconnection systems.

One important difference between PBS and NPR is that PBS was not permitted by CPB to produce programming. NPR, however, was, as it did not then have a large bank of programming to draw from. This distinction, however, has faded over the years.

"One important difference between PBS and NPR is that PBS was not permitted by CPB to produce programming. NPR, however, was, as it did not then have a large bank of programming to draw from. This distinction, however, has faded over the years."

PBS and NPR receive their financial support from the public television and radio stations that own them, who in turn are funded by CPB, local pledges, and corporate support. CPB, PBS and NPR operate as non-profit corporations in the District of Columbia and are governed under the District of Columbia Non-Profit Corporations Act (D.C. Code 29-526). CPB is also governed by amendments to the Communications Act of 1934 (47 U.S.C. 396 & ff.).

Concern over the structure of public broadcasting led to the formation of the Carnegie Commission on the Future of Public Broadcasting; the Commission's 1978 report entitled *A Public Trust* argued for the elimination of CPB and suggested that it be replaced by a new entity to be named the Public Telecommunications Trust. Although Congress chose not to eliminate CPB, they reorganized CPB's funding and set up separate accounts for program production and administrative expenses.

The Satellite Interconnection System

In 1969, with support from the Ford Foundation, CPB helped to create a national interconnection system using AT&T telephone land lines. What CPB set out to do was to institute a system whereby equal access to national programming could be obtained by all public television and radio broadcasting stations.

By the late 1970's PBS and NPR, seeking a less costly and more flexible way of distributing programming, began experimenting with a satellite interconnection system. PBS sent its first programming transmissions via satellite in 1978 using analog full-transponder technology: within two years NPR was also transmitting programming using analog SCPC methods. The eventual complete adoption of these system by PBS and NPR was to begin a revolution in program distribution for the entire broadcasting industry.

Both PBS and NPR leased C-band transponders on the old *Westar IV* satellite; PBS used four transponders to provide four video channels and NPR used one transponder to provide up to 22 high quality SCPC audio channels. Since a single transponder could support upwards of 60 high quality SCPC carriers, NPR began to administer the sublease of these extra carriers to commercial broadcasters. PBS followed suit with video and subleased time they were not using on one of their full transponders. Income generated from these activities was used to help offset costs of distributing public programming.

As early as 1962, with passage of the Educational Television Facilities Act, federal funding for public broadcasting had segmented into separate funds for programming and technology. The Educational Broadcasting Facilities Program (later the Public Telecommunications Facilities Program) was formed with funding from Congress as a competitive matching grant program, and came to be administered by the Department of Commerce.

Since 1967, CPB has assisted PBS and NPR with the developmental and operating expenses of their respective satellite systems and has established structural safeguards for system operations (e.g., all radio producers receiving funding from CPB must distribute their programming on the NPR operated Public Radio Satellite System).

By the late 1980's, CPB had recognized that the *Westar IV* satellite would soon run out of fuel and be retired, so they began preparations for requesting money from Congress for a one-time replacement fund. By this point, Congress had a legal obligation to help CPB fulfill its Congressional mandate to maintain a national program distribution system for public television and radio.

CPB proposed that Congress allocate $200 million, of which PBS would receive $143 million and NPR would receive $75 million, for the replacement costs of the satellite systems. This money would defray purchase costs of six transponders for PBS and two transponders for NPR.

NPR had argued that they were approaching full capacity on their single transponder and that the distribution needs of public radio would soon require transponder expansion, especially if digital transmission was contemplated (which NPR's engineers reasoned would require more spectrum space per carrier).

Congress responded to this request within the Public Telecommunications Act of 1988 (P.L. 100-626). In addition to the regular yearly allocation of money (some $245 million by 1991) to CPB and the regular yearly allocation of money ($42 million by 1991) to the Public Telecommunications Facilities Program, a special independent three-year appropriation of $200 million was authorized, to begin in 1991, for a new Public Broadcasting Satellite Interconnection Fund. According to the House (House Report 100-825) and Senate (Senate Report 100-444) reports on the Act, the intention of the fund was to:

> "ensure the continued provision of the high quality interconnection services presently offered by public broadcasting, facilitate the growth of public broadcasting's interconnection systems, and encourage innovative uses of such systems[.]" (House Report 100-825, p. 21.)

"NPR"

Beginning in 1991, PBS ... purchase(d) five Ku-band transponders, and one C-band transponder, on Telestar 401. They were able to contract with General Instrument (of San Diego) as the first user of the DigiCipher I system for compressing video programming.

Congress directed that the Public Broadcasting Satellite Interconnection Fund:

> "shall be distributed by the Corporation [CPB] to the licensees and permittees of noncommercial educational television broadcast stations...and to those public telecommunications entities participating in the public radio satellite interconnection system...[and was to be used] exclusively for the capital costs of the replacement, refurbishment, or upgrading of their national satellite interconnection systems and associated maintenance of such systems[.]" (47 U.S.C. 396 (a)(10)(D)(1))

In addition, since well-formulated final plans for the new satellite systems had not been submitted to the Congressional subcommittees in charge of reviewing the proposed legislation, Congress also required of CPB that:

> "On or before March 1, 1990, the Corporation for Public Broadcasting . . . shall submit to Congress a report...detailing the satellite replacement needs of public radio and public television[.]" (47 U.S.C. 396 (b))

Beginning in 1991, PBS used their allocation from this fund to purchase five Ku-band transponders, and one C-band transponder, on *Telestar 401*. They were able to contract with General Instrument (of San Diego) as the first user of the DigiCipher I system for compressing video programming. This made it possible for PBS to run as many as eight different high-quality video programming channels per full 54 MHz Ku-band transponder, thus vastly increasing PBS's ability to distribute programming.

The DigiCipher system includes an option for digital encryption of the signal, but PBS has elected not to use it; it has instead practiced the policy it used while experimenting with VideoCipher for the purpose of facilitating stereo sound transmission in the late 1980's—to run the system in ***fixed key mode*** so that any member of the public who might choose to buy a DigiCipher I receiver might receive the DigiCipher signals. PBS plans to convert to DigiCipher II sometime this month.

They are currently operating their five Ku-band transponders for distribution of their national programming service, backhauls and other educational services. For reasons to be discussed below, PBS has maintained their one C-band transponder in analog, and in the clear, so that backyard dish users may watch all of the programming constituting the national programming service on this one feed.

NPR, on the other hand, has used their allocation from the fund to purchase two C-band transponders on *Galaxy 4*. Since 1991, NPR has been in the process of upgrading its satellite facilities, which now include over 22 uplink sites and over 610 receive sites all around the country. All satellite traffic is computer controlled at NPR's main origination technical center (MOTC) in Washington, D.C.; the MOTC is connected via fiber optic cable to NPR's main uplink site in Fairfax County, Virginia.

NPR contracted with ComStream Corporation (also of San Diego) to build a proprietary SCPC digital audio encoding and decoding system. The use of a digital audio compression technique (MUSICAM) enabled ComStream to offer NPR a product which would vastly conserve channel spectrum space and enable them to fit in many more channels per transponder than even analog transmission formerly allowed.

The receiver developed by ComStream (the ABR700), would allow digital multiplexing of stereo programming on a single SCPC carrier, sampling bit rates of from 64 kbs to 396 kbs to be received on a dynamic bandwidth allocation basis and would permit encryption of the digital carriers. Beyond the use of compression, the use of multiple bit rates would also allow further conservation of spectrum space, and the carriers could be adjusted to accommodate the audio quality needs of various types of programming (e.g., a low bit rate for voice programs and a high bit rate for live music programs). The encryption feature would facilitate system security and allow NPR to provide affiliate stations with various programming packages which the station's receivers could be variously authorized to receive by NPR.

Soon NPR would be in a position to begin to require its commercial users to adopt this system as well, resulting in yet further conservation of spectrum space and added income to NPR, with ComStream equipment leased to them exclusively from NPR. The only problem which NPR had not fully anticipated was negative reaction from backyard dish owners with SCPC receivers who would no longer be able to receive the now digital signals.

The Problem

While commercial grade SCPC receivers have been available for some time, they are generally quite high in price and are not readily adaptable for home use. The requirement for a stable (generally Phase-Lock-Looped) LNA or LNB and/or further block-down conversion equipment all but prohibited most backyard dish enthusiasts from being able to afford to buy such equipment. However, some listeners did buy the needed hardware and, in the last few years, SCPC receivers designed for home use (which require less costly associated components) have begun to appear on the market.

With at least three companies currently manufacturing home SCPC receivers, the demand for such equipment has exceeded the supply. Nevertheless, backyard SCPC satellite radio listening has not yet approached the popularity of satellite video and appears now to be in the same position as the latter was in the early 1980's.

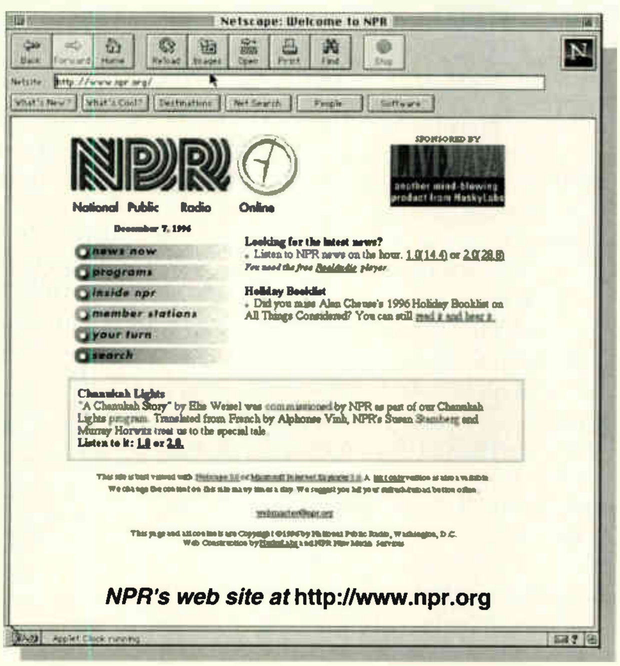
Those readers who recall how the rights of satellite video viewers were in question at that time may be able to understand the current plight of satellite SCPC listeners; many of the formerly analog carriers have been converted to digital in an attempt to upgrade audio fidelity and preserve system security. This was the concern, at least, of National Public Radio when they had the opportunity to design a new upgraded satellite interconnection system.

As to the rights of the public to receive NPR's SCPC satellite transmissions, NPR's official position, as expressed by their distribution division, is that their satellite interconnection system is supported by and operated on behalf of their participating stations and was not intended for access by private individuals. They argue that public radio was built upon a foundation of localism.

This concept is supported by Congressional declaration of policy, to wit:

> "public...radio and public telecommunications services constitute valuable local community resources for utilizing electronic media to address national concerns and solve local problems through community programs and outreach programs[.]" (47 U.S.C. 396 (a)(8))

There is a fear that the encouragement of satellite radio may result in reduced listening and, consequently, pledging to local public radio stations. NPR therefore encourages listeners to tune in to local affiliate public FM broadcast stations or the retransmissions of some of these stations available on the audio subcarriers of some satellite video programmers; alternatively, NPR has made some of its programming available on the Internet (with a World Wide Web address of **http://www.npr.org**).



NPR's web site at **http://www.npr.org**

This author has been informed unofficially that it was the concern of producers of programming for distribution by NPR that some of the smaller affiliate community stations were taking programming from the satellite and airing it without paying for it, which led to the concern for system security.

NPR manages its finances by selling programming to local public radio stations with costs to these stations based on the number of listeners served by the station and their yearly income from pledges and other contributions. Many of the smaller stations just cannot afford to purchase all of the programming available to them. This is the situation, NPR claims, encountered in a country where public radio has become competitive, allegedly due to a lack of full government funding.

Some at NPR are also concerned that providing a digital-quality audio signal to the public (the ABR700 receiver has a direct-out digital port for input to a DAT or other digital recorder) would encourage home taping and duplicating, thus threatening the income of such operations as the new Pubic Radio Music Source which provides tapes and CD's of music and other features heard through NPR distributed programming. Although it is not currently in operation, the encryption feature of NPR's new equipment is scheduled to go into effect beginning early this year. NPR feels that the laws preventing individuals in the public from receiving encrypted satellite signals will protect them from any *illegal* listening (e.g. see 47 U.S.C. 605).

Home SCPC satellite listeners, on the other hand, feel that they have a right to listen to public radio programming via satellite. Many satellite listeners live in parts of the country where there are no local NPR affiliate FM broadcast stations. Where stations are available, few, if any, of them are able to air all of the programming available to them.

Many public radio stations have adopted niche formats (e.g. talk radio, jazz, classical) and only broadcast public programming which fits into their idea of what format best meets the needs of their local community (often that which generates the most income in local pledge support). Only the largest urban areas can support multiple public radio stations with differing formats, allowing a diversity of programming to be available to FM broadcast listeners. On top of all of this, although the benefits of a foundation on localism may be desirable, many of the smaller public radio stations (and some of the larger ones) do little or nothing in the way of local programming and chiefly broadcast only the programs obtained from the satellite system.

Just as NPR justifies its position in legislation, however, home satellite listeners may also find support in Congressional declaration of policy, to wit:

> "it is in the public interest for the Federal Government to ensure that all citizens of the United States have access to public telecommunications services through all appropriate available telecommunications distribution technologies" (47 U.S.C. 396 (a)(9)) and "the Corporation [CPB] is authorized to...conduct...research...related to...the use of nonbroadcast communications technologies for the dissemination of noncommercial educational and cultural...radio programs[.]" (47 U.S.C. 396 (g)(2)(G))

It might also be argued that home satellite reception of the Public Radio satellite system would constitute an innovative use of such a system as is expressed as part of the legislative intent for the use of the Public Broadcasting Satellite Interconnection Fund (see House Report 100-825, p. 21., as quoted above).

A problem for FM broadcast listeners owning high quality audio systems is that, although NPR maintains extremely high quality audio throughout production of programs and their transmission via satellite, local broadcasters often compress and otherwise process their signals to simplify operation of station equipment and allow their station to be suitably heard over traffic and engine noise while listening in automobiles. Unfortunately, this often results in very low fidelity reception for home listeners.

These problems are not foreign to satellite audio subcarrier on video listening, where, in addition, the audio quality may be further degraded due to the many retransmissions involved in the connection of the signal (these signals are often taken off-air with an FM tuner and microwaved to satellite uplink locations before they are piggybacked onto satellite video broadcasts). Access to public radio programming via digital audio satellite signals would be welcomed by home audiophiles all across the country (and it would have been made much more feasible if NPR had converted to Ku-band, allowing dishes as small as 0.75 meters to be used, as PBS did).

Home taping of radio programs has been a concern of producers, particularly in the recording industry, ever since the introduction of the tape recorder some fifty years ago. Producers argue that the advent of digital recording and radio transmission now makes it possible to make perfect copies of broadcasts (despite the well documented position of many audiophiles who argue that such copies are nowhere near perfect) without any income paid to record companies, producers or artists, and they have fought for years to expand their rights and prevent home taping.

> " NPR "
>
> ***... since most of the money needed to create ... public radio programming comes from taxpayer dollars, neither NPR nor anyone else operating within the Public Radio satellite system should have the right to encrypt this programming or otherwise prevent home SCPC satellite listeners from receiving it.***

The introduction of the DAT recorder was delayed in this country due in large part to lobbying by the recording industry and, when it was finally introduced, consumer models of the recorders were required to have copy protection circuits built into them which would allow only a single-generation copy of a digital recording to be made. Lobbyists also succeeded in having a tax instituted on DAT tapes sold to consumers, with returns going to compensate producers, artists, and recording companies to make up for lost revenue due to home taping.

In spite of all these efforts and similar ones aimed at curbing home taping, including home video taping (which was objected to by officials in the motion picture industry), Congress has consistently upheld the right of consumers to make a single copy of any program delivered to their homes by radio or television transmission (including via satellite) as long as it is made for home use.

The Solution

Probably the most cogent argument presented by satellite home listeners in defense of their right to obtain NPR distributed programming is that, since most of the money needed to create, produce, and distribute via satellite public radio programming comes from taxpayer dollars, neither NPR nor anyone else operating within the Public Radio satellite system should have the right to encrypt this programming or otherwise prevent home SCPC satellite listeners from receiving it.

Some *ST* readers may well remember PBS's experiments with VideoCipher in the late 1980's and its effects on home satellite viewers. PBS was searching for an effective system for allowing stereo transmission of the audio part of its programming while still maintaining a monaural feed of the same so that affiliate stations who had not converted to stereo did not have to retrofit old equipment. Even though PBS operated its VideoCipher system in *fixed key mode*, thereby allowing viewers with VideoCipher modules to still view all of PBS's national programming service, there was an enormous outcry over this on the part of home satellite viewers.

Congress, in the same Public Telecommunications Act of 1988 which allocated $200 million for the Public Broadcasting Satellite Interconnection Fund, wrote legislation to protect the rights of home satellite viewers to receive PBS's satellite programming, to wit:

> "No person shall encrypt or continue to encrypt satellite delivered programs included in the National Program Service of the Public Broadcasting Service and intended for public viewing by retransmission by television broadcast stations; except that as long as at least one unencrypted satellite transmission of any program subject to this subsection is provided, this subsection

shall not prohibit additional encrypted satellite transmissions of the same program." (47 U.S.C. 605 (c))

This legislation led to the creation of the so called *PBS-X* analog service (Telestar 401 C-band, transponder 8) and, although satellite viewers no longer have three C-band feeds adjusted to different time zones to choose from, this one feed transmits all of the national programming service distributed by PBS. Support for this legislation was reflected by Senator Larry Pressler, who served on the Senate sub-committee charged with reviewing the Public Telecommunications Act of 1988, and contributed to the Senate Report, to wit:

> "PBS has a Congressional mandate to serve the American public. That includes satellite dish owners, who often have no other means of receiving PBS, especially in rural areas. And this means free, unscrambled access to PBS's entire program schedule. The satellite dish owner has paid for this service through his tax dollars and therefore has a right to receive the service without having to pay to descramble the programming." (Senate Report 100-444, p. 38.)

It is interesting to observe from Senator Pressler's language in this report that the subcommittees understood the word *scramble* in its broader sense, that is, the use of any system of transmission other than normal analog mode.

The question as to why Congress did not, at the time they were writing this legislation, extend these same home satellite owner protections to the Public Radio satellite system is a reasonable one to ask. Neither the Public Telecommunications Act of 1988, nor the later Public Telecommunications Act of 1992 (P.L. 102-356), nor the House nor Senate reports associated with these acts, nor the report required by Congress to be submitted by CPB under the 1988 Act detailing the satellite replacement needs of public radio and public television (submitted by CPB to Congress on 2 October 1989 and entitled *Report to Congress: Next Generation Public Radio and Public Television Satellite Interconnection Systems*) makes mention of the scrambling problem as applied to public radio.

Interestingly, although the imminent conversion to a digital transmission system is frequently mentioned, neither is there any language contained in these acts or reports to indicate that Congress or the Commerce Department or the Congressional subcommittees which reviewed the legislation were aware of NPR's intention to use their part of the Public Broadcasting Satellite Interconnection Fund to build a system which would intentionally prevent the public from receiving their satellite transmissions.

Quite possibly the issue just did not come up; at the time of the legislation NPR was still transmitting in an unscrambled analog format and the interests of satellite television viewers probably eclipsed the admittedly, in comparison, minority interests of satellite home radio listeners.

"NPR"

This author has been informed that talk has even taken place about restoring a single analog SCPC carrier (two would be necessary for stereo) with a limited amount of public radio programming for backyard SCPC listeners.

It may be that home satellite radio listeners will lobby Congress to extend the satellite viewer protections of PBS to listener protections for the Public Radio satellite system. It has not been determined how much revenue is allegedly lost when NPR affiliates retransmit satellite programming without paying for it and how much, if any, of a dent this puts on the budget of public radio.

The threat of lost revenue to home or illegal commercial tapers has also not been verified. (At least this has not been a problem for PBS's Home Video service, as perfect DigiCipher video feeds have been available to the public for over two years now and no reports of lost sales have been substantiated.) It could be that NPR might be required to find another way of policing its system against those who would use it to generate income in an illegal manner.

In the meantime, NPR is considering ways in which it might make some of its programming available to satellite listeners. It has been supplying a limited amount of programming to European satellite dish owners via the Astra satellite for some time now, and it could make arrangements with DBS providers in this country for inclusion of public radio programming within their regular audio services.

This author has been informed that talk has even taken place about restoring a single analog SCPC carrier (two would be necessary for stereo) with a limited amount of public radio programming for backyard SCPC listeners. This solution would not pass on the benefits of digital audio transmission to backyard users and would not provide all of the public radio programming available (keep in mind that as many as 22 separate SCPC carriers have been used simultaneously to deliver a wide variety of programming).

The best solution, at least from the point of view of home satellite SCPC listeners, may be that which would allow ComStream, or a licensee of the same, to market to the public the digital receivers needed to receive the Public Radio satellite system's signals.

Those home satellite dish owners who wish to express an opinion on the matter of the encryption of the Public Radio satellite system may do so by contacting their Congressional representatives and/or by writing or faxing the agencies listed below:

Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington, D.C. 20515
FAX: (202) 225-1919

Mr. Richard Carlson, President
Corporation for Public Broadcasting
901 E. Street, NW
Washington, D.C. 20004-2037
FAX: (202) 783-1020

Mr. Delano Lewis, President
National Public Radio
635 Massachusetts Avenue, NW
Washington, D.C. 20001-3753
FAX: (202) 414-3049 ST

By Jeff Wallach, Ph.D.
Dallas Remote Imaging Group

New LRPT Format Review

There has been a lot of interest in the new weather satellite picture transmission format that will be incorporated into the next generation of polar orbiting spacecraft. Starting with the launch of the European *METOP-1* satellite in 2002, Low resolution picture format transmission (LRPT) will provide a digital transmission of AVHRR imagery and atmospheric sounding data for the direct readout community.

The LRPT transmissions will be similar to the automatic picture transmission (APT) direct readout mode, but it will have some major differences. Upgrades to user groundstations will be required to receive and process the LRPT data.

NOAA plans to continue transmitting APT imagery until the NOAA-N and N' AVHRR imagery is no longer available or the satellites are decommissioned. This is not expected until 2005-2006, so there is still plenty of use for the current APT and HRPT ground station equipment.

The LRPT data transmission is based on a new standard for satellite data. Each instrument data is embedded into separate telemetry packets. This will allow a higher flexibility and improved data link quality because of the various error-checking systems allowed by these new protocols.

The LRPT data will consist of AVHRR, HIRS, AMSU-A and MHS. Other spacecraft sensor data may be added to LRPT by additional European payloads on the METOP series of satellites. The content of the LRPT data stream will be coordinated between NOAA and EUMETSAT.

The AVHRR data stream will provide either two or three channels of imagery depending on the data quality, complexity of the compression, link budget etc. In order to achieve and improved resolution of 1.1 km at nadir versus the exisiing 4 km for APT, the AVHRR data will be compressed with a compression ratio of 8. The AVHRR spatial resolution will be retained at 1.1 km at nadir, and approximately 7 km at the edge of the image scan.

Significantly, the LRPT data will be transmitted at 137.1 and/or 137.9125 MHz by the METOP satellites as well as the NOAA-N satellites. Thus, a change in receiver frequencies will be required. Other issues that may require upgrading the ground segment equipment include:

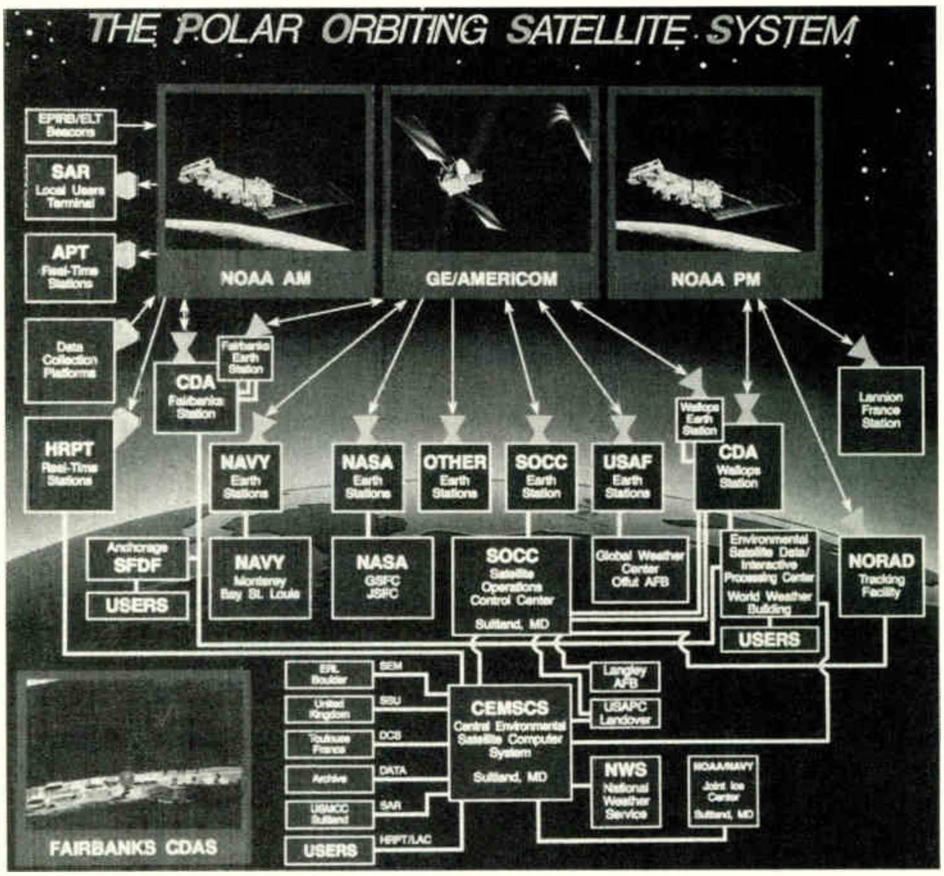


FIGURE 1

- LRPT will required a higher bandwidth of 150 kHz in order to transmit all the data to the user community (contrasted with approximately 40 kHz for APT)
- A replacement of an analog facsimile demodulator with a DQPSK demodulator and a special CCSDS packet interface will be required (current analog APT demodulators will not work with LRPT)
- Generally a Pentium-class microprocessor will be required to process the high data rates of the LRPT transmission

NOAA and EUMETSAT plan to provide software to process the data packets and to decompress the data. Display software and map projection software may also be provided by NOAA and EUMETSAT, as well as private organizations.

Speaking of POES......

Many of us who receive direct readout from the NOAA POES system take for granted the complexity involved in the space and ground segments of polar orbiting weather satellites. Simply turn on your computer, aim your antenna at the satellite, and start receiving the imagery, right?

Well, the NOAA POES constellation and ground stations are a highly complex, integrated system that deals with more than just APT and HRPT image transmission.

The NOAA POES constellation and ground stations are a highly complex, integrated system that deals with more than just APT and HRPT image transmission. NOAA/NESDIS has generated a nice composite diagram of the many segments of POES (see Figure 1 on previous page).

NOAA/NESDIS has generated a nice composite diagram of the many segments of POES, including the spacecraft, Satellite Operations Control Center, Suitland processing center, Navy, Air Force, NASA, and user earth stations, Command Data Acquisition Stations, and other ground space and ground segments. Figure 1 shows the many facets of POES.

FIGURE 2 *(see description at end of this month's column).*

Weather Satellite Conferences for 1997

There are several conferences scheduled for early 1997 that cover remote sensing and weather satellite imagery: Both of these conferences will provide timely updates on the NOAA POES and GOES programs and applications use of weather satellite imagery and other direct readout data. *Satellite Times* readers interested in remote sensing and direct readout will find value in these symposiums:

Satellite Applications Conference 1997
NOAA Conference On Satellite Applications
What Can The *Eyes In The Sky* Do For You?
March 4 - 6, 1997 Asheville, North Carolina USA

The themes for this conference are centered around:

- An information exchange among experienced and novice users;
- Exploration of unique and non-traditional applications;
- Exploration of blended products (multi-satellite; satellite/in-site; etc.

Concurrent sessions will be held, based on application:

- Commercial
- Research
- Operations
- Industry
- Agriculture
- Value-added
- Education

Registration Fees: Conference: $500. Note: All fees include continental breakfast, lunch and exhibitors' reception.

For more information write to: Satellite Applications Conference, c/o National Climatic Data Center, Climate Services Division, 151 Patton Avenue, Asheville, NC 28801-5001 USA. Send E-mail to: kmetcalf@ncdc.noaa.gov. Fax: 1-704-271-4876

West Chester University Satellites and Education Conference

This conference will be held on March 12-14, 1997 at West Chester University in West Chester, Pennsylvania, USA

The theme of the tenth anniversary conference will be "Sharing Environmental and Communications Satellite Technology." Invited speakers include:

- Al Gore, U.S. Vice President
- Bill Gates, Chairman and CEO, Microsoft Corporation
- Kathy Sullivan, former NASA Astronaut and President, COSI
- Perry Samson, Professor, Department of Atmospheric, Oceanic and Space Sciences, University of Michigan
- Robert Winokur, Assistant Administrator, NOAA/NESDIS

Early registration for this conference ends February 10, 1997. Registration fees for this three day conference is $175.00 by February 10, 1997, and $200.00 after that

An excellent source for technical information on NOAA POES and GOES satellites is the World Wide Web site for NOAA/NESDIS. Satellite transmission schedules, keplerian elements, daily updates and notifications, and a host of publications and technical reports are available.

date. Registration fee includes conference materials, continental breakfasts, luncheons, and breaks.

For more information, including exhibitors information, contact: Nancy McIntyre, 304 Recitation Hall, West Chester University, West Chester PA 19383, E-mail: nmcintyre@wcupa.edu, Fax: 1-610-436-3102 or telephone: 1-610-436-2393

TABLE 1: SATELLITE LAUNCH SCHEDULES

Satellite	Owner	Launch Date	Design Life
GOES-9	National Oceanic and Atmospheric Administration	May 23, 1995	5 years/Operational January 11, 1996
Sich 1	National Space Agency of Ukraine	August 31, 1995	1 year
Radarsat	Canadian Space Agency	November 4, 1995	5 years
IRS-1C	Indian Space Research Organization	November 28, 1995	3 years
IRS-P3	Indian Space Research Organization	March 21, 1996	3 years
Total Ozone Mapping Spectrometer (TOMS) Earth Probe	NASA		
July 2, 1996	2 years		
SeaStar	NASA	1st quarter 1996	5 years
Priroda module for Mir space station	Russian Space Agency	2nd quarter 1996	3 years
OKEAN-O	National Space Agency of Ukraine	2nd quarter 1996	1 year
Advanced Earth Observation Satellite (ADEOS)	National Space Development Agency of Japan	August 1996	3 years
China-Brazil Earth Resources Satellite (CBERS-1)	Brazilian National Institute of Space	4th quarter 1996	2 years
Feng Yun-2 (FY-2)	China Meterological Administration	1st quarter 1997	3 years
NOAA K	National Oceanic and Atmospheric Administration	3rd quarter 1997	2.5 years

Source: Committee on Earth Observation Satellites: Space News research

Remote Sensing Satellite Launch Schedules:

Several readers of *ST* have requested a listing of recent and future remote sensing satellite launches. Above is a recent listing for launches from 1995-1997 obtained from NOAA/NESDIS.

NOAA Publications/Technical Reports on the Internet

An excellent source for technical information on NOAA POES and GOES satellites is the World Wide Web site for NOAA/NESDIS. Satellite transmission schedules, keplerian elements, daily updates and notifications, and a host of publications and technical reports are available.

The primary site for the technical publications is: http://140.90.207.25:8080/EBB/ml/nic00.html. The following publications and technical reports may be obtained at this WWW site:

NOAA Publications and Technical Reports

(Note: Due to the length of these documents, some are broken into parts by chapter or section. Tables, graphs, and pictures have been included separately as GIF files.)

- NOAA Technical Report NESDIS 82: *An Introduction to the GOES I-M Imager and Sounder Instruments and the GVAR Retransmission Format* (November 1994)
- NOAA Technical Memorandum NESDIS 40: *The Geostationary Operational Environmental Satellite Data Collection System* (June 1994)
- June 1996 Satellite Direct Broadcast Services Symposium papers, preprint volume
- *NOAA Polar Orbiter Data Users Guide.* Also available as WordPerfect format and RTF (Rich Text Format) files via anonymous FTP.
- NOAA-K/L/M Level 1b data formats are available via anonymous ftp. Note: these are preliminary, draft documents subject to change.
- NOAA-J Advanced TIROS-N (ATN) Pamphlet: NASA and NOAA.
- *Introduction to GOES I-M.* An on-line tutorial describing the sensor and data changes that began with the launch of GOES-8, prepared by the Regional and Mesoscale Meteorology (RAMM) Team (NESDIS) at CIRA. Includes examples of improved GOES-8 data versus that of GOES-7.
- GOES I-M 3.9um Channel on-line Tutorial, prepared by the NESDIS RAMM Team. (See above)

Once connected to this site, you may find other NOAA/NESDIS and weather satellite related links on the Internet. For further information on this site, contact the NESDIS Satellite Information Team at: **satinfo@ssd.wwb.noaa.gov**

Some other interesting Internet weather satellite related sites include:

- Hurricane images, movie loops-National Climate Data Center **http://www.ncdc.noaa.gov/pub/data/images/olimages.html**

- HRPT images of Alaska and related areas **http://www.alaska.net:80/~nwsar/html/sat/sat.html**

- Canadian Radarsat imagery **http://www.ccrs.nrcan.gc.ca/ccrs/radarsat/rsate.html**

- **Polar Orbiting Weather Satellite Update**: (All frequencies reported are for the APT imagery)

U.S. NOAA Polar Orbiting Weather Satellites:

- **NOAA 9 137.620 MHz**
The imaging system on this twelve year old satellite has failed, but several other systems including the Solar Backscatter Ultraviolet radiometer are still functioning.
- **NOAA 10 137.500 MHz**
The APT transmitter on NOAA 10 is not operational, but good visible HRPT is

The Russians are not planning on launching the remaining Meteor spacecraft they have in inventory. They are planning on adding meteorological instruments to the RESURS 01-4 spacecraft that will be placed into a 835 km orbit in 1997. The first in the series of the upgraded Meteor 3M-1 spacecraft is projected to be launched in 1998.

still being transmitted by the spacecraft.

- **NOAA 11** This spacecraft is not operational
- **NOAA 12 137.500 MHz** This platform remains the primary southbound morning spacecraft and is transmitting APT and HRPT imagery
- **NOAA 14 137.620 MHz** Primary northbound afternoon spacecraft and transmitting good APT and HRPT imagery.
- **NOAA K** Scheduled for launch in early 1997. This satellite will be designated NOAA 15 upon orbital insertion.

Russian Meteor, Okean, and Sich Spacecraft:

- **Meteor 3-5 137.850 MHz** This satellite is five years old and is transmitting APT imagery on 137.850 MHz.
- **Meteor 2-21** This spacecraft is currently not transmitting
- **Meteor 3-6** Failed in 1995

The Russians are not planning on launching the remaining Meteor spacecraft they have in inventory. They are planning on adding meteorological instruments to the *RESURS 01-4* spacecraft that will be placed into a 835 km orbit in 1997. The first in the series of the upgraded *Meteor 3M-1* spacecraft is projected to be launched in 1998.

The Okean and Sich spacecraft (oceanographic imaging satellites, with side-looking radar, microwave, and visible imagery) continue to transmit over Europe at 137.400 MHz.

The next Chinese Feng Yun satellite (*Feng Yun 1C*) is due for launch in 1998. This satellite will not carry an APT transmitter. It will carry a new digital CHRPT radiometer which will not be compatible with existing HRPT ground stations.

HRPT Imagery

To commemorate the new higher quality printing and paper used in *Satellite Times*, we have included some composites of HRPT imagery.

Figure 2 on page 31 is the first test full-disk image from *GOES 9* taken on June 12, 1995. Figure 3 is a composite of Hurricane Fran imaged by NOAA 12 on September 4, 1996. This is 1 km HRPT image. And finally, Figure 4 is another composite image of Hurricane Hortense taken by *NOAA 14* on September 13, 1996. ST

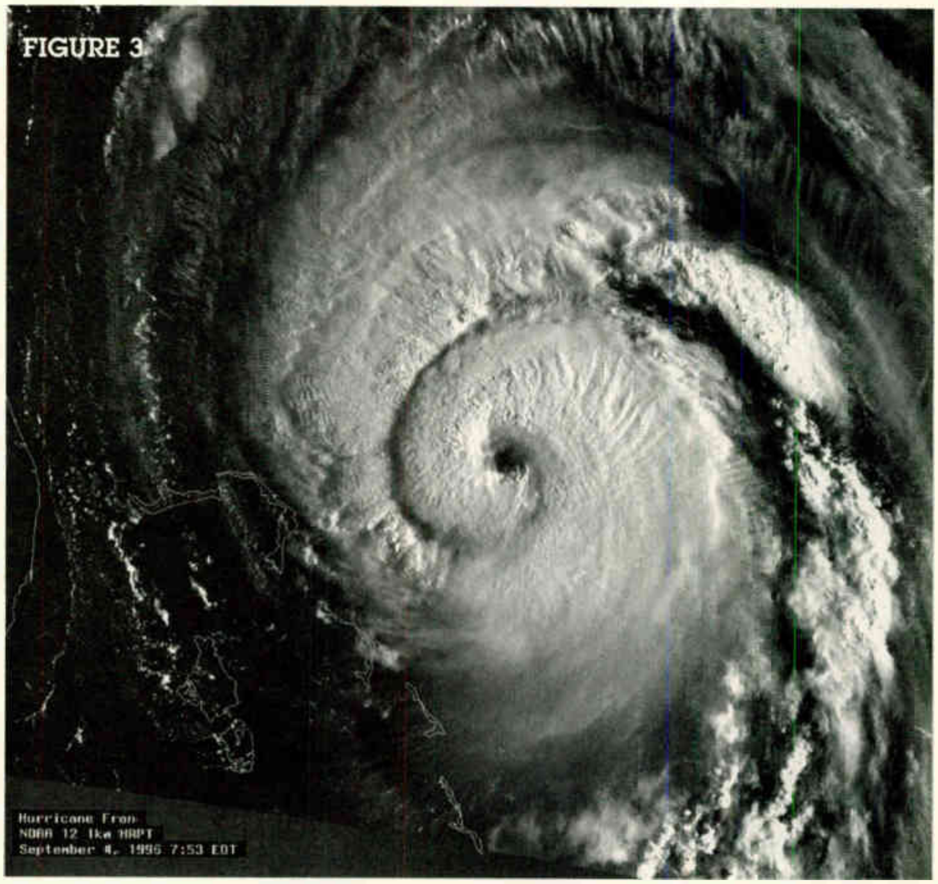


FIGURE 3

FIGURE 4

By John A. Magliacane
magliaco@email.njin.net

Digital OSCAR Communications

The Federal Communications Commission allow radio amateurs the privilege of using a myriad digital communication modes in various forms on the ham bands. Tuning across amateur frequencies, one might hear communications utilizing continuous wave (CW) telegraphy, radioteletype (RTTY), AMTOR, PACTOR, ASCII, and packet radio, just to name a few. These digital signals are modulated onto RF carriers using such methods as on/off keying (OOK), frequency shift keying (FSK), and phase shift keying (PSK).

In the world of amateur satellites, early OSCARs used CW and on/off keying to transmit telemetry information to ground stations through low-powered beacon transmitters they carried into earth orbit.

As technology advanced and home computers became popular, the digital communication modes, and the modulation methods that supported them, changed. Soon, CW shared telemetry downlink time with RTTY, ASCII, and packet radio. Specialized satellites were later designed that contained only digital communication transponders. These satellites are setting an important trend in amateur satellites.

Digital communications have a significant and growing impact in the telecommunications industry, and the non-commercial world of amateur radio is no different. In fact, amateur radio provides opportunities for research and experimentation within the digital communications field not possible or practical in the commercial world. It is, therefore, important to have a basic understanding of digital communications and the OSCAR satellites that support them if the amateur radio service is to continue to grow with advances in technology.

Radio Basics 101

Basically, radio transmissions are accomplished by modulating a radio frequency (RF) carrier with intelligence in a circuit known as a modulator. The modulated RF carrier is then amplified and radiated into space through an antenna system. The intelligence the RF signal carries may contain analog information, such as voice or video, or digital information, such as Morse telegraphy, packet radio, or any other form of binary data sent in a serial fashion.

There are three aspects of an RF carrier that may be modulated in order to carry intelligence. Either the amplitude of the RF carrier is modulated, or its frequency is modulated, or its instantaneous phase is modulated. In some cases, such as commercial broadcasts of color television, AM stereo, or even modern telephone modems, a combination of phase, frequency, and amplitude modulation is used to convey several discrete channels of intelligence on a single carrier. However, this combination of modulation methods is rarely seen in present day amateur radio communications.

Morse: The Essential Language

The first form of amplitude modulation used by amateur radio operators consisted of on/off keying of an RF carrier by Morse telegraphy.

Commonly referred to as CW, Morse telegraphy is still in wide use today for both terrestrial and satellite communications. CW was the first mode of communications adopted by OSCAR satellites for the transmission of telemetry information through beacon transmitters carried on amateur spacecraft, mainly because of its simplicity and communications effectiveness. It is still widely used today.

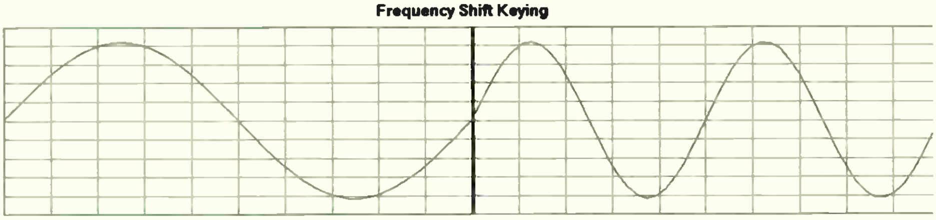
Morse telegraphy is typically copied by ear. Satellite telemetry conveyed in CW is interpreted through the use of look-up tables and calibration equations. One of the advantages of Morse telegraphy is that decoding is done by ear and requires no data demodulator or specialized electronics for reception.

During the mid 1970s, OSCAR satellites adopted more advanced techniques for making telemetry transmissions. *OSCAR 7*, launched on November 15, 1974, was the first amateur satellite to use radioteletype (RTTY) for the transmission of spacecraft telemetry. Frequency shift keying (FSK) modulation was used for the transmission of RTTY signals.

Radioteletype could transmit information at a higher rate than at speeds that could be comfortably copied by ear using CW. The speed at which data can be transferred between transmitter and receiver is an important consideration for low-earth orbiting satellites with limited access times. The disadvantage of RTTY was that it required expensive or bulky terminal equipment for reception, and was later shown to be relatively inefficient in terms of data rate per unit of power—another important consideration when dealing with low-powered OSCAR satellites with limited power supplies. For this reason, RTTY is rarely used today by OSCAR spacecraft.

During the 1980s, the FCC approved the use of the American Standard for Information Interchange (ASCII) for communications on amateur frequencies. This started a trend toward using more advanced data encoding techniques directly compatible with the home computers that were then becoming popular. This compatibility al-

Frequency Shift Keying



Frequency shift keying uses discrete carrier frequencies to represent each binary logic level. This example represents coherent FSK. Note that both mark and space tones are harmonically related. UoSAT-OSCAR-9 and -11 used AFSK of this type.

Like RTTY, ASCII required a data demodulator to be used at ground stations to convert the signals received from the satellite to voltage levels compatible with the computer performing the data processing functions. As in RTTY, frequency shift keying was the modulation most often used for making ASCII transmissions.

lowed PCs to be used to interpret, store, and directly process data received from space.

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UoSAT-OSCAR-9, launched on October 6, 1981, was the first amateur satellite to adopt advanced forms of digital transmissions such as ASCII for transmitting spacecraft telemetry.

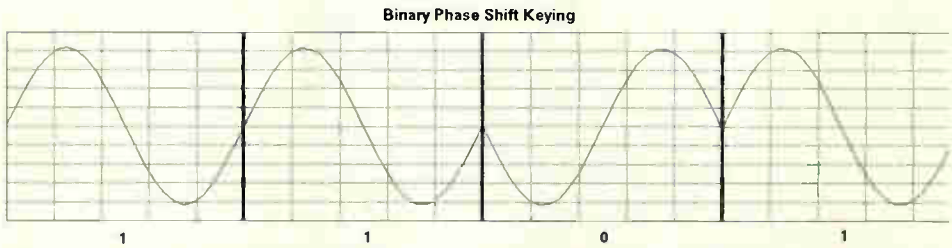
UoSAT-OSCAR-9, and later its younger sister *UoSAT-OSCAR-11*, assigned audio tones of 1200 Hz and 2400 Hz to represent the digital ones and zeros (marks and spaces) that comprised the ASCII serial data stream used to transmit spacecraft telemetry information to ground stations.

This form of modulation is known as audio frequency shift keying, or AFSK. The early UoSAT satellites used AFSK audio tones to modulate a narrowband FM beacon transmitter, making ground station reception as easy as turning on a 2-meter FM rig. The problem, of course, was demodulating the mark and space tones in ways that would be least affected by noise, and converting those audio tones to the appropriate logic levels suitable for interpretation by a home computer.

Also during the early 80's, AFSK-FM was adopted by early packet radio pioneers who used FM voice transceivers and surplus Bell 202 telephone modems that were widely available at the time. This combination provided a quick, easy, and low-cost method for transmitting digital information using a commonly available voice-grade FM voice transmitter without the need for making any circuit modifications to the communications equipment.

There was, however, a price to pay for this simplicity. AFSK-FM is essentially two FM signals in one, and as such, is terribly inefficient in terms of bandwidth and communication effectiveness. AFSK-FM requires a very strong signal for reliable communications-much higher than if other modulation methods are used.

Steve Goode, K9NG, studied this situation with respect to 1200 baud packet radio communications and concluded that a signal level that produced at least 25 dB of receiver quieting was required for reliable packet radio communications using AFSK-FM. This strong signal level is not easy to realize from OSCAR satellites operating many miles from earth with only a few hundred milliwatts of transmitter power. Clearly, a better solution was needed if digital communications were to be effective via OSCAR satellites.



Binary phase shift keying uses reversals in carrier phase to represent different binary logic levels. An accurate phase reference is required for proper demodulation.

Coherent Communications and BPSK

For many years, a small group of amateur radio operators and low frequency radio enthusiasts (LOWFERS) have been experimenting with coherent continuous wave (CCW) communications. CCW permits the detection of radio signals at levels too weak to be copied by ear, and allows transmitter power levels to be reduced dramatically as a result. CCW achieves its stellar weak signal performance by being sensitive not only to the frequency and amplitude of the desired radio signal, but also to its phase. Coherent CW achieves high signal sensitivity while remaining relatively immune to interfering signals and noise since these undesired signals have random frequency and phase characteristics compared to the desired signal.

Coherent CW is great for Morse telegraphy communications, but it can be shown that if the phase of the RF carrier were modulated instead of its amplitude, an additional 6 dB in signal-to-noise ratio could be realized over CCW's on/off keying technique, without any increase in transmitter output power. The 6 dB advantage comes when the phase modulation is antipodal—that is, it shifts by exactly 180 degree intervals. Phase shift keying comes in many different varieties. Antipodal PSK is commonly referred to as binary phase shift keying (BPSK).

BPSK is a very robust form of digital modulation and has been used to good advantage in copying extremely weak signals from several interplantery deep space probes. BPSK was adopted by the *AMSAT-OSCAR-10* and *AMSAT-OSCAR-13* amateur satellites for telemetry transmissions, and later by several other OSCARs carrying digital transponders.

The problem with coherent communications is that proper signal demodulation requires a reference carrier with which to compare the received signal in a synchronous phase detector. A phase detector functions by comparing two signals and producing an output voltage based on how well those two signals match in terms of frequency and phase. If the frequency and phase of both signals match, a voltage of a certain polarity is produced, whereas if both signals are completely out of phase, an output voltage of opposite polarity is produced. Finally, if both signals are 90 or 270 degrees out of phase, the phase detector produces no output voltage.

Although BPSK offers a tremendous advantage in terms of signal-to-noise ratio over FSK and on/off keying, its reception can be a bit tricky. If viewed in the frequency domain, a BPSK signal may be thought of as being a double sideband (DSB) suppressed carrier AM signal. This is not too different from the single sideband suppressed (SSB) carrier AM that is popular on the HF ham bands for voice communications. Proper demodulation requires re-insertion of a locally generated carrier having identical frequency and phase char-

PACSATs operating at a data rate of 1200 bits per second (BPS) respond to FSK uplink signals that have been Manchester encoded. Manchester encoding modulates the transmit data with a carrier equal in frequency to the bit rate (1200 Hz).

acteristics as the carrier suppressed in the BPSK transmitter.

The technique is similar to that used to receive single sideband voice transmissions, except that in the case of SSB the phase of the locally generated carrier (beat frequency oscillator, or BFO) is unimportant, since only one sideband is transmitted. Compounding the problem of requiring an accurate frequency and phase reference for properly demodulating BPSK signals is Doppler shift, which is inherent in all amateur satellite communications. Doppler shift causes the radio frequency of the signal received from the satellite to constantly drift lower in frequency as the slant range to the satellite changes during a pass, making it even more difficult to perform proper phase detection.

Since the BPSK carrier is suppressed by the BPSK transmitter, the key to demodulating BPSK emissions from satellites lies in the regeneration of the needed carrier reference from the upper and lower sideband components of the BPSK signal. Two popular methods exist for doing this. One method uses a circuit known as a Costas Loop, while the second method uses a Squaring Loop. In theory, the Costas Loop offers slightly better performance at the expense of added circuit complexity. The simpler Squaring Loop, however, can be made to provide performance comparable to that of the Costas Loop with additional filtering.

Other issues come into play when comparing the sensitivity of a BPSK receiver. Radio signals received via satellite often fade in amplitude as the slant range to the satellite changes; signal polarization also changes during a pass. In order to accommodate a wide range of signal levels, some BPSK demodulator designs incorporate amplitude limiters. Limiters are often used in FM receivers and are responsible for a characteristic in FM communications known as the "capture effect." If more than one signal is received at the same time on the same frequency, the stronger signal will "capture" the limiter and be the only signal detected by the receiver. If the stronger signal happens to be noise, the desired signal will be completely lost.

Designing a BPSK demodulator with non-limiting automatic gain control (AGC) has been shown to produce a significant weak signal sensitivity advantage over designs incorporating hard limiting. Furthermore, post detection filtering that closely matches the bandwidth of the transmitted signal allows the detection of BPSK signals, even if they are received at a level below the ambient noise.

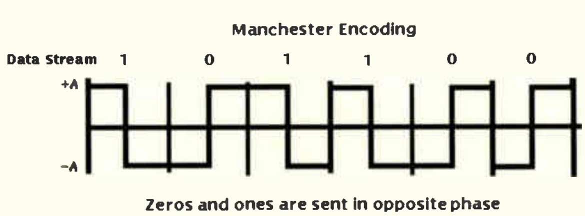
BPSK signals are typically copied with receivers designed for reception of single sideband (SSB) voice transmissions. SSB receivers are essentially linear frequency converters that convert radio frequency signals to the audio spectrum where they can be copied by ear. Virtually all ground stations that access the 1200 baud PACSAT satellites use SSB receivers and BPSK demodulators for downlink reception. Uplink transmissions, however, use FSK and a data encoding technique named after its birthplace in Manchester, England.

Manchester Encoding

PACSATs operating at a data rate of 1200 bits per second (BPS) respond to FSK uplink signals that have been Manchester encoded. Manchester encoding modulates the transmit data with a carrier equal in frequency to the bit rate (1200 Hz). The resulting product is actually BPSK with a suppressed carrier frequency of 1200 Hz, although it is not necessarily handled as such. Manchester code is also known as "split phase."

In terms of PACSAT communications, signals from a standard packet radio terminal node controller (TNC) are combined to produce Manchester code in a phase modulator, the output of which is low-pass filtered and used to frequency modulate an FM voice transmitter, producing FSK. Manchester encoding eliminates the DC component of a digital data stream, allowing it to pass without distortion through the speech circuits of an FM voice transmitter. A direct connection to the FM varactor diode is not needed for 1200 bit per second PACSAT communications.

Even phase modulated voice transmitters can be used to generate PACSAT uplinks. The lack of a DC component also makes a Manchester receiver immune to small changes in carrier frequency, such as those caused by Doppler shift, and allows for easy bit clock extraction by the receiver.



Manchester encoding is similar to BPSK in that changing logic levels are represented by reversals in carrier phase.In this example, a falling edge within a bit interval represents a logic "1", while a rising edge within a bit interval represents a logic "0".

PACSAT Receivers

The PACSAT receivers carried onboard the *AMSAT-OSCAR-16, WEBERSAT-OSCAR-18*, and *LUSAT-OSCAR-19* satellites were designed around a Motorola MC3362 dual conversion single chip FM receiver, with one complete receiver chip employed for each of the four uplink channels on each satellite. A single GaAsFET-based frequency downconverter with an intermediate frequency (IF) in the 40 to 50 MHz range is shared by all PACSAT uplink receivers.

The first IF in each FM receiver chip operates at a center frequency of 10.7 MHz, and is preceed by a filter with a very sharp skirt. The frequency response of the filter rolls off by approximately 20 dB at 20 kHz, and achieves a total of 70 dB of adjacent channel rejection. Impedance matching techniques used on the input and output of each IF filter minimizes passband ripple to approximately one decibel.

Rather than using a final IF frequency of 455 kHz as is typical in applications using the Motorola MC3362, PACSAT designers instead used a final IF frequency of 1.8 MHz in an effort to realize a highly linear FM discriminator characteristic across the entire 20 kHz bandwidth of the uplink channel. While PACSAT receivers employ no automatic frequency control to compensate for Doppler shift, ground stations employing approximately 3 kHz of peak frequency deviation need not be concerned with Doppler shift of their uplink signals.

The intended result of this discussion is to show that there is a method to the madness of amateur data communications, and that data transmission protocols and modulation methods are not subjects that are shrouded in secrecy.

High Speed Data Communications

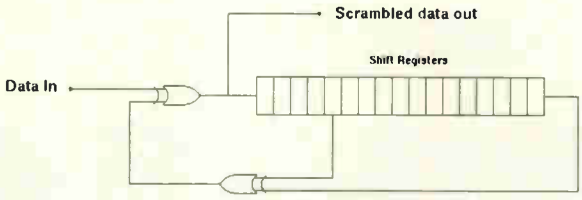
High speed data communications by satellite is currently no different than terrestrial high speed data communications, except for the fact that satellite communications are full duplex, while terrestrial communications, unless crossband, typically are not.

The same hardware is used in either case, and data is transferred at 9600 bits per second (also referred to as "9k6") using frequency shift keying (FSK). Because high speed serial data occupies a wider frequency bandwidth than audio frequencies typically used for voice communications, standard FM voice communications equipment can be used for high speed data communications, provided that direct connections to the receiver's discriminator and transmitter's varactor diode are made. These connections are needed to ensure a response characteristic that is flat in terms of frequency and phase across the entire bandwidth of the receiver. Such characteristics are a necessity for high quality data communications.

It is interesting to point out that 9600 bit per second FSK communications require no more RF bandwidth than that required by 1200 bit per second AFSK-FM. In fact, 9600 bps data communications require slightly less. However, in order to realize this bandwidth, the transmitted data must be first processed through a low-pass filter having a low group delay and sharp cutoff prior to modulation. In addition, high-speed data is often "scrambled" to randomize the data pattern and provide for rapid bit clock recovery in the receiver and minimize the DC component of the signal, making automatic frequency control (AFC) both practical and effective.

Psuedo Random Scrambling

As stated earlier, 1200 bps FSK data is Manchester encoded to eliminate the DC component of transmitted data. In doing so, however, it effectively doubles the bandwidth of the transmitted signal. This is not a major concern in terms of 1200 bit per second data communications, but carries a negative impact in terms of 9600 bps communications.



Circuit used to scramble 9600 bps data transmissions

Circuit representative of those used to scramble or randomize 9600 bps FSK data transmissions. A complementary circuit is used at the receiver to restore the data stream to its original format.

In an effort to conserve bandwidth, a different approach is taken to reduce the DC component of high speed binary data. Instead of Manchester encoding, high speed is randomized or scrambled prior to transmission, and unscrambled during reception. Scrambling significantly reduces the chances of transmitting long strings of zeros and ones, which by virtue of their constant and unchanging polarity, carry a strong DC component. It is the DC component of a digital signal that makes receiver clock extraction slow and unreliable, data carrier detection difficult, and receiver automatic frequency control (AFC) nearly impossible.

The Federal Communications Commission allows several forms of data scrambling to facilitate high speed data and spread spectrum communications on amateur frequencies. Note, however, that scrambling is not used to obscure the meaning of the transmitted signal, since the methods used to scramble data on amateur frequencies are published and FCC approved for use by amateurs.

The method most often used to scramble high speed data normally employs a cascaded string of shift registers. Seventeen such devices are typically used. Taps made to the output of the 5th and 17th shift register are combined with the 9600 bit per second data in a pair of exclusive OR (XOR) gates. During transmit, the shift registers are driven by a bit clock derived from the sending TNC. On receive, the process is reversed, and the bit clock is derived from the clock extraction circuits of the FSK data demodulator. It is interesting to note that if scrambled data transmissions are monitored on a narrowband FM voice receiver, the psuedo random nature of the data's content makes the transmissions sound very much like the white noise of an unsquelched FM receiver.

Data scrambling is not a panacea, by any means. While scrambling techniques reduce the DC component of serial data transmissions, they do not eliminate it completely. As a result, a frequency response down to 5 Hz, or preferably DC, is required by the modem and the radio equipment with which it is used. There is also some concern as to whether scrambling reduces the bit error rate of a communications channel, since an incorrectly received bit fed into a string of shift registers will corrupt bits received at a later time. If a corrupted bit is received at the end of one packet, it can destroy the next packet received, even if the second packet is received without error. Nevertheless, the data scambling and unscrambling technique described here is highly effective and is used by most 9600 bps terrestrial and all satellite data communication links.

Conclusion

The intended result of this discussion is to show that there is a method to the madness of amateur data communications, and that data transmission protocols and modulation methods are not subjects that are shrouded in secrecy. In some areas, modulation methods are selected for simplicity. In other areas, they are chosen because of their performance superiority over other methods.

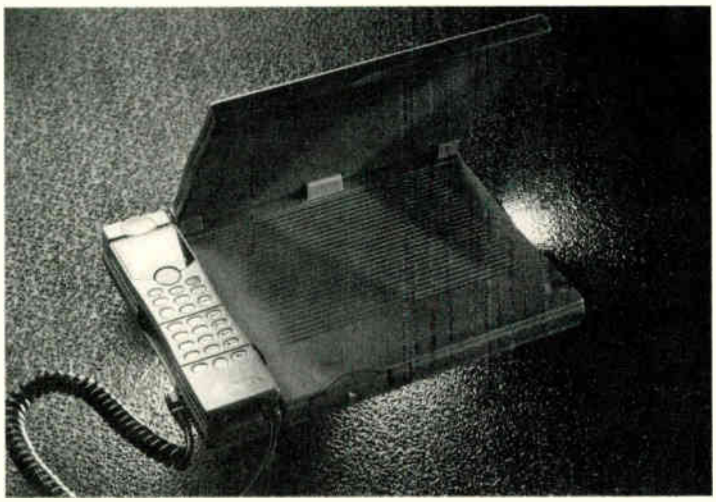
The entire subject of digital communications and the OSCARs is far too detailed to effectively cover in this column. However, those interested in a more in-depth understanding of this subject matter are encouraged to consider reading *Packet: Speed, More Speed and Applications*, published by the ARRL, 225 Main Street, Newington, CT 06111. This book not only covers the subject of data communications in depth, but also provides block diagrams and schematics of projects that can further the understanding of the concepts used to convey digital information on amateur frequencies.

See you on the birds! ST

By Donald E. Dickerson, N9CUE

World's Smallest Satellite Terminal?

The world's smallest commercially available satellite terminal will soon be on the market. It's called Planet 1 and it is the size of your laptop computer measuring 8.3 x 9.5 x 1.6 inches. This self-contained satellite terminal weighs only six pounds. It will allow you to communicate with virtually anyone, anywhere in the world through a series of four geostationary satellites.



Planet 1 is expected to be the world's first portable, global personal satellite communications system. This notebook-sized satellite phone is manufactured by NEC America and will provide digital communications services via Inmarsat-3 satellites. That's right, the people of Inmarsat are at it again. The system is designed to enable individuals living and traveling in remote areas to call anywhere in the world on a portable phone that will be inexpensive, compact, and easy to use.

Planet 1 will be able to provide global roaming, voice mail, short messaging, call forwarding, caller ID, and Internet connection. Subscribers Identification Modules (SIMs) are issued to improve security and consolidate billing for both cellular and satellite services. The SIM is simply a credit card which allows access to the keyboard of the satellite terminal at the time of use. Companies can form phone pools in which employees are assigned SIM cards and share a single phone as needed.

The Planet 1 terminal has a remote antenna for high gain applications. The 4.8 Kbps voice, 2.4 Kbps fax is Hayes compatible in data mode. It has an intelligent LCD multilingual display, back-lit keys, and user-friendly handset.

Planet 1 Inmarsat services, which are provided by Comsat in North America, will use a new network of digital satellites. The first of these third generation Inmarsat spacecraft was launched in April of this year and placed in service over the Indian Ocean were it will serve Russia, Africa, the Middle East, Japan, China, India, Asia, and western Australia. A second spacecraft was launched in September and placed in geostationary orbit over the Atlantic to serve the Eastern United States and Canada, South America, Africa, Europe, and the Middle East.

This month (January 1997), a third satellite will be launched and placed over the Atlantic to service all of North and South America, Europe, and North Central Africa. In May of 1997 the Pacific rim will get its own third generation Inmarsat satellite. A spare will be sent aloft in October of 1997.

The launch of the first third-generation Inmarsat spacecraft was unique not only because it will be one of the first world phone providers in service nor because it uses a new fleet of digital, high power satellites, but for another reason as well. It was the first completely commercial launch of a communications satellite. Inmarsat Headquarters in London controlled the launch and orbit portion of the satellite's trajectory, while leased ground stations in Italy, China, and two in Canada maintained contact with the satellite throughout the launch. Gateway stations, used to interface with public telephone networks and cellular systems, will be located in France, Norway, Australia, Greece, Turkey, and Japan.

This third generation spacecraft is much more powerful than its predecessors and uses five separate high gain spot beam antennas. The spot beams allow for system management of services as never before. The beams can be repositioned over land mass areas where there is the greatest demand for services and permit a distinction between national and international calls, enabling new pricing strategies to be devised. The four-satellite network will provide 2,200 channels for communications.

According to Virginia Brooks, Manager of Network Access Technologies, "Planet 1 is an important step in the development of the information skyway a wireless public information highway that brings the power of our communications technologies for voice and data down to a personal level throughout the world."

Just two years ago Inmarsat brought out a new portable digital satellite terminal for use with their current fleet of satellites. This terminal is much like the Planet 1 terminal in operation. It is a little larger as it measures 9 x 11 x 2 inches.

Known as an M-terminal, it fit into a brief case and has become very popular in its own right. If any of you have tuned the HF utility bands in SSB, you know there are certain frequencies that are known to be used by that unique type of businessman known as a drug smuggler. In recent years, this high frequency radio traffic has fallen off considerably, due in part to the introduction of the M-terminal. Most major drug traffickers have upgraded to satellite communications, leaving the HF bands to the "small fry," as it were.

Current Technology

Well, if you intend to pull signals off these satellites do not let all this talk of digital terminals deter you. While digital is the wave of the future, there are over 10,000 analog stations using unencrypted FM voice terminals on Inmarsat satellites worldwide.

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Inmarsat's current fleet of satellites can be found at the following location: 15.5°W (F-2), 55.0°W (F-4), 192.0°W (F-3) and 295.5°W (F-1).

During national emergencies, natural disasters, and military operations all four Inmarsats can fill to capacity very quickly. When this happens Inmarsat rolls excess traffic over to two Mareces satellites they lease from the European Space Agency (ESA). These satellites are located at 117.5°E and 26.0°W.

Who might you hear on these satellites? Ships, yachts, shortwave broadcasters, disaster relief, the Army, Navy or Air Force, and national news services to name a few. Virtually any type station you have heard on HF frequencies you can find on Inmarsat.

Current frequency allocations allow Inmarsat satellites to operate in the 1.5 GHz band. Ship communications are downlinked on 1530-1544 MHz. Mobile and portable on 1544-1545 MHz and aero communications are downlinked on 1545-1560 MHz on various Inmarsat spacecraft. The satellites use a 1626-1646 MHz uplink band. Gateway stations uplink signals to the spacecraft on 6.4 GHz and downlink on 3.6 GHz.

How to Hear Them

Now that you know what is up there and where, you might like to know how to tune in on some of the action. First, you will need a dish antenna: don't panic, it's not as bad as you think. Then you will have to have a feedhorn and an LNA for 1.5 GHz, a DC block, (more about that later), and a receiver that will tune 1.5 GHz.

Let's start on the roof. Bigger is better as a general rule of thumb when it comes to antennas in general. That was especially true in the case of the early C-band TV satellites. Fortunately, with the Inmarsats you can get by with a dish as small as two feet in diameter. Remember, these are relatively high power satellites and you are going to be pulling an audio signal off the bird. This means you don't need the same gain figures you would need if you were going to try to get a snow-free picture instead. This should be good news to anyone on a budget or who lives in an apartment.

If you already have a C-band antenna you can simply add a 1.5 GHz feedhorn to your dish and you are on your way. If you happen to already be equipped to tune in signals from weather satellites you already have the basic Inmarsat station. You can use the same feedhorn and line amps; you only tune a slightly lower frequency range.

The feedhorn can be homemade if you like. You can make one out of a two pound coffee can. Taggart's *Weather Satellite Handbook* has a feed horn plan that can be used, or you can use the plans from John Wilson's recent articles in *Monitoring Times*. For more information on John's articles and a starter kit for putting an Inmarsat station together, write John at 6413 Bull Hill Rd, Prince George, Virginia 23875, or call him at (804) 862-1262. Tell him the *ST PCS* column sent you.

You will then want to pull the signal off the TVRO or dish antenna feed line. Before you connect any feed line or coax from a TVRO type antenna you must run the signal through a DC block or through tap. This will remove the DC voltage from the line and prevent you from destroying your receiver. (Failing to follow this advice has caused many a radio hobbiest to take up gardening). Then connect the coax to the antenna connection on your receiver and you are ready to go.

All the equipment you need for an Inmarsat station can be purchased from suppliers like Swagur Enterprises who have specially priced kits. They have additional equipment you can use to enhance the signal you pull off these satellites. For example, with a Swagursat unit you can pull the signal off the IF output of an Icom 7000/7100/8500 at the proper bandwidth, which gives better fidelity and amplification.

This just about rounds out our look at what Inmarsat is doing to provide worldwide satellite communications. Inmarsat has been there since the beginning and is still providing leading edge technological innovation in personal communication satellites. ST

Satellite Listening Post

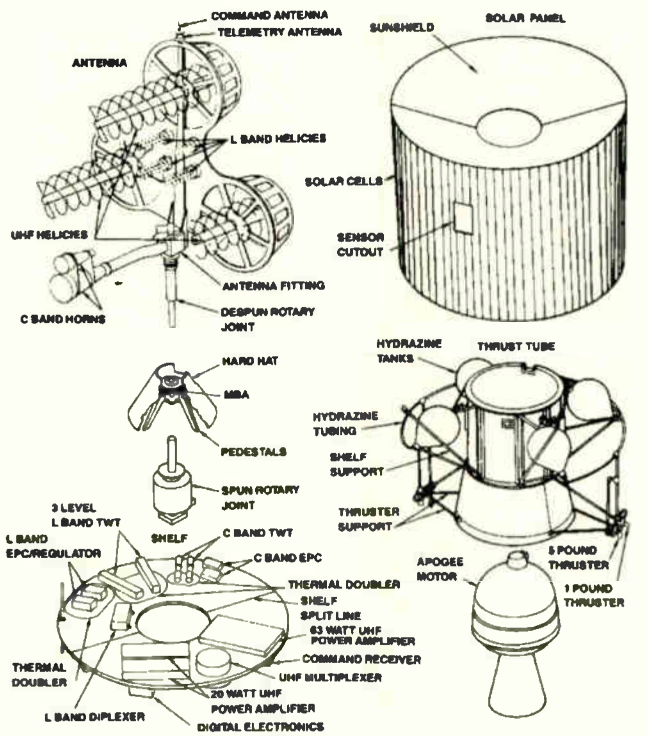
By Keith Stein
kstein@erols.com

Astronauts Mixing with the Military Band

Happy New Year, and welcome to another year of the *Satellite Listening Post.*

Well, another outstanding Grove Communications Expo has been put in the Grove history books, but a sad announcement follows. It has been decided that the 1996 Expo is the last one. The Groves have decided they need to put their energies elsewhere.

But 1997 is still going to be a outstanding year: get ready for the International Space Station (ISS). If all goes according to plan, the first piece of ISS will be launched into orbit on November 1, 1997, aboard a Russian Proton rocket. That brings us to our first order of business, the space shuttle in the UHF-band.



Exploded view of Marisat Spacecraft

Monitoring Shuttle UHF Voice

"Can I monitor the UHF air-to-ground voice communications directly from the space shuttle?" is another one of those million dollar questions asked by every hobbyist. The answer is yes, but only during portions of its mission and depending upon its orbit.

The UHF frequencies listed below are usually confined to launch, spacewalks, and landings only: at all other times an S-band shuttle-to-relay satellite-to-ground system is used. Listening posts on the East Coast of the U.S. have the best chance of catching shuttle direct voice transmissions during launch. Everyone has a chance of monitoring a spacewalk. Florida and California residents would be best for landings. An average UHF receiver (225-400 MHz) with a simple discone antenna will do the trick. Give it a try and let us know what you hear.

243.000 (AM) Space Shuttle Emergency Voice Channel
259.700 (AM) Space Shuttle Primary Voice Channel
279.000 (AM) Space Shuttle EVA Voice Channel
296.800 (AM) Space Shuttle Voice Channel

MARISAT

In the early 1900's the primary way of communications for the Navy was the high frequency band (HF). In April 1976 things changed with the first MARISAT satellite positioned at 105.5 degrees West in geostationary orbit.

These satellites are orbiting over the Atlantic, Pacific, and Indian Oceans. Recent reports indicate the possibly that the U.S. Drug Enforcement Agency (DEA) is using this constellation for operations in Central America. Some traffic has been heard in the clear on 254.15 MHz.

For more details on this satellite system, check out the March/April 95 issue of *Satellite Times.*

248.850 500-kHz	Wideband Channel 1
248.875 500-kHz	Wideband Channel 2
248.900 500-kHz	Wideband Channel 3
248.925 500-kHz	Wideband Channel 4
248.950 500-kHz	Wideband Channel 5
248.975 500-kHz	Wideband Channel 6
249.000 500-kHz	Wideband Channel 7
249.025 500-kHz	Wideband Channel 8
249.050 500-kHz	Wideband Channel 9
249.075 500-kHz	Wideband Channel 10
249.100 500-kHz	Wideband Channel 11
249.125 500-kHz	Wideband Channel 12
249.150 500-kHz	Wideband Channel 13
249.175 500-kHz	Wideband Channel 14
249.200 500-kHz	Wideband Channel 15
249.225 500-kHz	Wideband Channel 16
249.250 500-kHz	Wideband Channel 17
249.275 500-kHz	Wideband Channel 18
249.300 500-kHz	Wideband Channel 19
249.325 500-kHz	Wideband Channel 20
254.150 25-kHz	Narrowband Channel A
257.550 25-kHz	Narrowband Channel B

Starlink Project Ready for Operational Phase

NASA's satellite telemetry and return link (STARLink) project utilizes an ER-2 aircraft—the civilian equivalent of the military U-2 spy plane—to conduct stratospheric, tropospheric, earth resources, and disaster support flights. The aircraft can fly to the range of 70,000 ft; in December 1996, the 76,000-ft. range was attempted. The project utilizes NASA's Tracking and Data Relay Satellite constellation to transmit science data to ground stations. The first test flights were conducted in July 1995 with error free results, operational status is set for this year.

Three NASA ER-2 aircraft are based at Moffett Federal Airfield, California, and use the callsigns NASA 706, NASA 708, and NASA 709.

Moffett Federal Airfield

Common Traffic Advisory Freq.	126.200 MHz
Automatic Terminal Information Service	283.000 MHz
Bay Approach Control	120.100 MHz
Bay Approach Control	134.500 MHz
BAY Approach Control	317.600 MHz
Bay Approach Control	350.800 MHz
Bay Approach Control	346.000 MHz
Tower	126.200 MHz
Tower	353.200 MHz
Tower	340.200 MHz
Ground Control	121.850 MHz
Ground Control	336.400 MHz
Bay Departure Control	121.300 MHz
Bay Departure Control	322.000 MHz

The Interdepartment Radio Advisory Committee (IRAC) has denied the use of the 117.975-137 MHz band to operate the International Space Station VHF Voice Communication Link (IVVCL). A resubmission to use the 138-143.5 MHz band has been submitted, but this would be in conflict with military fixed service utilization.

Clearance Delivery .... 380.800 MHz
Base Operations .... 251.700 MHz
Army Operations .... 34.500 MHz
Army Operations .... 124.950 MHz
Army Operations .... 241.200 MHz

International Space Station Frequency Request

The Interdepartment Radio Advisory Committee (IRAC) has denied the use of the 117.975-137 MHz band to operate the International Space Station VHF Voice Communication Link (IVVCL). A resubmission to use the 138-143.5 MHz band has been submitted, but this would be in conflict with military fixed service utilization. Stay tuned.

TDRSS Will Support New Boeing Sea Launch Missions

Boeing Sea Launch managers and engineers were briefed on TDRSS expandable launch vehicle support in September. The new Boeing SeaLaunch service will use Russian ELVs launched from a converted off shore oil platform in the Pacific Ocean. Boeing indicated their plan is to get one successful launch off in the first or second quarter of 1998. After this first mission, they plan to convert to TDRSS for launch support. The new launch service has already sold 15 launches so far.

Bermuda Next on the Chopping Block

NASA's Office of Space Communications, Washington, DC, plans to close the Bermuda tracking station in the Atlantic Ocean by September 30, 1998. Bermuda's primary role has been to support space shuttle launch phases, but the need will be eliminated when NASA's Tracking and Data Relay Satellite (TDRS) takes over in November 1997.

The external tank (ET) flight termination system (FTS) has been removed, eliminating the need for a UHF command destruct from Bermuda (416.5 MHz).

UHF air-to-ground (A/G) voice support (259.7 and 296.8 MHz) will be maintained by moving the equipment to a less expensive site.

Listening Post Intercepts (all times in UTC)

K3840	AMSAT North America East Coast Net heard at 0110, LSB with W3STW, Al, as net control in Trevose, PA (Keith Stein-Woodbridge, VA)
K7185	Heard amateur radio retransmission of space shuttle air-to-ground communications (STS-80 mission), 1657, LSB (Vincent Everett)
K7765	Cape Radio, 1956, USB, with lift-off announcement (shuttle mission STS-80) followed by progress reports (Paul Scalzo)
K8968	Active at 2037, USB with ARIA ONE occasionally calling Hickam Global with what sounded like "ground comms schedule on 8968", but may have been something different. Fair to weak level into coastal Texas; no reply from Hickam heard (Jeff Haverlah-Texas). NASA 931 (KC-135, tail no. N931NA) running a phone patch through Lajes to Bangor confirming PPR for arrival on 6 December (Johan Drost-Northern Holland)
K10780	ARIA1 calling ARIA Control, Ascension Radio, and Cape Radio without luck, 2305, USB (Paul Robbins-England) This was after they supported the launch of NASA's Pegasus/SAC-B/HETE mission at Wallops Island, VA-Keith
K11175	Albrook working phone patch to Miami for NOAA43. Unable to receive data transmission from NOAA43, passed partial vortex message, position 2030N 04317W. (Alan Doherty-U.K.)
K29352	Amateur radio satellite RS-15 CW beacon heard at 2332, USB (David Bate-Bowmanville, Ontario, Canada)
K29408	Amateur radio satellite RS-12/13 CW beacon heard at 2325, USB (David Bate-Canada)
M119.100	Washington National Airport tower working NASA3, 1500, AM mode (David Stein-Springfield, VA) This is a Gulfstream 1 aircraft (tail no N3NA) used by NASA's Marshall Space Flight Center in Huntsville, AL-Keith. NASA2 (G-159, tail no N2NA) heard landing at Washington National, 1600Z, AM mode, used by NASA's Johnson Space Center, TX (K. Stein-Washington, DC)
M121.950	NASA 432 (F-27 aircraft, tail no. N432NA) heard, AM mode, monitoring ship movements off the coast of NASA's Wallops Island, VA launch site. At 0541 a 3-stage sounding rocket was launched carrying a classified Department of Defense payload (K. Stein-VA) Also several weeks later Orbital1 (L-1011 aircraft, tail no N140SC), NASA511 (T-38A aircraft, tail no N511NA) were heard conducting the launch of a Pegasus XL rocket carrying the SAC-B and HETE spacecraft from Wallops, VA, 1709, AM mode (D. Stein-VA)
M123.400	NASA 432 (F-27 aircraft, tail no N432NA) heard tracking ship movements off the coast of NASA's Wallops Island, VA during launch of Pegasus/SAC-B/HETE mission, 1709, AM mode (K. Stein-Wallops Island, VA)
M126.500	NASA 432 (F-27 aircraft, tail no N432NA), Orbital1 (L-1011, tail no N140SC), and NASA 511 (T-38A aircraft, tail no N511NA) heard talking with Wallops tower during launch of Pegasus/SAC/HETE mission, 1709, AM mode (K. Stein-Wallops Island, VA)
M136.770	U.S. weather satellite *NOAA 12* beacon heard at 1244, NFM (David Bate-Canada)
M137.500	U.S. weather satellite *NOAA 12* heard at 1240, NFM (John Corby-Caledon, Ontario, Canada)
M137.620	U.S. weather satellite *NOAA 14* heard at 1950, NFM (David Bate-Canada)
M137.770	U.S. weather satellite *NOAA 14* beacon heard at 1827, NFM (David Bate-Canada)
M137.850	Russian weather satellite *Meteor 3-5* heard at 2021, NFM. Signal off northern N.W.T. (David Bate-Canada)
M143.625	U.S. astronaut John Blaha was heard talking with mission control Moscow from *MIR* at 0640, NFM. He used both English and Russian language during the conversation (Sven Grahn-Solna, Sweden).
M145.200	U.S. astronaut John Blaha (KC5TCQ) heard aboard Russian space station *Mir* at 1346, NFM mode (Joe Dreifuss) This is the new amateur voice downlink being used aboard *Mir*, 145.800 MHz is the new uplink-Keith
M145.550	Cosmonaut Valery Korzun aboard *Mir* space station heard speaking English with

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amateur callsigns N2ORQ, AA2DR, and W2LYR in New York area. Korzun stated he was "going to do some physical exercises with treadmill." (K Stein-Woodbridge, VA). *Mir* packet telemetry heard at 1444, NFM (David Bate-Canada)

M145.800 Several amateur radio operators heard calling U.S. astronaut John Blaha (KC5TCQ) aboard Russian space station *Mir* at 1346, NFM mode (J. Dreifuss) This is the new amateur voice uplink being used to call crew members aboard Russia's space station *Mir*-Keith

M145.825 Amateur radio satellite *DO-17* packet telemetry heard at 1539, NFM (David Bate-Canada)

M145.850 Heard U.S. astronaut John Blaha, KC5TZQ aboard space station *Mir* talking with group of school kids at Cedar Bluff School, TN (Brett Saylor, N3EVB-State College, PA)

M145.985 Amateur radio satellite *AO-13* engineering beacon carrier only, later CW heard at 2258, NFM (David Bate-Canada)

M145.987 Amateur radio satellite *AO-21* voice downlink heard at 2318, NFM (David Bate-Canada)

M148.035 TV Operations Net for Eastern Test Range was monitored here during the launch of *Mars Pathfinder* mission, 0654, NFM (David Beardsley-Lutz, FL)

M148.485 Range CTS contractor for Instrumentation Net heard here during launch of *Mars Pathfinder* mission, 0654, NFM (Beardsley-FL)

M149.940 Russian navigation satellite *Cosmos 2218* heard at 0856, NFM (K. Stein-VA)

M149.970 Russian navigation satellite *Cosmos 2173* heard at 1247, NFM (J. Corby-Canada)

M150.000 Russian navigation satellite *Cosmos 2315* heard at 1735, NFM (K. Stein-VA)

M150.030 Russian navigation satellite *Cosmos 2142* was heard at 1223, NFM (J. Corby-Canada). *Cosmos 2334* heard at 1712, NFM (K. Stein-VA)

M166.000 Signals from *Progress M-33* heard in WBFM at 0531. Also on 922.750, and 926.05, signal was heard being commanded on (S. Grahn-Sweden)

M171.2625 STS TV Coord. Comm. heard here during launch of *Mars Pathfinder* mission, 0654, NFM (Beardsley-FL)

M171.905 Wireless mike being used at NASA Headquarters at 1650, NFM (K. Stein-Washington, DC)

M179.985 Chinese reconnaissance imaging satellite, *FSW-2*, was monitored sending a dead carrier at 0110, NFM. Data downlink also on M479.97 (K. Stein-Woodbridge, VA)

M311.200 Used by Orbital Sciences Corp. L-1011 aircraft as ground control during launch of Pegasus/SAC-B/HETE mission, 1709, AM mode (K. Stein-Wallops Island, VA)

M326.300 Backup to M121.950, AM mode, see above (K. Stein-Wallops Island, VA)

M408.400 NASA Headquarters Security responding to Administrator's suite to remove animal rights activist protesting a NASA/Russian funded space mission (Bion 11 & 12) to carry two monkeys into space. Seven females were removed from the building and later arrested by Federal Protective Services (FPS) (M415.2) after continued attempts were made to enter the building a second time. (K. Stein-Washington DC)

M435.0955 Received *Mars Global Surveyor* signal between 0625 and 0700 slowly drifting downwards some 50 Hz during pass (Werfried Kuneth, OE8FNK-Villach, Austria)

M437.950 Voice heard from *Mir* space station at 0548, NFM (David Bate-Canada)

G5.800 *GE-1* (103 deg. W), transponder 6, WCNJ-FM Hazlet, NJ (a 10-watt station with a 38-foot antenna height, variously listed as playing oldies and a polka show). Transponder 7, American Freedom Network (has been on shortwave, at least in the past) (Mike Cooper-Atlanta, GA)

G6.200 *GE-1* (103 deg. W), transponder 14, and G7.6, Christian Music Radio (describes itself as continuous music with no commercials) (Cooper-GA)

G7.420 *GE-1* (103 deg. W), transponder 20, Armed Forces Radio & Television Service (nice and strong subcarrier mixes various radio network programs) (Cooper-GA)

G11.7600 Saw a backhaul on *GE-1* (103 deg. W) channel 3, H, 0300, (Keith Knipschild)

G11.8200 Two carriers on *GE-1* (103 deg. W) channel 6- one at G118105.6 and one at G118112.7, V, 0300 (K. Knipschild)

G11.8400 *GE-1* (103 deg. W) channel 7, V, NBC Pacific feeds (K. Knipschild)

G11.8600 CW on center with subs and dispersal, *GE-1* (103 deg. W) channel 8, V, 0300 (K. Knipschild)

G11.8800 Saw a backhaul on *GE-1* (103 deg. W) channel 9, H, 0300 (K. Knipschild)

G11.9000 Testing saturation on *GE-1* (103 deg W) channel 10, V, 0300 (K. Knipschild)

G12.0000 *GE-1* (103 deg W) channel 15, V, NBC Contract Channel (K. Knipschild)

G12.0200 Test pattern "GE 1 TRANS 16K" GE-1 (103 deg W) channel 16, V, 0300 (K. Knipschild)

G12.1000 Cyclesat car ads and slates on *GE-1* (103 deg W) channel 20, V, 0300 (K. Knipschild)

G12.1200 *GE-1* (103 deg W) channel 21, V, NBC Contract Channel (K. Knipschild)

G12.1400 Chinese Comm. Channel (CCC) GE-1 (103 deg W) channel 22, V, 0300 (K. Knipschild)

G12.1600 *GE-1* (103 deg W) channel 23, V, NBC Contract Channel (K. Knipschild)

G12.1800 FedEx on GE-1 (103 deg W) channel 24, V, 0300 (K. Knipschild)

G12.4000 *GE-1* (103 deg W) channel 17, V, NBC Contract Channel (K. Knipschild)

G12.8000 *GE-1* (103 deg W) channel 19, V, NBC News Channel Newsfeeds (K. Knipschild)

Keith Stein is a freelance writer based in Woodbridge, Virginia. You can contact him through his Internet World Wide Web home page at: **http://www.newspace.com/casr**

INTRODUCTION

The Satellite Services Guide (SSG) is designed to keep the satellite listening enthusiasts up to date with the latest information available on a wide variety of hard-to-obtain space and satellite information. Many hours of personal observations and contributor reports have been compiled into this section. Errors are bound to happen, especially since services and elements sets change often, and geostationary satellites constantly change orbital positions. Care has been taken to check the accuracy of the information presented and it does represent the most current information available at press deadline.

How to Use the Satellite Service Guide

The various sections of the SSG include:

1. **Satellite Radio Guide** — This is a listing of audio subcarrier services that can be heard with a standard C-band (3.7 - 4.2 GHz) and in some cases a Ku-band (11.7-12.2 GHz) TVRO satellite system (no additional equipment is required). Services are broken down into various categories and provide the user with the satellite/transponder number and frequencies in megahertz of the various audio channels. These audio subcarriers are broadcasting on active TV channels that are either scrambled or not scrambled. You do not need a subscription for any of the radio services listed. Tuning in to an audio subcarrier will disrupt the TV sound, but not the TV picture. Listings with a 'N' are narrow bandwidth, 'DS' indicates discrete stereo.

2. **Single Channel Per Carrier (SCPC) Services Guide — A** SCPC transmitted signal is transmitted with its own carrier, thus eliminating the need for a video carrier to be present. Dozens of SCPC signals can be transmitted on a single transponder. In addition to a standard TVRO satellite system, an additional receiver is required to receive SCPC signals. Most SCPC signals will be found in the C-band.

3. **International Shortwave Broadcasters via Satellite** — This section of the SSG list all the various shortwave radio broadcasters currently being heard via satellite audio channels. Most of the channels listed are audio subcarriers and only require a C-band TVRO satellite system to monitor these broadcasts.

4. **DSS/USSB/Primestar Channel Listings** — This is a complete channel guide at press deadline of the channels and services found on the various direct broadcast satellite systems transmitting in the Ku-band (12.2-12.7 GHz). Addresses and telephone numbers are provided so that the reader can obtain additional information direct from the providers. We would be grateful if you would mention to these providers that you heard about their service from *Satellite Times* magazine.

5. **Satellite Transponder Guide** — This guide list video services recently seen from satellites transmitting in C-band located in the U.S. domestic geostationary satellite arc. A standard TVRO satellite system is required to view these services. White boxes indicated video services in the clear or non-video services. Gray shaded boxes indicated video services that are scrambled using the VideoCipher 2+ encryption system and are only available via subscription. Black boxes are video services that are scrambled using various other types of encryption schemes and are not available in the U.S. Transponders that are encrypted have the type of encryption in use listed between the brackets (i.e. - [Leitch]). O/V indicates that wild feeds, network feeds and other random video events have been monitored on that transponder. (none) means that no activity of any kind has been observed on the transponder indicated.

6. **Ku-band Satellite Transponder Services Guide** — This section of the SSG performs the same service as the C-band Satellite Transponder Guide listed above, but covers signals found in the Ku-band from 11.7 to 12. 2 GHz.

7. **Amateur and Weather Satellite Two Line Orbital Element Sets** — This section of the guide presents the current (as of press deadline) two line orbital element sets for all of the active amateur and weather satellites. These element sets are be used by computerized orbital tracking programs to track the various satellites listed.

8. **Geostationary Satellite Locator Guide** — This guide shows the space catalog object number, International payload designator, common name, location in degrees east/west and type of satellite/frequency bands of downlinks for all active geostationary satellites in geostationary orbit at publication deadline.

9. **Amateur Satellite Frequency Guide** — This guide list the various amateur radio satellites (hamsats) and their frequency bandplans. Most of the communications you will hear on these satellites will utilize narrow bandwidth modes of operation (i.e- upper and lower sideband, packet, RTTY, morse code). *Satellite Times* would like to thank the officers and staff of AMSAT for this use of this chart in the magazine.

10. **Satellite Launch Schedules** — This section presents the launch schedules and proposed operating frequencies of satellites that will be launched during the cover date of this issue of the magazine.

Satellite Radio Guide

By Robert Smathers and Larry Van Horn

AUDIO SUBCARRIERS

An audio sub-carrier requires the presence of a video carrier to exist. If you take away the video carrier, the audio sub-carrier disappears as well. Most TVRO satellite receivers can tune in audio subcarriers and they can be found in the range from 5.0 to 9.0 MHz in the video carrier.

Audio frequencies in MHz, All satellites/transponders are C-band unless otherwise indicated. DS=Discrete Stereo, N=Narrowband, W=Wideband

Classical Music

SuperAudio—Classical Collections	G5, 21	6.30/6.48 (DS)
WFMT-FM (98.7) Chicago, IL.	G5, 7	6.30/6.48 (DS)
WQXR-FM (96.3) New York, NY, ID-*96.3 FM*	C4, 15	6.30/6.48 (DS)

Satellite Computer Services

Planet Connect, Planet Systems, Inc 19.2 kbps srvc	G4, 6	7.398
	T402R, 4	7.398
Planet Connect, Planet Systems, Inc 100 kbps srvc	G1, 9	7.80
	T402R, 4	7.80
Skylink, Planet Systems, Inc	G1, 9	7.265
	T402R, 4	7.264
	G4, 6	7.264
Storyvision	G5, 3	7.30
Superguide	G5, 7	5.48

Contemporary Music

Radio Romance (from Philippines)	G4, 24 (Ku-band)	6.20
SuperAudio—*Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
Upbeat music (no identification)	C4,5	5.58

Country Music

SuperAudio—*American Country Favorites*	G5, 21	5.04/7.74 (DS)
Transtar III radio network	S3, 9	5.76/5.94 (DS)
WOKI-FM (100.3) Oak Ridge-Knoxville, TN., ID-*The Hit Kicker*	E2, 18	6.20
WSM-AM (650) Nashville, TN	C4, 24	7.38, 7.58

Easy Listening Music

Easy listening music, unidentified station	G4, 6	7.69
SuperAudio—*Soft Sounds*	G5, 21	5.58/5.76 (DS)
United Video—easy listening	C4, 8	5.895 (N)

Foreign Language Programming

Antenna TV (Greece)	T402R, 18	7.78
Arab Network of America radio network	G6, 10	5.80
CBC Radio-East (French)	E2, 1	5.38/5.58 (DS)
	E2, 1	7.36
CHIN-AM/FM (1540/100.7) Toronto, ON Canada, ID-*CHIN*—multilingual	E2, 2	7.89
DZMM-Radyo Patrol (from Philippines)	G4, 24 (Ku-band)	6.80
French language audio service	E2, 11	6.12
India ethnic radio	E2, 2	7.61
Indian Sangeet Sager	E2, 16 (Ku-band)	6.12
Irish music (Sat 1430-0000 UTC)	S3, 3	6.20
KAZN-AM (1300) Pasadena, CA—Asian Radio	GE-1, 22 (Ku-band)	6.20
Northern Native Radio (Ethnic)	E2, 26 (Ku-band)	6.43/6.53 (DS)
RAI Satelradio (Italian)	G7, 14	7.38
Radio Canada (French)	E2, 11	5.40/5.58 (DS), 5.76
Radio Dubai (Arabic)	G7, 10	7.48
Radio Maria (Italian-Religious programming)	G7, 10	5.80
Radio Maria	G7, 10	8.03
Radio Sedeye Iran (Farsi)	S3, 15	6.20 (N)
Radio Tropical (Haitian Creole)	S2, 11	7.60
Reteotto Network (Italian)	T402R, 18	5.80
Russian-American radio network	SBS5, 12 (Ku-band)	6.20
Trinity Broadcasting radio service (Spanish) SAP—religious	G5, 3	5.96
WLIR-AM (1300) Spring Valley, NY (Ethnic)	S2, 1	7.60
XEW-AM (900) Mexico City, Mexico (Spanish), ID-*LV de la America Latina*	M2, 14	7.38
XEW-FM (96.9) Mexico City, Mexico (Spanish), ID-*W-FM 96.9*	SD1, 7	7.38
XEWA-AM (540) Monterrey, Mexico (Spanish), ID-*Super Estelar*—contemporary music	M2, 8	7.38

Jazz Music

KLON-FM (88.1) Long Beach, CA., ID-*Jazz-88*	G5, 2	5.58/5.76 (DS)
Superaudio—*New Age of Jazz*	G5, 21	7.38/7.56 (DS)

News and Information Programming

Business Radio Network	C4, 10	8.06 (N)
	E2, 2	7.43 (N)
Cable Radio Network	C3, 23	7.24 (N)
CNN Headline News	G5, 22	7.58
CNN Radio News	S3, 9	5.62
	G5, 5	7.58
Standard News	S3, 17	5.20
USA Radio Network—news, talk and information	S3, 13	5.01 (Ch 1), 5.20 (Ch 2)
WCBS-AM (880) New York, NY—news	G7, 19	7.38
WCCO-AM (830) Minneapolis, MN	G6, 15	6.20
WGN-AM (720) Chicago, IL/Interstate Radio Network (overnight)—talk	E2, 2	5.22

Religious Programming

Ambassasor Inspirational Radio	S3, 15	5.96, 6.48 (DS)
Brother Staire Radio	G5, 6	6.48
CBN Radio Network/Standard News	G5, 11	6.12
Christian Music Network Lakeland, FL	GE-1, 14	6.20, 7.60
Inspirational/Gospel music (no identification)	G5, 6	7.38
KHCB-FM (105.7) Houston, TX	C1, 10	7.28
Salem Radio Network	S3, 17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
WHME-FM (103.1) South Bend, IN, ID-*Harvest FM*	G4, 15	5.58/5.78
WROL-AM (950) Boston, MA (occasional Spanish)	S3, 3	6.20
Z-musis—Christian rock	G1, 6	7.38/7.56

Rock Music

SuperAudio—*Classic Hits*-oldies	G5, 21	8.10/8.30 (DS)
SuperAudio—*Prime Demo*-mellow rock	G5, 21	5.22/5.40 (DS)
WCNJ-FM (89.3) Hazlet, NJ/Skylark Radio network—Oldies	GE-1, 6	5.80

Speciality Formats

Aries In Touch Reading Service	C4,10	7.87
C-SPAN I ASAP (program schedule)	C3, 7	5.58
C-SPAN II ASAP (program schedule)	C4, 19	5.58
In-Store Networks	S3, 24	5.04, 5.21, 5.40
SuperAudio—Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
The Weather Channel-USA—occasional audio	C3, 13	6.80
The Weather Channel-USA—classical music	C3, 13	7.78

Satellite Radio Guide

Voice Print Reading Service	E2, 6	7.44 (N)
Yesterday USA—nostalgia radio	G5, 7	6.80
	T402R, 11	5.80

Talk Programming

American Freedom Radio network	GE-1, 7	5.80
Amerinet Broadcasting	G6, 23	8.10
People's Radio Network (Chuck Harder)—talk and information	C1, 2	7.50
Prime Sports Radio—sports talk and information	S3, 24	5.80
One on One Sports radio network—sports talk	E2, 2	7.51
Talk America Radio Network #1—talk programs	S3, 9	6.80
Talk America Radio Network #2—talk programs	S3, 9	5.41
Talk Radio Network—talk programs	C1, 5	5.80
WOKIE Network (tech talk)	SBS6, 13B (Ku)	6.20 (occasional network on when Megabingo is present)
Worldwide Freedom Radio network	GE-1, 7	7.56
WWTN-FM (99.7) Manchester, TN—news and talk	G5, 18	7.38, 7.56

Variety Programming

American Urban Radio—news/features/sports	S3, 9	6.30/6.48 (DS)
CBC Radio (English)	E2, 6	5.40/7.58, 5.58
CBC Radio (occasional audio)	E2, 1	5.78
CBC-FM Atlantic (English)	E2, 6	6.12/6.30 (DS)
CBC-FM Eastern (English)	E2, 6	5.76/5.94 (DS)
CBM-AM (940) Montreal, PQ Canada—variety/fine arts	E2, 1	6.12
CJRT-FM (91.1) Toronto, ON Canada—fine arts/jazz-nights	E2, 26 (Ku-band)	5.76/5.94 (DS)
KBVA-FM (106.5) Bella Vista, AR., ID-*Variety 106.5*	G4, 6	5.58/5.76 (DS)
KSL-AM (1160) Salt Lake City, UT—news/talk/country-overnight	C1, 6	5.58
WUSF-FM (89.7) Tampa-St. Petersburg, FL (Public Radio), ID-*Concert 90*	C4, 10	8.26 (N)

Spacenet 3 Transponder 18

Data Transmissions: 4.800 MHz

Galaxy 4 Transponder 3 (Ku-band)

Blank Audio Carriers: 1.155, 2.070, 2.790, 3.250, and 4.400 MHz
Data Transmissions: 2.950, 3.040, 3.090, and 3.160 MHz
Generic News: 3.510 MHz (occasional audio)
In-Store audio network ads: .710, .795, .880, 1.245, 3.420, 3.600, 3.690, 3.780, 3.860, and 3.960 MHz
MuZAK Services: .275, .390, .510, .975, 1.065, 1.355, 1.470, 1.590, 1.710, 1.830, 1.945, 2.190, 2.310, 2.430, 2.550, 2.670, 2.790, 3.330, and 4.080 MHz

Galaxy 4 Transponder 4 (Ku-band)

Blank Audio Carriers: .960, .1.180, and 1.350 MHz
Data Transmissions: .255, .300, .350, .470, .575, .650, .710, .740, .765, .845, .890, .930, and 1.225 MHz

Galaxy 4 Transponder 16 (Ku-band)

Blank Audio Carriers: 1.230, and 2.280 MHz
Data Transmissions: .645, 2.140, 2.350, 2.730, 3.205, 3.245, 3.265, 3.620, 3.735, and 3.970 MHz
In-Store audio networks: .150, .270, .390, .755, .870, .990, 1.110, 1.350, 1.470, 1.590, 1.710, 1.800, 1.965, and 2.070 MHz

Anik E1 Transponder 7 (Ku-band)

Nova Network FM Squared Services

FM CUBED (FM³) AUDIO SERVICES

This audio is digital in nature and home dish owners have not been able to receive it by normal decoding methods yet. The only satellite that FM Cubed transmissions have been discovered on so far is Galaxy 4, transponder 1. WEFAX transmissions and Accu-Weather (for subscribing stations) are transmitted on this transponder.

FM SQUARED (FM²) AUDIO SERVICES

Another type of satellite audio is known as FM Squared. FM Squared signals require a video carrier to exist. These signals are similar to audio subcarriers as we know it except for the fact that they are located below the 5.00 MHz audio subcarrier frequency that a normal satellite receiver can tune to.

Spacenet 3 Transponder 13

Ambassador Inspirational Radio: 1.420, 4.470, and 4.650 MHz
Blank audio carriers: 1.050, 3.390, 3.570, 3.750, & 4.110 MHz
International Broadcasting Network: 4.830 MHz
Religious Backhauls (various): 1.235 MHz
USA Radio Network: .330 MHz
VCY America: .540 and .780 MHz

Spacenet 3 Transponder 17

Blank audio carriers: 3.570 and 3.750 MHz
Childrens Sunshine Network: 1.275 MHz
Data Transmission: .800 and 1.225 MHz
Focus on the Family: 1.050 and 1.400 MHz
In-Touch—religious: 4.470 MHz
Salem Satellite Network: 4.650, 4.840, and 5.010 Mhz
Skylight—religious: 1.770 and 4.260 MHz
UPI Radio Network: .330 MHz
WGNR-FM (88.9) Monee, IL—Good News Radio: 2.500 and 2.650 MHz

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

The frequency in the first column is the 1st IF or LNB frequency and the second column frequency (in parentheses) is the 2nd IF for the SCPC listing. Both frequencies are in MHz.

Spacenet 2 Transponder 12-Vertical (C-band)

1202.30 (77.7)	U.S.Information Agency *Radio Marti* (ISWBC), Spanish language broadcast service to Cuba

Galaxy 6 Transponder 3-Horizontal (C-band)

1405.60 (54.4)	KIRO-AM (710) Seattle, WA—news, talk, and sports talk radio/Seattle Seahawks NFL radio network
1405.40 (54.6)	Sports Byline USA/Sports Byline Weekend
1404.60 (55.4)	Talk America Radio Network
1403.80 (56.2)	Occasional audio
1403.20 (56.8)	Motor Racing Network (MRN)
1393.00 (67.0)	USA Radio Network/Agrinet
1391.60 (68.4)	XEPRS-AM (1090) Tijuana, Mexico—Spanish language programming, ID - *Radio Express*
1385.10 (74.9)	For the People Radio Network
1383.80 (76.2)	KJR-AM (950) Seattle, WA—sports talk radio/Seattle Supersonics NBA radio network
1375.40 (84.6)	USA Radio Network/Grow-wise Gardner Network/Agrinet/James Madison University Sports

Spacenet 3 Transponder-Horizontal 13 (C-band)

1207.90 (52.1)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious
1207.20 (52.8)	Good News Radio Network—christian radio
1207.00 (53.0)	Good News Radio Network—christian radio
1206.70 (53.3)	Data Transmission
1204.45 (55.55)	KJAV-FM (104.9) Alamo, TX—spanish language religious, Nuevo Radio Christiana Network
1204.25 (55.75)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious
1201.50 (58.5)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious
1201.30 (58.7)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious

Spacenet 3 Transponder 17-Horizontal (C-band)

1123.50 (56.5)	Salem Radio Network—religious
1123.30 (56.7)	Salem Radio Network—religious
1123.10 (56.9)	Salem Radio Network—religious

Galaxy 4 Transponder 1-Horizontal (C-band)

1443.80 (56.2)	Voice of Free China (ISWBC) Taipei, Taiwan
1443.60 (56.4)	KBLA-AM (1580) Santa Monica, CA—*Radio Korea*
1443.40 (56.6)	Voice of Free China (ISWBC) Taipei, Taiwan
1438.30 (61.7)	WWRV-AM (1330) New York, NY—Spanish religious programming and music, ID - *Radio Vision Christiana de Internacional*
1436.50 (63.5)	West Virginia Metro News
1436.30 (63.7)	KOJY-AM (540) Costa Mesa, CA/ KJQI-AM (1260) Beverly Hills, CA—all news
1431.00 (69.0)	Occasional audio

Galaxy 4 Transponder 3-Horizontal (C-band)

1405.00 (55.0)	Illinois News network/Chicago Blackhawks NHL radio network
1404.20 (55.8)	Tribune Radio Networks
1403.00 (57.0)	KSJN-FM (99.5) Minneapolis/St. Paul, MN—Minnesota Public Radio
1402.70 (57.3)	WLAC-AM (1510) Nashville, TN—news/talk/Tennessee Volunteers sports
1402.10 (57.9)	KNOW-FM (95.3) St. Paul, MN—fine arts, Minnesota Public Radio
1401.80 (58.2)	Michigan News Network//Michigan State sports/Central Michigan University sports
1399.30 (60.7)	Talk America radio network
1399.10 (60.9)	Sports Byline USA/Sports Byline Weekend/"On Computers" radio show
1398.80 (61.2)	People's Radio network—talk
1398.50 (61.5)	Occasional audio
1398.30 (61.7)	WSB-AM (750) Atlanta, GA—news/talk/University of Georgia sports
1398.00 (62.0)	Occasional audio
1397.80 (62.2)	Occasional audio/Colorado Avalanche NHL radio network
1397.50 (62.5)	Minnesota Talking Book network
1397.30 (62.7)	Clemson University sports
1397.10 (62.9)	WTMJ-AM (620) Milwaukee, WI - talk/Green Bay Packers NFL radio network/Univeristy of Wisconsin sports
1396.90 (63.1)	Dallas Cowboys NFL radio network (Spanish)/KRLD-AM (1080) Dallas, TX - news/talk
1396.40 (63.4)	Georgia Network News (GNN)
1396.20 (63.8)	WCNN-AM (680) Atlanta, GA—all sports talk radio/Georgia Tech sports
1396.00 (64.0)	WHO-AM (1040) Des Moines, IA—talk/Iowa News Network/University of Iowa sports
1395.80 (64.2)	WTMJ-AM (620) Milwaukee, WI - talk/Green Bay Packers NFL radio network/University of Wisconsin sports
1395.60 (64.4)	WGST-AM/FM (640/105.7) Atlanta, GA—news/talk/Atlanta Falcons NFL radio network
1395.40 (64.6)	Michigan News Network/University of Michigan sports radio network
1395.00 (65.0)	Occasional audio
1394.70 (65.3)	WJR-AM (760) Detroit, MI—news/talk
1394.00 (66.0)	KSJN-FM (99.5) Minneapolis/St. Paul, MN—Minnesota Public Radio
1391.00 (69.0)	Occasional audio
1388.90 (71.1)	Data transmissions (burst)
1387.80 (72.2)	Data transmissions (constant)
1384.40 (75.6)	KOA-AM (850)/KTLK-AM (760) Denver, CO—news/talk/Denver Broncos NFL radio network/ University of Colorado sports
1384.20 (75.8)	WSB-AM (750) Atlanta, GA—news and talk/University of Georgia sports
1383.70 (76.3)	Motor Racing Network (occasional audio)
1383.40 (76.6)	United Broadcasting Network—talk
1382.90 (77.1)	Occasional audio
1382.60 (77.4)	Soldiers Radio Satellite (SRS) network—U.S. Army information and entertainment
1382.00 (78.0)	University of Tennessee sports/ University of Kentucky sports
1381.80 (78.2)	WHO-AM (1040) Des Moines, IA - news/talk/Iowa News Network/ University of Iowa sports
1381.60 (78.4)	KEX-AM (1190) Portland, OR—news/talk
1381.40 (78.6)	Occasional audio
1381.20 (78.8)	KJR-AM (950) Seattle, WA - sports talk/Seattle Supersonics NBA radio network
1377.40 (82.6)	Data transmission (packet burst/ tones)
1377.10 (82.9)	In-Touch—reading service for blind
1376.00 (84.0)	Kansas Audio Reader Network

Galaxy 4 Transponder 4-Vertical (C-band)

1376.00 (64.0)	Data transmissions

Anik E2 Transponder 11-Horizontal (C-band)

1246.00 (54.0)	Radio Canada International (ISWBC)
1245.50 (54.5)	Canadian Broadcasting Company (CBC) Radio—Yukon service

Anik E2 Transponder 13-Horizontal (C-band)

1206.00 (54.0)	Canadian Broadcasting Company (CBC) Radio—southwestern Northwest Territories service

Single Channel Per Carrier (SCPC) Services Guide

Anik E2 Transponder 15-Horizontal (C-band)

1166.00 (54.0)	Canadian Broadcasting Company (CBC) Radio—eastern Northwest Territories service

Anik E1 Transponder 17-Horizontal (C-band)

1126.00 (54.0)	Canadian Broadcasting Company (CBC) Radio—northern Northwest Territories service
1125.50 (54.5)	Canadian Broadcasting Company (CBC) Radio—Newfoundland and Labrador service

Anik E2 Transponder 19-Horizontal (C-band)

1086.00 (54.0)	Canadian Broadcasting Company (CBC) Radio—Quebec and Labrador service

Anik E1 Transponder 21-Horizontal (C-band)

1024.30 (75.7)	Canadian weather conditions and warnings
1036.70 (63.3)	In-store music
1037.00 (63.0)	In-store music
1037.50 (62.5)	In-store music

SBS5 Transponder 2-Horizontal (Ku-band)

1010.60 (83.4)	Wal-Mart in-store network (English)
1010.20 (83.8)	Wal-Mart in-store network (English)
1009.80 (84.2)	Sam's Wholesale Club in-store network (English)
1001.40 (92.6)	Wal-Mart in-store network (English)
1001.00 (93.0)	Wal-Mart in-store network (English and Spanish ads)
1000.60 (93.4)	Wal-Mart in-store network (English)

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2)	RFD Radio Service
1404.60 (55.4)	Wyoming News Network/University of Wyoming sports
1400.60 (59.4)	Learfield Communications/Indiana University sports
1400.40 (59.6)	Learfield Communications/Missouri Net/Los Angeles Rams NFL radio network
1400.20 (59.8)	Occasional audio/Data transmissions
1400.00 (60.0)	Learfield Communications/ University of Purdue sports
1396.60 (63.4)	Kansas Information Network/Kansas Agnet/Kansas State sports/SW Missouri State sports
1396.40 (63.6)	Nebraska Agriculture Network/ University of Nebraska sports
1396.20 (63.8)	Missouri Network
1396.00 (64.0)	Occasional audio
1395.90 (64.1)	Wyoming News Network/University of Wyoming sports
1395.70 (64.3)	Missouri Net/WIBW-AM (580) Topeka, KS—news and talk/Kansas City Chief NFL radio network
1387.30 (72.7)	WPTF-AM (680) Raleigh, NC/North Carolina News Network
1386.40 (73.6)	Learfield Communications/Kansas City Chiefs NFL radio network
1386.20 (73.8)	Radio Iowa/University of Iowa sports
1385.00 (74.0)	People's Radio Network
1384.60 (75.4)	North Carolina News Network/ Capitol Sports Network/Washington Redskins NFL radio network/North Carolina State sports
1384.00 (76.0)	Occasional audio/ABC Direction Network
1383.80 (76.2)	Occasional audio/Oklahoma State sports
1383.60 (76.4)	WROW-FM (590), Albany, NY - news/talk
1383.40 (76.6)	Capitol Sports Network/Carolina Panthers NFL radio network/North Carolina University sports
1382.90 (77.1)	Missouri Net/University of Missouri sports
1382.60 (77.4)	North Carolina News Network
1382.30 (77.7)	Virginia News Network
1382.10 (77.9)	Learfield Communications/Missouri Net/University of Illinois sports
1378.10 (81.9)	Occasional audio

RCA C5 Transponder 21-Vertical (C-band)

1045.00 (55.0)	Occasional audio
1043.60 (56.4)	Unistar Music Radio — *Today's Hits, Yesterday's Favorites*
1043.40 (56.6)	CNN Radio Network
1043.20 (56.8)	Unistar Music Radio — *Today's Hits, Yesterday's Favorites*
1042.80 (57.2)	Unistar Music Radio — *Original Hits*
1042.60 (57.4)	Unistar Music Radio — *Original Hits*
1042.40 (57.6)	Unistar Music Radio — *Good Times and Great Oldies*
1042.20 (57.8)	Data transmissions
1042.00 (58.0)	Unistar Music Radio — *Good Times and Great Oldies*
1041.80 (58.2)	CNN Radio Network
1034.80 (65.2)	Unistar Music Radio — *Country and Western*
1034.60 (65.4)	Unistar Music Radio — *Country and Western*
1034.40 (65.6)	Unistar Music Radio — *Hits from 60s, 70s, 80s, and Today*
1034.20 (65.8)	Data transmissions
1034.00 (66.0)	Unistar Music Radio — *Hits from 60s, 70s, 80s, and Today*
1033.70 (66.3)	CNN Radio Network
1033.20 (66.8)	Unistar Music Radio — *Country and Western*
1032.80 (67.2)	Data transmissions
1032.40 (67.6)	Unistar Music Radio — *Country and Western*

International Shortwave Broadcasters via Satellite

By Larry Van Horn and Robert Smathers

AFRICA NO. 1
B.P. 1, Libreville, Gabon. Telephone +241 760001 (voice), +241 742133. Intelsat 601 (27.5 west) Tr 23B (3915 MHz RHCP). 8.20 MHz audio (French).

ARAB REPUBLIC OF EGYPT RADIO
(Arabic ID: Idha'at Jumhuriyat Misr al-Arabiyah min al-Qahirah) P.O. Box 1186, Cairo, Egypt. Eutelsat II F3 (16.0 east) Tr 27 (11176 Mhz V) 7.02 MHz audio.

ARMED FORCES RADIO AND TELEVISION SERVICE (AFRTS)
AFTRS-BC, 10888 La Tuna Canyon Road, Sun Valley, CA 91352-2098. AFRTS radio service carries a variety of radio network news and sports programming for servicemen overseas aboard Navy ships. Satellites carrying AFTRS transmissions include: Intelsat 703 (177.0 east) Tr 38 (4177 MHz LHCP) 7.41 MHz audio

BRITISH BROADCASTING CORPORATION (BBC)
Bush House, The Strand, London, WC2B 4PH. Telephone: +44 171 240 3456 (voice), +44 171 240 8760 (fax)
English BBC World Service transmissions can be found on the following satellites: Astra 1B (19.2 east) Tr 23 (11552 MHz H) 7.38 MHz audio, Eutelsat II F1 (13.0 east) Tr 25 (10987 MHz V) 7.38 MHz audio, Intelsat 601 (27.5 west) Tr 73 (11155 MHz V east spot) 7.56 MHz audio, Asiasat 1 (105.0 east) Tr 5 (3900 MHz V south beam) 7.20 MHz audio, and Satcom C3/F3 (131.0 west) Tr 7 (3840 MHz V) 5.41 MHz audio

C-SPAN AUDIO SERVICES
C-SPAN Audio Networks, 400 North Capitol Street, NW, Suite 650, Washington, D.C. 20001 Attn: Tom Patton. Telephone: (202) 626-4649 (voice)

C-SPAN Audio 1
Satcom C3/F3 (131.0 west) Tr 7 (3840 MHz.V) 5.20 MHz audio. A complete schedule of C-SPAN 1 audio services can be found in the November-December, 1995 issue of *Satellite Times*.

C-SPAN Audio 2
Satcom C3/F3 (131.0 west) Tr 7 (3840 MHz.V) 5.40 MHz audio. The BBC World Service in English is broadcast continuously 24-hours a day on this audio subcarrier.

CHINA RADIO INTERNATIONAL
China Radio International, Beijing, China 100866. Telephone +86-10-6092274/6092760 (voice), +86-10-8513174/5 (fax). Asiasat-1(105.5 east) FDM transmission centered on 4160 MHz

DEUTSCHE WELLE (DW)
P.O.Box 100 444, 50968 Cologne, Germany. Telephone: +49 221 389 4563 (voice), +49 221 389 3000 (fax)
Deutsche Welle services are available on the following satellites: Satcom C4/F4 (135 west) Tr 5 (3800 MHz V) 7.02, 7.22, 7.38/7.56, 7.74 MHz audio, Astra 1A (19.2 east) on Tr 2 (11229 MHz V) 7.38/7.56 MHz audio, Eutelsat (13.0 east) Tr 27 (11163 MHz V) 7.02/7.20 MHz. audio, Intelsat K (21.5 west) Tr H7 (11605 MHz H), 7.38/7.56 MHz audio, and Intelsat 707 (1.0 west) Tr 23B (3.911 MHz RHCP) digital MPEG-2 subcarrier.

ISLAMIC REPUBLIC OF IRAN BROADCASTING (IRIB)
External Service, P.O. Box 3333, Tehran, Iran. Telephone: +98 21 291095 (fax). Intelsat 602 (63.0 east) Tr 71 (11002 MHz V) for IRIB Radio 2 Farsi service using 5.60/6.20 MHz. audio. IRIB Radio 1 in various languages uses 5.95 MHz and Tr 73 (11155 MHz V) 6.20 MHz audio..

ISRAEL RADIO
P.O. Box 1082, Jerusalem 91010, Israel. Intelsat 707 (1.0 west) Tr 73 (11178 MHz V) 7.20 MHz audio.

LA VOIX DU ZAIRE
Station Nationale, B.P. 3164. Kinshasa-Gombe, Zaire. Telephone +243 12 23171-5. Intelsat 510 (66.0 east) Tr 12 (3790 MHz RHCP) 7.38/7.56 MHz audio with French.

RADIO ALGIERS INTERNATIONAL
21 Blvd des Martyrs, Alger, Algeria. Eutelsat II F3 (16.0 east) Tr 34 (11678 MHz H) 7.38 MHz audio with Spanish at 1900-2000 UTC and English 2000-2100 UTC.

RADIO AUSTRALIA
GPO Box 428G, Melbourne, Vic. 3001, Australia. Telephone: +613 9626 1800 (voice), +613 9626 1899 (fax)
Palapa C1 (113.0 east) Tr 9 (3880 MHz H) 7.20 MHz audio

RADIO BELGRADE
Hilandarska 2, 11000 Beograd, Serbia. Telephone: +381 11 344 455 (voice), +381 11 332014 (fax)
Eutelsat II F4 (7.0 east) Tr 22 (11181 MHz H) 7.02 MHz audio with Serb/English.

RADIO BUDAPEST
Body Sandor u. 5-7, 1800 Budapest, Hungary. Telephone: +36 1 138 7224 (voice), +36 1 138 8517 (fax) E-mail: *h9563mes@ella.hu*. Eutelsat II F3 (16.0 east) Tr 33 (11596 MHz H) 7.02 MHz audio from 2300-0500 UTC

RADIO CANADA INTERNATIONAL
P.O. Box 6000, Montreal, Canada H3C 3A8. Telephone: (514) 597-7555 (voice), (514) 284-0891 (fax). Eutelsat II F6 (Hot Bird 1 at 13 east) 11265 MHz H 7.20 MHz audio for Canadian troops in Bosnia.

RADIO EXTERIOR DE ESPANA (REE)
Apartado 156202, Madrid 28080, Spain. Telephone +34 13461083/1080/1079/1121 (voice); 34 13461097 (fax).
Eutelsat II F6 (Hot Bird 1 at 13.0 east) (11220 MHz H) 7.92 MHz audio, Hispasat 1A/B (31.0 west) Tr 6 (12149 MHz RHCP) 7.92 MHz audio, and Asiasat-2 (100.5 east) 4000 MHz H. MPEG-2.

RADIO FRANCE INTERNATIONAL (RFI)
B.P. 9516, Paris F-75016, France. Telephone: +33 1 42 30 30 62 (voice), +33 1 42 30 40 37 (fax)
RFI broadcast can be heard in French, 24-hours a day.on the following satellites: Intelsat 601 (27.5 west) Tr 23B (3915 MHz RHCP) 6.40 MHz audio to Africa/Middle east, and Palapa B2P (113 east) Tr 8 (3860 MHz V) 6.15 MHz audio to Asia.

RADIO MEDITERRANEE INTERNATIONALE
3 et 5, rue Emisaliah (B.P. 2055), Tanger, Morocco. Intelsat 513 (53.0 west) Tr 14 (3990 MHz RHCP) 7.20/8.20 MHz audio in Arabic/French.

RADIO NETHERLANDS
P.O..Box 222, 1200JG Hilversum, The Netherlands. Telephone +31 35 724222 (voice), +31-35-724252 (fax) E-mail: *letters@rnw.nl*. Various languages are relayed via Astra 1C (19.2 east) Tr 64 (10935 MHz V) 7.74 and 7.92 audio.

RADIOSTANTSIYA MAYAK
The Mayak radio service consists of light music, sports, news and weather on the hour and half hour in Russian. On the air continuously. The service can be found on Tr 6 (3675 MHz RHCP) 7.50 MHz audio on the following satellites: Gorizont 27 (53.0 east), Gorizont 22 (40.0 east), Gorizont 26 (11.0 west), Gorizont 18 (140.0 east), Gorizont 19 (96.5 east), Gorizont 28 (90.0 east), and Gorizont 24 (80.0 east).

RADIO SWEDEN
S-10510 Stockholm, Sweden.. Telephone: +46 8 784 7281 (voice), +46 8 667 6283 (fax). E-mail: *wood@stab.sr.se* Tele-X (5.0 east) Tr 40 (12475 MHz) 7.38 MHz audio and Astra 1B (19.2 east) Tr 33 (10964 MHz H) 7.38 or 7.56 MHz audio.

RADIOTELEVISIONE ITALIANA (RAI)
Viale Mazzini 14, 00195 Roma, Italy. Telephone: +39 6 5919076. Selected programs of RAI's external service are carried on Eutelsat II F6 (Hot Bird 1 @ 13.0 east) (11446 MHz V) 7.56 MHz audio. This is a feed to the BBC Atlantic relay station on Ascension Island. Galaxy 7 (91.0 west) Tr 14 (3980 MHz V) 7.38 MHz audio.

RADIO VLAANDEREN INTERNATIONAL
P.O. Box 26, B-1000, Brussels, Belgium. Telephone: +32 2 741 3802 (voice), +32 2 734 7804 (fax) E-mail: *rvi@brtn.be* Astra 1C (19.2 east) Tr 63 (10921 MHz H) 7.38 MHz audio.

RDP INTERNATIONAL
Av. 5 de Outubro 197, 1000 Lisbon, Portugal. Telephone: +351 1 535151 (voice), +351 1 793 1809 (fax).
RDP International uses the following satellites for various broadcast to the indicate coverage areas:
Asiasat 2 (service due to start on this satellite in September 1995), Eutelsat II F2 (10.0 east) Tr 39 (11658 MHz V) 7.02/7.20 MHz audio to Europe. Express 2 - Russian Statsionar 4 (14.0 west) on 4025 MHz (RHCP) 7.0 MHz audio to South America, Africa, the US east coast and southern Europe, Gorizont 22 - Russian Statsionar 12 (40 east) Tr 11 (3925 MHz RHCP) 7.02 MHz audio to Africa, southern Europe, and the Indian Ocean region.

SWISS RADIO INTERNATIONAL
Giacomettstrasse 1, CH-3000 Bern 15, Switzerland. Telephone: +41 31 350 9222 (voice), +41 31 350 9569 (fax). SRI uses the following satellites for its external services: Astra 1A (19.2 east) Tr 9 (11332 MHz H) 7.38 MHz audio Multilingual/7.56 MHz English 24-hours, Eutelsat II (13.0 east) (11321 MHz V) 7.74 MHz. audio, and Intelsat K (21.5 west) Tr 7 (11605 MHz H) 8.10 MHz audio multilingual 24 hours.

International Shortwave Broadcasters via Satellite

TRANS WORLD RADIO (TWR)
Astra 1A (19.2 east) Tr 16 (11436 MHz V) 7.38/7.56 MHz audio with German language programming from Evangeliums Rundfunk and TWR-UK. Astra 1C (19.2 east) Tr 38 (11038 MHz V) 7.38 MHz audio Multilingual from TWR-Europe.

TUNIS INTERNATIONAL RADIO
71 ave de la Liberte, Tunis, Tunisia. Eutelsat II F2 (16.0 east) Tr 39 (11658 MHz V) 7.20 MHz audio.

VATICAN RADIO
I-00120, Vatican City State, Italy. Telephone: +396 6988 3551 (voice), +396 6988 3237 (fax) Eutelsat Hotbird (13 east) 10987 MHz V; Intelsat 603 (34.5 west) 4097.75 MHz LHCP; and Intelsat 704 (66 east) 4152.45 MHz RHCP.

VOICE OF AMERICA (United States Information Agency)
Washington, D.C. 20547. The Voice of America (VOA) transmits a variety of audio programs in various languages on the following satellites and audio subcarriers:.

Eutelsat II F1	13.0 east	Tr 27	11163 MHz.	PAL system
Intelsat 704	66.0 east	Tr 38	4177.5 MHz.	PAL system
Intelsat 601	27.5 west	Tr 14	3995 MHz.	PAL system
Intelsat 601	27.5 west	Tr 81	3742 MHz.	PAL system
Spacenet 2	69.0 west	Tr 2H	3760 MHz.	NTSC system
Intelsat 511	180.0 west	Tr 14	3974 MHz.	PAL system

NTSC system baseband subcarrier frequencies

Primary Television Audio (USIA Worldnet)	6.80 MHz
Channel 1	5.94 MHz
Channel 2	6.12 MHz
Channel 3	7.335 MHz
Channel 4	7.425 MHz
Channel 5	7.515 MHz
Channel 6	7.605 MHz
Wireless File (data)	6.2325 MHz
E-mail (data)	6.2775 MHz

PAL system baseband subcarrier frequencies

Primary Television Audio (USIA Worldnet)	6.60 MHz
Channel 1	7.02 MHz
Channel 2	7.20 MHz
Channel 3	7.335 MHz
Channel 4	7.425 MHz
Channel 5	7.515 MHz
Channel 6	7.605 Mhz
Wireless File (data)	6.2325 MHz
E-mail (data)	6.2775 MHz

VOICE OF THE ARABS
P.O. Box 566, Cairo 11511, Egypt. Transmissions from this external radio service have been heard on Arabsab 1C at 31 east on 3882 MHz (LHCP) FDM at 1440 MHz. Broadcast have also been noted on Eutelsat II-F3 at 16 east, Tr 27 (11176 MHz V) 7.20 MHz audio.

VOICE OF SAHEL
Niger Radio and Television Service. Transmissions of the domestic radio shortwave service have been reported on Intelsat 707 at 1.0 west. No other details are available at this time.

VOICE OF THE IRAQI PEOPLE (CLANDESTINE)
Programming has been reported on Arabsat 1C at 31.0 east on a FDM tranmission centered at 3940 MHz RHCP. Transmissions have been noted from 24.5 kHz to 2700 kHz in USB between 1300-0100 UTC.

WORLD HARVEST INTERNATIONAL RADIO, WHRI-South Bend, Indiana
P.O. Box 12, South Bend, IN 46624. Religious broadcaster WHRI/KHWR uses audio subcarriers to feed their three shortwave broadcast transmitters as follows: Galaxy 4 (99.0 west) Tr 15 (4000 MHz.H) 7.46/7.55 MHz audio with WHRI programming relayed to their broadcast transmitters in Indianapolis, Ind. for shortwave transmissions beamed to Europe and Americas and 7.64 MHz audio for KHWR programming relayed to their broadcast transmitter in Naahlehu, Hawaii for shortwave transmissions beamed to the Pacific and Asia.

WORLD RADIO NETWORK
Wyvil Court, 10 Wyvil Road, London, SW8 2TG, England, Telephone: +44 171 896 9000 (voice), +44 171 896 9007 (fax). In North America, call at local rates on (202) 414-3185. E-mail via Internet: *online@wrn.org.* WRN can also be heard live on the World Wide Web to users with high speed connections at: http//town.hall.org/radio/wrn.html. WRN schedules are subject to change. Complete schedules for North America (WRN2), Europe (WRN1 and WRN2), and the new Africa/Asia-Pacific (WRN1) services are listed in page 92 of this issue of *Satellite Times.*

WRN 1 North American English Program Schedule

Galaxy 5 (125 deg West) tr 6-3.820 GHz V (TBS) 6.8 MHz audio. WRN is also available on cable and local radio stations. WRN program details can be heard at 0625, 1425 and 1955 Eastern Time, and are also available on TBS text page 204. All times below are Eastern (UTC +5 hours)

0000	RTE Dublin, Ireland-*Irish Collection*
0100	SABC Channel Africa, Johannesburg (Mon-Sat)
0130	*BBC Europe Today* (Mon-Fri)
0130	Glenn Hauser's *World of Radio* (Sat)
0130	UN Radio from New York (Sun)
0200	Polish Radio-Warsaw
0230	Radio Canada International
0300	ABC Radio Australia
0400	KBS Radio Korea International
0500	Voice of Russia
0530	Radio Netherlands
0630	SABC Channel Africa, Johannesburg (Mon-Sat)
0630	Radio Romania International (Sun)
0700	ABC Radio Australia
0800	RTE from Dublin, Ireland
0900	Radio Prague
0930	RTHK-News from Hong Kong (Mon-Fri)
0930	Radio Romania International (Sat)
0930	UN Radio from New York (Sun)
1000	YLE Radio Finland
1030	Radio Vlaanderen-Brussels Calling
1100	Radio France International
1200	Voice of Russia
1230	ORF Radio Austria International
1300	RTE from Dublin, Ireland
1330	Radio Netherlands
1430	YLE Radio Finland
1500	Blue Danube Radio, Vienna (Mon-Fri)
1500	Glenn Hauser's World of Radio (Sat)
1500	SABC Network Africa (Sun)
1530	Radio Vlaanderen-Brussels Calling
1600	*BBC Europe Today* (Sun-Fri)
1600	UN Radio from New York (Sat)
1630	Polish Radio
1700	RTE Dublin, Ireland-*Ireland Tonight* at 1800
1900	Radio Netherlands
2000	ABC Radio Australia
2100	YLE Radio Finland
2130	Radio Sweden
2200	Radio Prague
2230	Radio Austria International
2300	Polish Radio
2330	Radio Budapest

WRN 2 North American Multilingual Program Schedule
Galaxy 5 (125.0 west) Tr 6 (3820 MHz V) 6.20 MHz audio. New 24 hour multi-lingual channel for North America designed for the re-broadcasting of programs in a variety of languages for domestic FM/AM relays and cable distribution.

WRN European Service

WRN1 - Astra 1B (19.2 east) Tr 22 (11538 MHz V) 7.38 MHz audio. All broadcasts are in English. Program information is available on Astra 1B VH-1 text page 222, 223 and 224. WRN network information can be heard on the European service daily at 0125, 1025 and 2050 BST.
WRN2 - Eutelsat II F-1 (13 east) Tr 25 (10987 MHz V) 7.38 MHz. Multi-lingual programming.

WRN Asia-Pacific Service

AsiaSat-2 (100.5 deg East) 4.000 GHz V, MPEG2 DVB, Symbol Rate 28.125 Mbaud, FEC 3/4, Select WRN1 from audio menu.

WRN Middle East and Africa Service

Intelsat 707 (1 deg West) 3.9115 GHz, RHCP, Symbol Rate 8.022 Mbaud, FEC 3/4, MPEG2 Audio Stream.

WORLDWIDE CATHOLIC RADIO - WEWN
P.O. Box 176, Vandiver, AL 35176 USA. Telephone: (205) 672-7200 (voice), (205) 672-9988 (fax). WWW URL: http://www.ewtn.com. WEWN broadcasts are available on: Galaxy 1R (133 west) Tr 11 (3920 MHz H) 5.40 MHz (English) and 5.58 MHz (Spanish). WEWN is also available internationally on Intelsat 601 (27.5 west) Tr 22.7, 5.59 MHz (English) and 5.68 MHz (Spanish).

YLE RADIO FINLAND
Box 10, SF-00241 Helsinki, Finland. Telephone: +358 9 1480 4320 (voice), +358 9 1481 1169 (fax). Toll free in the US 800-221-YLEX (9539). WWW URL: www.yle.fi/fbc/radiofin.html. E-mail: *rfinland@yle,fi* Most of YLE's broadcasts to Europe are available on Eutelsat II F1 (13.0 east) Tr 27 (11163 MHz V) 8.10 MHz. audio, and Asiasat 2 (100.5 east) Tr 10B (4000 MHz H) early this year.

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

Alphastar (United States)

Alphastar is a new medium power Direct-to-Home satellite service for the United States. The service will use some of the Telstar 402R (Ku-band 11.7-12.2 GHz) segment. The satellite is located at 89° West. Channel assignments were not available at presstime.

Alphastar Digital Television, 208 Harbor Drive, Building One, First Floor, Stamford, CT 06904. Telephone: (203) 359-8077. Web site: **http://www.teecomm.com**

Programming: A&E Network, ABC (WJLA Washington DC), Alpha Preview Channel, C-Span 1 (US House), C-Span 2 (US Senate), Cartoon Network, CBS (WRAL Raleigh, NC), Cinemax, Cinemax 2, Cinemax West, Classic Sports Network, CNBC, CNN, CNN International/CNN fn, Comedy Central, Country Music Television, Court TV, Discovery Channel, Disney Channel (E), Disney Channel (W), E! Entertainment Television, Encore, Encore Plus, ESPN, ESPN2, Family Channel, FOX Network (Foxnet), Golf Channel, HBO, HBO 2, HBO 3, HBO West, Headline News, History Channel, Learning Channel, Lifetime, Local Regional Sports Networks (tba), MTV, Nashville Network, NBC (WNBC New York), NewsTalk Television, Nickelodeon / Nick at Nite, PBS Network (National), Playboy TV, 10 PPV Channels, Sci-Fi Channel, Showtime, Showtime 2, Showtime West, Starz!, Sundance Film Channel, TBS Atlanta, The Movie Channel, The Movie Channel West, Three Sports Channels (tba), Turner Classic Movies, Turner Network Television (TNT), TV Land, Two Liberty Sports Channels (tba), USA Network, VH-1, Weather Channel, 30 DMX Channels

DirecTV and USSB (United States)

These two DBS services are carried on the Hughes high power DBS-1/2/3 satellites located at 101° West (Ku-band 12.2-12.7 GHz).

DirecTV, 2230 East Imperial Highway, El Segundo, Calif. 90245, 1-800-DIRECTV (347-3288), Web site: **http://www.directv.com**

100	Direct Ticket Previews (DTV)	Previews
101-199	Direct Ticket Pay Per View (DTV)	PPV
120/121	Letterbox (LTBX)	
140-142	Unknown service (LC)	
200	Direct Ticket Previews (DTV)	Previews
201	DirecTV Information Updates (DTV)	Promo
202	Cable Network News (CNN)	News
203	Court TV (CRT)	Speciality
204	CNN Headline News (HLN)	News
205	DirecTV Special Events Calendar (DTV)	Promo
206	ESPN 1 (ESPN)	Sports
207	ESPN Alternate (ESNA)	Sports
208	ESPN 2 (ESN2)	Sports
210	DirecTV Sports Schedule (DTV)	Promo
212	Turner Network Television (TNT)	TV programming
213	Home Shopping Network (HSN)	Home Shopping
214	Home and Garden TV (HGTV)	Home Improvement
215	E! Entertainment TV (E!)	Speciality
216	MuchMusic (MUCH)	Music Videos
217	Black Entertainment TV (BET)	Entertainment
219	American Movie Classics (AMC)	Movies
220	Turner Classic Movies (TCM)	Movies
221	Arts and Entertainment (A&E)	TV
222	The History Channel (HIST)	History
223	The Disney Channel East (DIS1)	Movies/Kids
224	The Disney Channel West (DIS2)	Movies/Kids
225	The Discovery Channel (DISC)	Science/TV documentary
226	The Learning Channel (TLC)	Science/TV documentary
227	Cartoon Network (TOON)	Cartoons
229	USA Network (USA)	TV
230	Trio (TRIO)	TV
232	The Family Channel (FAM)	TV
233	WTBS-Ind Atlanta, Ga.(TBS)	Superstation
235	The Nashville Network (TNN)	Country/Outdoors
236	Country Music TV (CMT)	Country Music Videos
240	The Sci-Fi Channel (SCFI)	Science Fiction
242	C-SPAN 1 (CSP1)	Congress-House of Representatives
243	C-SPAN 2 (CSP2)	Congress-U.S. Senate
245	Bloomberg Information Television (BIT)	News
246	CNBC (CNBC)	Financial/Talk
247	MSNBC (MSNBC)	News
248	The Weather Channel (TWC)	Weather
250	Newsworld International (NWI)	News
252	CNN International (CNNI)/CNN fN	News/Financial
254	The Travel Channel (TRAV)	Travel Shows
258	Bravo (BRAV)	Arts
266	Independent Film Channel (IFC)	Movies
268	Direct Ticket Previews (DTV)	Previews
269	STARZ! - West (STZW)	Movies
270	STARZ! (STZE)	Movies
271	Encore (ENCR)	Movies
272	Encore-Love Stories (LOVE)	Movies
273	Encore-Westerns (WSTN)	Movies
274	Encore-Mystery (MYST)	Movies
275	Encore-Action (ACTN)	Movies
276	Encore-True Stories (TRUE)	Movies
277	Encore-WAM! (WAM!)	Movies
278	Plex Encore 1	Movies
282	WRAL Raleigh, NC (CBS)	Network TV
283	KPIX San Francisco, CA (CBSW)	Network TV
284	WNBC New York, NY (NBC)	Network TV
285	KNBC Los Angeles, CA (NBCW)	Network TV
286	PBS National Feed (PBS)	Network TV
287	WJLA Washington, DC (ABC)	Network TV
288	KOMO Seattle, WA (ABCW)	Network TV
289	FoxNet. (FOX)	Network TV
297	Informational Channel	
298	TV Asia (TVA)	Ethnic Programming
299	In-store dealer info channel (DTV)	Retailers only
300-399	Regional and PPV Sports	Sports
300	DirecTV Sports Offers (DTV)	Promo
301	Sports Special Events Calendat (DTV)	Promo
302	Special Events Calendar (DTV)	Promo
303	Newsport (NWSP)	Sports
304	The Golf Channel (GOLF)	Sports
305	Classic Sports Network (CSN)	Sports
306	Speedvision (SV)	Sports
307	Outdoor Life Channel (OL)	Sports
309	SportsChannel New England (SCNE)	Sports
310	Madison Square Garden (MSG)	Sports
311	New England Sports Network (NESN)	Sports
312	SportsChannel New York (SCNY)	Sports
313	Empire Network (EMP)	Sports
314	SportsChannel Philadelphia (SCPH)	Sports
315	Fox Sports Pittsburgh (PKBL)	Sports
316	Home Team Sports (HTS)	Sports
317	SportsSouth (SPTS)	Sports
318	Sunshine (SUN)	Sports
319	SportsChannel Florida	Sports
320	Pro AM Sports (PASS)	Sports
321	SportsChannel Ohio (SCOH)	Sports
322	SportsChannel Cincinnati (SCCN)	Sports
323	SportsChannel Chicago (SCCH)	Sports
324	Midwest SportsChannel (MSC)	Sports
325	Fox Sports Southwest (PSSW)	Sports
326	Fox Sports Midwest/Rocky Mountain/ Intermountain West (PS)	Sports
329	Fox Sports Arizona	
330	Fox Sports Northwest (PSNW)	Sports
331	Fox Sports West (PSW)	Sports
332	SportsChannel Pacific (SCP)	Sports
330-348	NFL Sunday Ticket	Sports
335	DirecTV Sports Schedule (DTV)	Promo
350	NFL Sunday Ticket/NBA League Pass	Sports
356	NFL Sunday Ticket/NBA League Pass	Sports
380	DirecTV Sports Schedule (DTV)	Promo
401	Spice (SPCE)	Adult
402	Playboy (PBTV)	Adult
501	Music Choice — Hit List (MC1)	Audio
502	Music Choice — Dance (MC2)	Audio
503	Music Choice — Hip Hop (MC3)	Audio
504	Music Choice — Urban Beat (MC4)	Audio
505	Music Choice — Reggae (MC5)	Audio
506	Music Choice — Blues (MC6)	Audio
507	Music Choice — Jazz (MC7)	Audio
508	Music Choice — Jazz Plus (MC8)	Audio
509	Music Choice — Contemporary Jazz (MC9)	Audio
510	Music Choice — New Age (MC10)	Audio
511	Music Choice — Electric Rock (MC11)	Audio
512	Music Choice — Modern Rock (MC12)	Audio
513	Music Choice — Classic Rock (MC13)	Audio
514	Music Choice — Rocks Plus (MC14)	Audio
515	Music Choice — Metal (MC15)	Audio
516	Music Choice — Solid Gold Oldies (MC16)	Audio
517	Music Choice — Soft Rock (MC17)	Audio
518	Music Choice — Love Songs (MC18)	Audio
519	Music Choice — Progressive Country (MC19)	Audio
520	Music Choice — Contemporary Country (MC20)	Audio
521	Music Choice — Country Gold/ Classic Country (MC21)	Audio
522	Music Choice — Big Bands Nostalgia (MC22)	Audio
523	Music Choice — Easy Listening (MC23)	Audio
524	Music Choice — Classic Favorites (MC24)	Audio
525	Music Choice — Classics in Concerts (MC25)	Audio
526	Music Choice — Contemporary Christian (MC26)	Audio
527	Music Choice — Gospel (MC27)	Audio

Direct Broadcast Satellite (DBS) Systems

528	Music Choice — Big Kids Music (MC28)	Audio
529	Music Choice — Sounds of the Seasons (MC29)	Audio
530	Music Choice — Bluegrass (MC30)	Audio
531	Music Choice — Rock New Release Show (MC31)	Audio
550	Music Choice — Lite Classical	Audio
551	Music Choice — EE - Vocals	Audio
552	Music Choice — Soft Album Mix	Audio
553	Music Choice — The Trend	Audio
554	Music Choice — Tropical	Audio
555	Music Choice — Mexicana	Audio
599	NRTC Radio Service (NRTC) For private use only	
790	RealNet — Real Estate Channel (REAL)	

USSB

USSB, 3415 University Avenue, St. Paul, Minn. 55114, 1-800-204-USSB (8772)

899	USSB Programming Higlights	Promo
900	Special Event programming (BIG 1)	Special Events
910	Special Event Programming (BIG 2)	Special Events
960	TVLand (TVLD)	Variety
963	All New Channel (ANC)	News
965	Video Hits One (VH1)	Rock Music Videos
967	Lifetime (LIFE)	TV
968	Nickelodeon (NICK)	TV/Kids
970	Flix (FLIX)	Movies
973	Cinemax East (MAX)	Movies
974	Cinemax 2 (MAX2)	Movies
975	Cinemax West (MAXW)	Movies
977	The Movie Channel East (TMC)	Movies
978	The Movie Channel West (TMCW)	Movies
980	HBO East (HBO)	Movies
981	HBO 2 East (HBO2)	Movies
982	HBO 3 (HBO3)	Movies
983	HBO West (HBOW)	Movies
984	HBO 2 West (HB2W)	Movies
985	Showtime East (SHO)	Movies
986	Showtime 2 (SHO2)	Movies
987	Showtime West (SHOW)	Movies
989	MusicTV (MTV)	Rock Music Videos
990	Comedy Central (COM)	Comedy
995	Sundance Channel (SUND)	Movies
999	USSB Programming Highlights	Promo

ECHOSTAR

EchoStar (United States)

The new Echostar 1 high power DBS (Ku-band 12.2-12.7 GHz) satellite is now operational at 119° West. Echostar 2 was launched September 10, 1996. It should be operational by November 1, 1996. Echostar's service is called "TheDISH (Digital Satellite Network) Television Network.

Echostar, 90 Inverness Circle East, Englewood, CO 80112, Telephone: (303) 799-8222, Fax: (303) 799-3632. Web Site: **http://www.echostar.com**

100	DISH Network Channel	Promo
102	USA Network	TV
104	Comedy Central	Comedy
106	TVLand	Variety
108	Lifetime	TV
110	TV Food Network	Food
112	Home and Garden Network	Speciality
114	E! Entertainment TV	TV
116	Game Show Network	TV
118	Arts and Entertainment	TV
120	History Channel	History
122	Sci-Fi Channel	Science Fiction
124	Black Entertainment TV	TV
132	Turner Classic Movies	Movies
138	Turner Network Television	TV
140	ESPN	Sports
141	ESPN Alternate	Sports
142	ESPN2	Sports
143	ESPN2 Alternate	Sports
144	ESPNews	Sports
160	MusicTV (MTV)	Music Videos
162	VH-1	Music Videos
166	Country Music Television	Music Videos
168	The Nashville Network	Country
170	Nickelodeon	Kids
172	The Disney Channel	Movies/Kids
176	The Cartoon Network	Cartoons
178	The Learning Channel	Science/TV Documentary
180	The Family Channel	TV
182	The Discovery Channel	Science/TV Documentary
200	Cable News Network	News
202	CNN Headline News	News
204	Court TV	Speciality
206	CNN International/CNNfn	News/Financial
208	CNBC	Financial/Talk
210	C-SPAN	Government
212	C-SPAN 2	Government
214	The Weather Channel	Weather
216	National Empowerment TV (NET)	Politics
220	The Travel Channel	Travel Shows
226	QVC Shopping Network	Home Shopping
230	WTBS Atlanta, GA	Superstation
232	KTLA Los Angeles, CA	Superstation
234	WPIX New York, NY	Superstation
236	WSBK, Boston	Superstation
240	WGN Chicago, IL.	Superstation
241	WNBC-NBC New York, NY	Network TV
242	KNBC-NBC Los Angeles, CA	Network TV
243	WRAL-CBS Raleigh, NC	Network TV
244	KPIX-CBS San Francisco, CA	Network TV
245	WJAL-ABC Washington, DC	Network TV
246	KOMO-ABC Seattle, WA	Network TV
247	FOXNet	Network TV
249	PBS	Network TV
260	Trinity Broadcasting Network	Religious
261	Eternal Word TV Network	Religious
300	HBO East	Movies
301	HBO2 East	Movies
302	HBO3 East	Movies
303	HBO West	Movies
304	HBO2 West	Movies
310	Showtime East	Movies
311	Showtime West	Movies
312	Showtime East 2	Movies
318	Sundance	Movies
319	FLIX	Movies
320	Cinemax East	Movies
321	Cinemax East 2	Movies
322	Cinemax West	Movies
330	The Movie Channel East	Movies
331	The Movie Channel West	Movies
401	The Golf Channel	Sports
412	Madison Square Garden (MSG)	Sports
414	Fox Sports Rocky Mountain	Sports
416	Fox Sports Southwest	Sports
417	Fox Sports West	Sports
418	Fox Sports Midwest	Sports
420	SportSouth	Sports
422	Sunshine Network	Sports
424	Home Team Sports	Sports
426	Fox Sports Northwest	Sports
428	Fox Sports Pittsburgh	Sports
430	Pro-Am Sports (PASS)	Sports
432	Empire Sports Network	Sports
434	New England Sports Network	Sports
436	Midwest Sports Channel	Sports
500	PPV 1 DISH-on-Demand (events)	Pay per view
501	PPV 2 DISH-on-Demand	Pay per view
502	PPV 3 DISH-on-Demand	Pay per view
503	PPV 4 DISH-on-Demand	Pay per view
504	PPV 5 DISH-on-Demand	Pay per view
505	PPV 6 DISH-on-Demand	Pay per view
506	PPV 7 DISH-on-Demand	Pay per view
507	PPV 8 DISH-on-Demand	Pay per view
508	PPV 9 DISH-on-Demand	Pay per view
509	PPV 10 DISH-on-Demand	Pay per view
600	RAI (Italy)	International
602	ART (Arab Radio and Television)	International
604	Antenna TV Greece	International
620	MTV Latino	International
622	Univision	U.S. Spanish-language Network
624	Galavision	U.S. Spanish-language Network
626	Fox Sports Americas	International
628	Telemundo	International
700	DISH 2 (Showroom Promo Channel)	Promo
900	Business TV 1	Financial
901	Business TV 2	Financial
DISH CD ™		
950	Young Country	Audio
951	Country Classics	Audio
952	Country Currents	Audio
953	Jukebox Gold	Audio
954	70's Song Book	Audio
955	Adult Favorites	Audio

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

956	Adult Contemporary	Audio
957	Album Adult Alternative	Audio
958	HitLine	Audio
959	Classic Rock	Audio
960	The Edge	Audio
961	Power Rock	Audio
962	Non-Stop Hip Hop	Audio
963	Urban Beat	Audio
964	Latin Styles	Audio
965	Fiesta Mexicana	Audio
966	Eurostyle	Audio
967	Jazz Traditions	Audio
968	Contemporary Jazz Flavors	Audio
969	Expressions	Audio
970	Contemporary Instrumentals	Audio
971	Concert Classics	Audio
972	Light Classical	Audio
973	Easy Instrumentals	Audio
974	Big Band Era	Audio
975	Contemporary Christian	Audio
976	KidZone	Audio
977	LDS Radio Network	Audio
978	Blues	Audio
979	Reggae	Audio
980	New Age	Audio

ExpressVu (Canada)

This is Canada's first digital medium power Direct-to-Home satellite TV service. The service will provide Canadian, American, and international video and audio programs. 110 channels will be offered using Canada's Anik E1 (Ku-band 11-.7-12.2 GHz) satellite at 111° West. Channel assignments and programming were not available at presstime.

ExpressVu

ExpressVu Inc, 1290 Central Parkway West, Suite 1008, Mississauga, ON L5C 4R3, Telephone 1-800-339-6908 in Canada. Web Site: **http://www.expressvu.com**

Galaxy Latin America (Mexico, Central and South America)

Ft. Lauderdale, FL
Web site: **http://www.sattv.com**
New Latin American DBS service carried on Galaxy 3R at 95° West (Ku-band, 11.7-12.2GHz). Medium power Direct-to-Home service for Mexico, Central and South America. Galaxy Latin America will have 144 channels of video (72 channels in Spanish/72 channels in Portuguese). Pay-per-view movies and events will also be provided. A .6-1.1 meter dish will be needed to utilize the service. Channel assignments were not available at presstime.

DIRECTV. GLA

Programming: AS, BBC, Bloomberg Business TV in Espanol, Bloomberg Business TV in Portuguese, Bravo Brasil, Canal de Noticias NBC, Cartoon Network, CBS TeleNoticias, Cinelatino, Cinemax Brasil, Cl@se (Latin America Channel for Educational Services), CNA (Brasil all news channel), CNN en Espanol, CNN International, Discovery Latin America, ESPN Brasil, GEMS, HBO Brasil, HBO Cinemax Multiplex, HBO Ole Multiplex, KID, MTV Brasil, MultiCinema, RBN News (Brasil), RTP (Portugal), Sony Entertainment TV (SET), Televen International, The Warner Channel (WBTV), TNT Latin America, Univision, Venevision International, ZAZ, Zeta, 60 CD-Quality Audio Channels

PRIMESTAR®

Primestar (United States)

Primestar is a medium power Direct-to-Home satellites service carried on Satcom K1 at 85° West (Ku-band 11.7-12.2 GHz). Primestar uses K1 transponders 2-13 and 15-16 19 transponders).

Primestar Partners, 3 Bala Plaza West, Suite 700, Bala Cynwyd, PA 19004, 1-800-966-9615

1	HBO (East)	Movies
2	HBO 2 (East)	Movies
3	HBO 3	Movies
7	Cinemax (East)	Movies
8	Cinemax 2	Movies
13	TV Japan (English)	Not inclu. in $50/mo. pck.
14	TV Japan (Japanese)	Not inclu. in $50/mo. pck.
15	Future service (Also 15/17/56/149/157)	
27	Starz!	Movies
31	Encore 3 — Westerns	Movies
32	Encore 4 — Mystery	Movies
33	Encore	Movies
34	The Disney Channel (East)	Movies/Kids
35	The Disney Channel (West)	Movies/Kids
40	The Golf Channel	Sports
47	C-SPAN	Congress
48	CNBC—occasional service	Financial/Talk
49	The Weather Channel (TWC)	Weather
50	CNN International (CNNI)/CNN fN	News/Financial
51	Cable Network News (CNN)	News
52	CNN Headline News	News
	Ingenius News Service	Data Wire Services
55	PreVue Channel	Program Guide
58	Turner Network Television (TNT)	TV
59	Turner Classic Movies (TCM)	Movies
60	TV Land	TV
61	Comedy Central	TV
63	WTBS-Ind Atlanta, GA (TBS)	Superstation
65	The Discovery Channel (TDC)	Science/TV documentary
66	The Learning Channel (TLC)	Science/TV documentary
68	Arts & Entertainment (A&E)	TV
70	USA Network	TV
71	The Sci-Fi Channel	Science Fiction
72	The Family Channel	TV
73	The Cartoon Channel	Cartoons
74	Nickelodeon/Nick at Nite	Kids
75	E! Entertainment Network	Speciality
76	Lifetime	TV
77	The Nashville Network (TNN)	Country/Outdoors
78	Country Music TV (CMT)	Country music videos
80	MTV	Music Videos
83	Odyssey	Religious
84	QVC—occasional service	Home Shopping
111	WHDH-NBC Boston, MA	Network TV
112	WSB-ABC Atlanta, GA	Network TV
117	WUSA-CBS Washington, DC	Network TV
120	KTVU-FOX Oakland/San Francisco, CA	Network TV
124	WHYY-PBS Philadelphia, PA	Network TV
131	ESPN	Sports
133	ESPN2	Sports
137	Classic Sports Network (occ)	Sports
138	Mega+1	Sports
141	New England Sports Network (NESN)	Sports
142	Madison Square Garden Network (MSG)	Sports
143	Empire Sports Network	Sports
144	Fox Sports Pittsburgh	Sports
145	Home Team Sports (HTS)	Sports
146	SportSouth	Sports
147	Sunshine	Sports
148	Pro American Sports (PASS)	Sports
152	Fox Sports Midwest	Sports
153	Fox Sports Rocky Mountain	Sports
154	Fox Sports Southwest	Sports
155	Fox Sports Inter-Mountain West	Sports
156	Fox Sports Northwest	Sports
157	Fox Sports Arizona	Sports
158	Fox Sports West	Sports
159	Midwest SportsChannel	Sports
181	HBO en Espanol	Movies
182	HBO2 en Espanol	Movies
183	HBO3 en Espanol	Movies
187	Cinemax Selecciones	Movies
188	Cinemax2 Selecciones	Movies
190	Univision	Spanish language
201	Viewer's Choice	PPV
202	Request 1	PPV
203	Request 5	PPV
204	Hot Choice	PPV
205	Continuous Hits 1	PPV
207	Continuous Hits 3	PPV
208	Request 2	PPV
210	Request 4	PPV
221	Playboy—occasional service	Adult
301	Superadio—Classical Hits	Audio
302	Superadio—America's Country Favorites	Audio
303	Superadio—Lite 'n' Lively Rock	Audio
304	Superadio—Soft Sounds	Audio
305	Superadio—Classic Collections	Audio
306	Superadio—New Age of Jazz	Audio
311	DMX Audio—Lite Jazz	Audio
312	DMX Audio—Classic Rock	Audio
313	DMX Audio—70's Oldies	Audio
314	DMX Audio—Adult Contemporary	Audio
315	DMX Audio—Hottest Hits	Audio
316	DMX Audio—Modern Country	Audio
317	DMX Audio—Traditional Blues	Audio
318	DMX Audio—Salsa	Audio
527	Testing Channel	Tests

Ku-band Satellite Transponder Services Guide

By Robert Smathers

H = Horizontal polarization, V = Vertical polarization, Occ video = Occasional Video, [ ] = Type of encryption or video compression

Spacenet 2 (S2) 69° West

19	11740-H	Data transmissions
21	11900-H	TV ASAHI [Leitch]
22	11980-H	Occ video
23	12060-H	Kentucky Educational TV (occ) - uses half transponders
24	12140-H	Occ video

SBS 6 (SBS6) 74° West

1	11717-H	Data transmissions
2	11749.5-V	Occ video
3	11774-H	Occ video
4	11798.5-V	Occ video
5	11823-H	Occ video
6	11847.5-V	Occ video
7	11872-H	Occ video
8	11896.5-V	Occ video
9	11921-H	Occ video
10	11945.5-V	Occ video/CONUS Communications (occ)
11	11963-H	CONUS Communications (half transponders)
12	11994.5-V	CONUS Communications (half-transponders)
13	12019-H	CONUS Communications (half transponders)
14	12043.5-V	Occ video
15	12075-H	Occ video
16	12092.5-V	Occ video
17	12110-H	Occ video
18	12141.5-V	Occ video
19	12174-H	CNN Newsbeam (occ)

SBS 4 (SBS4) 77° West (Inclined orbit)

1	11725-H	Data transmissions
2	11780-H	NBC feeds
3	11823-H	NBC feeds
4	11872-H	NBC feeds
5	11921-H	NBC feeds
6	11970-H	NBC feeds
7	12019-H	NBC feeds
8	12068-H	NBC feeds
9	12117-H	NBC feeds
10	12166-H	NBC feeds

GE K2 (K2) 81° West

1	11729-H	Data transmissions
14	12112.5-V	(None)

Transponders 2-13 and 15-16 consists of Primestar programming encrypted and compressed using the Digicipher system. A complete Primestar channel guide is presented in the DBS section of *Satellites Times* Satellite Service Guide.

Spacenet 3R (S3) 87° West

19	11740-H	Data transmissions
20	11820-H	Data transmissions
22	11980-H	NYNET (SUNY) Ed Net/NY Lottery feeds (East spot beam)
23	12060-H	Oregon Educational Network (West spot beam)
24	12140-H	Occ video (East spot beam)

Telstar 402R (T402) 89°West

Alphastar DBS uses many T402 Ku-band transponders

1	11730-V	AT&T Tridom [digital]
2	11743-H	AT&T Tridom [digital]
3	11790-V	AT&T Tridom [digital]
4	11803-H	AT&T Tridom [digital]
5	11850-V	Occ video
9	11971-V	Occ video (half transponder)
15	12157-V	DMX for Business [digital data] (upper half)/Occ video (lower half)

Galaxy 7 (K7) 91° West

1	11720-V	Occ video
2	11750-H	Data transmissions
3	11750-V	Indiana Higher Education [Compressed video]
4	11780-V	TCI Headend in the Sky?
6	11810-V	TCI Headend in the Sky?
7	11840-V	TCI Headend in the Sky?
8	11870-H	Data transmissions
9	11870-V	TCI Headend in the Sky?
10	11900-V	TCI Headend in the Sky?
11U	11945-H	[Compressed video]
12	11930-V	TCI Headend in the Sky?
13	11960-V	TCI Headend in the Sky?
14	11990-H	Occ video (half transponders common)
15	11990-V	TCI Headend in the Sky?
16	12020-V	Occ video/The People's Network (TPN)
17	12050-H	Westcott Communications ASTN [B-MAC]/National Weather Networks (occasional)
18	12050-V	TCI Headend in the Sky?
19	12080-V	TCI Headend in the Sky?
20	12110-H	Data transmissions
21	12110-V	TCI Headend in the Sky?
22	12140-V	TCI Headend in the Sky?
23	12170-H	Data transmissions
24	12170-V	TCI Headend in the Sky?

Galaxy 3R (G3R) 95° West

Ku-band side of this satellite is used entirely for the Galaxy Latin American DBS System.

Telstar 401 (T401) 97° West

1	11730-V	Data transmissions
2	11743-H	AT&T Skynet TV [compressed video]
3	11790-V	South Carolina Educational TV State Network [Digicipher]
4	11798-H	National Tech University [compressed video]
5	11845-V	PBS [Digicipher]
6	11855-H	Occ video
7	11902-V	PBS educational services (half-transponders)
8	11915-H	PBS stations/regionals and backhauls
9U	11986-V	PBS digital video [Digicipher]/VSAT traffic
10	11962.5-H	Louisiana Public TV State Network [Digicipher]
11	12040-V	Occ video
12	12046-H	Occ video
13	12095-V	Spectradyne Hotel Hotel In-room movies [compressed video]
14L	12093-H	Peachstar Educational Network (Distance Learning)
14U	12123-H	Georgia Public TV State Network (GPTV)
15	12147-V	ABC network and affiliate feeds (half-transponders)
16	12167-H	ABC network and affiliate feeds (half-transponders)

Galaxy 4 (K4) 99° West

1	11720-H	SCPC services/Data transmissions
2	11750-V	Data transmissions
3	11750-H	FM² services/MUZAK/Data transmissions
4	11780-H	FM² services/Planet Connect computer service (19.2 kbps)/Data transmissions
5	11810-V	Data transmissions
6	11810-H	Occ video
7	11840-H	Chinese Television Network *Chung Ten* - Chinese/Taiwan all-news service
8	11870-V	Occ video
9	11870-H	Occ video
10	11900-H	CNN Airport Network [SA MPEG]
11	11930-V	Occ video (half-transponders common)
12	11930-H	Occ video/Channel One (occ)/Microsoft TV (occ)
13	11960-H	Occ video
14	11990-V	Occ video (half-transponders common)
16	12020-H	FM² services/Data transmissions
17	12050-V	CBS Newsnet and affiliate feeds (half-transponders)
18	12050-H	Honk Kong TVB Jade Channel (Chinese) [videocrypt]
19	12080-H	Data transmissions
20	12110-V	Occ video (half-transponders common)
21	12110-H	Asian-American TV Network (occ)
22	12140-H	Family Net [Digicipher]
23	12170-V	CBS Newsnet and affiliate feeds (half-transponders)
24	12170-H	The Filipino Channel [Oak]

Spacenet 4 (S4) 101° West

24	12140-H	E.M.G. courses [digicipher]

DBS-1 101.2° W/DBS-2 & DBS-3 100.8°W

A complete DIRECTV‡ and USSB channel guide is presented in the DBS section of *Satellites Times* Satellite Service Guide. These satellites operate in the 12.2-12.7 GHz range.

GE-1 (GE1) 103° West

1	11720-H	Qualcomm data [digital]
2	11740-V	Data transmissions
3	11760-H	NBC Eastern Time Zone programming
4	11780-V	Data transmissions
5	11800-H	Qualcomm data [digital]
6	11820-V	Data transmissions/Empire Sports [DVB-2000]
7	11840-H	NBC Pacific Time Zone programming
8	11860-V	Qualcomm data [digital]
9	11880-H	NBC Mountain Time Zone programming
10	11900-V	Qualcomm data [digital]
11	11920-H	NBC feeds [digital]/Data transmissions
12	11940-V	Microspace [digital]
13	11960-H	NSN data transmissions/NBC feeds [digital]
14	11980-V	Qualcomm data [digital]
15	12000-H	NBC Contract Channel
16	12020-V	Occ video
17	12040-H	NBC Contract Channel
18	12060-V	Data transmissions
19	12080-H	NBC News Channel
20	12100-V	Cyclesat [analog/digital]/Occ video
21	12120-H	NBC Contract Channel
22	12140-V	Chinese Communications Channel (CCC) [Oak]
23	12160-H	NBC Newschannel SNG/NBC Contract Channel
24	12180-H	Fed Ex TV [BMAC]/Occ video

GSTAR-4 (GST4) 105° West

1	11730-H	Data transmissions
2	11791-H	Data transmissions
3	11852-H	CNN Newsource (Primary) [Leitch]/some feeds in clear
4	11913-H	Occ video
5	11974-H	Occ video
6	12035-H	Occ video
7	12096-H	CNN Newsbeam/Occ video
8	12157-H	CNN Newsource International/Occ video
9	11744-V	Data transmissions
11	11866-V	ABC SNG feeds
12	11927-V	Occ video
13	11988-V	CNN Newsbeam/occ video
15	12110-V	CNN Newsource/occ video
16	12171-V	Occ video

Anik E2 (A1) 107.3° West

1	11717-V	Telesat Canada DVC: MovieMax!, Family Channel E&W, SuperChannel [digital video compression]
2	11743-V	DirectPC [digital]
3	11778-V	Data transmissions
5	11839-V	Canadian Parliamentary Access Channel, Youth TV E&W, Vision TV, CHSC Shopping [digital video compression]
6	11865-V	Moviepix!; The Movie Network [digital video compression]
7	11900-V	Rogers Network [digital video compression]
8	11926-V	Rogers Network [digital video compression]
9	11961-V	Data transmissions
10	11987-V	Data transmissions
12	12048-V	Saskarchewan CommunicaNetwork
13	12083-V	Data transmissions
14	12109-V	Data transmissions
15	12144-V	Telesat Canada stationkeeping (GLACS)
16	12170-V	Knowledge Network
18	11756-H	Showcase E&W/Discovery Channel Canada/Life Network [digital]
21	11852-H	Data transmissions
22	11878-H	Data transmissions
24	11939-H	Ontario Legislature
25	11974-H	La Chaine (TV Ontario's French lanaguage service)
26	12000-H	TV Ontario (English)
27	12035-H	Data transmissions
28	12061-H	Data transmissions
29	12096-H	Atlantic Satellite Network (ASN)
30	12122-H	Telesat Canada stationkeeping (GLACS)
31	12157-H	CBC Newsworld feeds
32	12183-H	RDI feeds

Solidaridad 1 SD1 109.2° West

(No video has been seen on any Ku-band transponder)

Anik E1 (A2) 111° West

Note: Due to loss of power from the satellite south solar panel on March 26, 1996, Anik E1 Ku-band transponders 7-16 and 21-32 are off indefinitely according to Telesat officials.

1	11717-V	Data transmissions
2	11743-V	Data transmissions
3	11778-V	Data transmissions
4	11804-V	Data transmissions
5	11839-V	Business TV [digital]
6	11865-V	NovaNet FM² Services
17	11730-H	Woman's Television Network E&W [digital video compression]
18	11756-H	Data transmissions
19	11791-H	Data transmissions
20	11817-H	SCPC/Data transmissions/New Country Network, Access Network of Alberta [Shaw digital video compression]

Solidaridad 2 (SD2) 112.9° West

(No video has been seen on any Ku-band transponder)

Anik C3 (C3) 114.9° W (Inclined Orbit)

(This satellite rarely has video transmissions)

7	11900-V	Occ video

Morelos 2 (M2) 116.8° West

(No video has been seen on any Ku-band transponder)

EchoStar 1/2 119°West

A complete channel guide for TheDISH Television Network is presented in the DBS section of *Satellites Times* Satellite Service Guide. These satellites operate in the 12.2-12.7 GHz BSS band.

SBS 5 (SBS5) 123° West

1	11725-H	Comsat Video in-room programming [B-MAC] (half transponders) — Satellite Cinema 1/3
2	11780-H	SCPC services
4	11872-H	Comsat Video in-room programming [B-MAC] (half transponders) — Satellite Cinema 4/2
5	11921-H	Data transmissions
6	11970-H	Data transmissions
7	12019-H	Data transmissions
8	12068-H	Occ video
10	12166-H	WalMart [V2+]/Occ video
11	11748-V	Data transmissions
12	11898-V	WMNB Russian-American TV [inverted video]
13	11994-V	Occ video
14	12141-V	Occ video

GSTAR-2 (GST2) 125° West

9	11744-V	Data transmissions
11	11866-V	GSTAR-2 ID slate
13	11988-V	Occ video
14	12049-V	Occ video
15	12110-V	Occ video
16	12171-V	Occ video

SATELLITE SERVICES GUIDE

Satellite Transponder Guide

By Robert Smathers

	Spacenet 2 (S2) 69°	Galaxy 6 (G6) 74°	Telstar 302 (T2) 85°	Spacenet 3 (S3) 87°	Telstar 402R (T4) 89°	Galaxy 7 (G7) 91°	Galaxy 3R (G3R) 95°	Telstar 401 (T1) 97°	Galaxy 4 (G4) 99°	Spacenet 4 (S4) 101°	GE-1 1
1	SC New York [V2+]	Tokyo BS New York feeds	(none)	(none)	o/v	Sega Channel Interactive [digital]	TVN Theatre 1 [V2+]	Exxxtasy (adult) Promo/VTC Syndication feeds	SCPC services	Data Transmissions	U.S. Inf Agency
2	(none)	Canadian Horse Racing/o/v	(none)	American Independent Network (AIN) [CLI Spectrumsaver]	o/v	CBS West [occ VC1]	TVN Theatre 2 [V2+]	Data Transmissions	Data Transmissions	STARZ! 2 [V2+]	(no
3	USIA Worldnet TV	SCPC services	o/v	WSBK-Ind Boston [V2+]	The Babe Channel/o/v	Action PPV [V2+]	TVN Theatre 3 [V2+]	Keystone/Parmount feeds/o/v	SCPC services	Data Transmissions	(no
4	(none)	Canadian Horse Racing/o/v	(none)	Nebraska Educational TV (NETV) [digital]	Shop at Home	fX East	TVN Theatre 4 [V2+]	Group W Videoservices/o/v	Data Transmissions	Encore-Westerns [V2+]	S Ohio/Cinci da [
5	NASA Contract Channel-o/v [Leitch]	o/v	(none)	Univision [V2+]	FOX feeds East	fX West	TVN Theatre 5 [V2+]	Keystone o/v	4 Media Company feeds	Data Transmissions	Hero T [dig
6	Data Transmissions	NHK (TV Japan) feeds	o/v	CNN/SI [V2+]	The X! Channel (adult) [V2+]	Game Show Network [V2+]	TVN Theatre 6 [V2+]/TVN Promos (occ) [fixed key V2+]	Buena Vista TV feeds	Shepherd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	WNBC-N York (PT2
7	(none)	(none)	(none)	Data Transmissions	Cable Video Store/Adam & Eve/Spice (adult) [digital]	The Golf Channel [V2+]	TVN Theatre 7 [V2+]/GRTV infomercials	o/v	Warner Brothers Dom TV/WB Network	Basil Bassett Bingo	Cornerstor
8	Data Transmissions	Horse Racing [digital]	(none)	Data Transmissions	Fantasy Cafe TV (adult) [V2+]/o/v	o/v	TVN Theatre 8 [V2+]	PBS X	Telemundo [SA MPEG]	KOMO-ABC Seattle (PT24W) [V2+]	SC Chica
9	NASA TV	MuchMusic U.S. [V2+]	(none)	WPIX-Ind New York [V2+]	Horse Racing [digital]	Eye on People Network [digital]	TVN Theatre 9 [V2+]	FOX feeds	o/v	Data Transmissions	SportSou
10	Data Transmissions	Arab Network of America (ANA)	ABC West [Leitch]	Empire/Fox Pittsburgh-Arizona feeds [V2+]	XXXplore/XXXpose (adult) [V2+]	United Arab Emirates TV Dubai	TVN Theatre 10 - adulTVision (adult) [V2+]	FOX feeds	o/v	FOXNet (PT24E) [V2+]	WJLA Washingto [V2
11	SC Philadelphia [V2+]	Keystone o/v	(none)	CNN feeds/o/v	Outdoor Channel	Intro Television [V2+]	o/v	ABC feeds	o/v	STARZ! East [V2+]	Univisio
12	Data Transmissions	TV Asia [digicipher]	(none)	Data Transmissions	Horse Racing [digital]	Romance Classics [V2+]	MCI Andover o/v/RAI TV	ABC NewsOne channel	Keystone o/v	(none)	TurnerVisi Channel
13	Data Transmissions	RTPi	(none)	SCPC/FM2 services	FOX feeds West	CSN/Kaleidoscope/F-ox Sports/The Box [digicipher]	o/v	FOX feeds East	o/v	Data Transmissions	Sports Alternate
14	Data Transmissions	Canadian Horse Racing (occ)/o/v	(none)	(none)	o/v	Independent Film Channel [V2+]	o/v	FOX News Service	o/v	NPS Promo Channel	SC New [V2
15	La Carpa-Spanish (Rel) o/v	Midwest Sports Channel [V2+]	(none)	KTLA-Ind Los Angeles [V2+]	o/v	(none)	Gospel Music TV [V2+]	True Blue (adult) [V2+]	World Harvest TV (Rel)	Data Transmissions	o/
16	Data Transmissions	o/v	(none)	CNN International/CNN fN [V2+]	Eurotica (adult) [V2+]	(none)	HBO 2 East [V2+]	o/v	CBS West [occ VC1]	NPS Promo Channel	SC Pacif
17	Data Transmissions	Keystone (occ)/MSG-II (occ)	(none)	FM2/SCPC services	FOX feeds	ESPN Intl Pacific Rim [B-MAC]	Cinemax 2 East [V2+]	o/v	CBS East [occ VC1]	Data Transmissions	SC Alte (occ
18	SC New York Plus o/v	Canadian Horse Racing (occ)/o/v	(none)	America's Collectibles Network	Kelly Broadcast Systems contract channel/o/v	Teleport Minnesota/CBS feeds/o/v	Inforamerica TV (Informercials)	Keystone o/v	CBS feeds/o/v	STARZ! West [V2+]	(no
19	Data Transmissions	University Network/Dr. Gene Scott (Rel)	(none)	(none)	o/v	CBS East [occ VC1]	HBO 3 [V2+]	Keystone o/v/UPN	CBS East [occ VC1]	Data Transmissions	Nati Empower (N
20	(none)	CNN Headline News Clean Feed [V2+]	ABC East [Leitch]	America's Collectibles Network	o/v	FOX News Channel	HBO 2 West [V2+]	ABC East [Leitch]	CBS East [occ VC1]	Data Transmissions	AFRTS
21	(none)	o/v	(none)	SSN Pro Am Sports (Pass) [V2+]	o/v	BET on Jazz	Infoamerica TV (Informercials)	ABC East [Leitch]	CBS feeds/o/v	Data Transmissions	Univisio
22	o/v	Horse Racing [digital]	(none)	Infomercials (occ)	ABC feeds	(none)	Horse Racing [digital]	ABC West [Leitch]	o/v	Data Transmissions	Tau Commu (oc
23	NHK TV Japan secondary feeds	Worship TV (Rel)	(none)	SSN Home Teams Sports (HTS) [V2+]	La Cadena de Milagro-Spanish (Rel)	fX Movies [V2+]	3 Angels Broadcasting	ABC East [Leitch]	SCOLA [Wegener]/Blue & White Network (occ)	Data Transmissions	o/
24	o/v	Horse Racing [digital]/o/v	(none)	America One	PandaAmerica (Home Shopping)	International Channel [V2+]	(none)	Exxxtasy (adult) [V2+]	CBS Newspath feeds	KPIX-CBS San Francisco (PT24W) [V2+]	WRAL-CB (PT24E

Unscrambled/non-video — Subscription — Not available in U.S. — o/v = occasional video

Satellite Transponder Guide

By Robert Smathers

GE1) °	Anik E2 (A1) 107.3°	Solidaridad 1 (SD1) 109.2°	Telesat E1 (A2) 111°	Morelos 2 (M2) 116.8°	Galaxy 9 (G9) 123°	Galaxy 5 (G5) 125°	Satcom C3 (F3) 131°	Galaxy 1R (G1) 133°	Satcom C4 (F4) 135°	Satcom C1 (F1) 137°	
rmation (USIA)	CBC-H English Eastern	(none)	Data Transmissions	Data Transmissions	Global Access o/v/BBC Breakfast News (occ)	Disney East [V2+]	Family Channel West [SA MPEG]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	Prime Network [V2-]	1
ie)	The Sports Network (TSN) [SA MPEG]	(none)	(Inactive)	Data Transmissions	Global Access (occ)	Playboy (adult) [V2+]	The Learning Channel	Spanish language networks [SA MPEG]	Request TV PPV [digicipher]	KMGH-ABC Denver [V2-]	2
ne)	Telesat [digital video compression]	SCPC services	Data Transmissions	Data Transmissions	NHK TV Japan	Trinity Broadcasting (Rel)	Viewer's Choice PPV [V2+]	Encore [V2+]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2-]	3
nati/Flori- 2+]	Cancom Video Compression [SA-MPEG]	(none)	Data Transmissions	Data Transmissions		Sci-Fi [V2+]	Lifetime West [V2+]	TV Food Network [digicipher]	Lifetime East [V2+]	SC Pacific [V2+]	4
leport tal]	Telesat [digital video compression]	o/v	Data Transmissions	Data Transmissions	(none)	CNN [V2+]	Odyssey (Rel)	Classic Arts Showcase	Deutsche Welle TV (German)	KDVR-Fox Denver [V2-]	5
BC New 4E) [V2+]	CBC Newsworld	(none)	(Inactive)	Data Transmissions	o/v	WTBS-Ind Atlanta [V2+]	Court TV [digicipher]	Z-Music	Madison Square Garden [V2+]	KCNC-CBS Denver [V2-]	6
e TV (Rel)	CBC-M English	XEQ-TV canal 9	Data Transmissions	Data Transmissions	TVN Video Compression [digital]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN FOX Sports West [V2+]	7
go [V2+]	Global TV [Leitch]/Global feeds	(none)	(Inactive)	XHGC canal 5	General Communication [digital]	HBO West [V2+]	QVC-2 Fashion Channel	Cartoon Network [V2+]	Prevue Guide	NBC-East	8
th [V2+]	CBC-B English Atlantic	o/v	(Inactive)	(none)	TVN Video Compression [digital]	ESPN [V2+]	Music Choice [digital]	ESPN2 Blackout [V2+]/SAH	QVC Network	FOX Sports Net Base	9
-ABC n (PT24E) -]	Cancom Video Compression [SA-MPEG]	Mexican Parliament	(Inactive)	XEIPN canal 11	TVN Video Compression [digital]	MOR Music	Home Shopping Club Spree	MSNBC [V2+]	Home Shopping Network (HSN)	SSN FOX Sports SW [V2+]	10
[digital]	CBC-A French	(none)	(Inactive)	(none)	TVN Video Compression [digital]	Family Channel East [V2+]	Newsport [V2+]	Eternal Word TV Network (Rel)	SpeedVision [V2+]	Network One 'N1'	11
on Promo (occ)/o/v	Cancom Video Compression [SA-MPEG]	Data Transmissions	(Inactive)	Data Transmissions	General Communication [digital]	Discovery West [V2+]	History Channel [V2+]	Valuevision	Starnet	Data Transmissions	12
South (occ)/o/v	CBC-C English Pacific	(none)	(Inactive)	(none)	GRTV infomercials	CNBC [V2+]	The Weather Channel [V2+]	Encore [digicipher]	Travel Channel [V2+]	Fox Sports Alternates (occ)	13
England +]	Cancom Video Compression [SA-MPEG]	Data Transmissions	o/v	XEW canal 2	Sundance Channel [V2+]	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Blackout [V2+]/SAH	Fit TV	KUSA-NBC Denver [V2+]	14
v	o/v	Multivision [digicipher]	(Inactive)	Data Transmissions	Showtime West [V2+]	HBO East [V2+]	Showtime East [V2+]	Turner Broadcasting [digital]	WWOR-Ind New York [V2+]	SC Cincinnati/Ohio/Florida [V2+]	15
ic [V2+]	Cancom Video Compression [SA-MPEG]	Data Transmission	CTV Network [digital]	Canal 22	General Communication [digital]	Cinemax West [V2+]	M2: Music Television [V2+]	Turner Classic Movies [V2+]	Request TV 1 [V2+]	FOX Sports Arizona/ FOX Sports America [digicipher]	16
rnates /o/v	CBC-D feeds	o/v	(Inactive)	o/v	Nickelodeon West [V2+]	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	MTV East [V2+]	SSN FOX Sports (various) [V2+]	17
ne)	Video Catalog Channel	(none)	(Inactive)	Clara Vision (Rel)	The Movie Channel West [V2+]	TNN [V2+]	TVLand	HBO Multiplex [digicipher]	Viewer's Choice [digicipher]	FOX Sports Midwest/ Alternates/Cal-Span	18
onal ment TV et)	o/v	Multivision [digicipher]	TV Northern Canada [digital]	(none)	MTV West [V2+]	USA East [V2+]	Showtime/MTV [digicipher]	Cinemax East [V2+]	C-SPAN 2	FOXNet [V2+]	19
BMAC]	o/v	o/v	Canadian Horse Racing/o/v	Data Transmissions	General Communication [digital]	BET [V2+]	Jones Intercable [digicipher]	Home and Garden Network [V2+]	Showtime 2 [V2+]	o/v	20
n feeds	Telesat [digital video compression]	(none)	SCPC services/ Data Transmissions	(none)	ESPNews [V2+]	Knowledge TV	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	SC Florida (occ) [V2+]	21
rus ications c)	Venus (adult) [V2+]	(none)	(Inactive)	XHIMT canal 7	Global Access (occ)	CNN/HN [V2+]	Your Choice TV/Animal Planet [digicipher]	Nostalgia Channel	FLIX [V2+]	SSN FOX Sports NW [V2+] (occ)	22
v	CBC-E English	(none)	(Inactive)	(none)	Computer Television Network	A&E [V2+]	E! Entertainment TV [V2+]	(none)	VH-1 [V2+]	KWGN-Ind Denver [V2+]	23
S Raleigh) [V2+]	Inactive (Failed Transponder)	(none)	(Inactive)	XHDF canal 13	General Communication [digital]	Showtime/Movie Channel [SA MPEG]	Digital Music Express Radio (DMX) [digital]	Global Shopping Network	CMT [V2+]	SSN Sunshine [V2+]	24

Unscrambled/non-video — Subscription — Not available in U.S. — o/v = occasional video

Geostationary Satellite Locator Guide

By Larry Van Horn

This guide shows the orbital locations of 255 active geostationary/synchronous satellites at publication deadline. Synchronous satellite location information is supplied to *Satellite Times* by NASA's Goddard Space Flight Center-Orbital Information Group (Mr. Adam Johnson). We are particularly grateful to the following individuals for providing payload information and analysis: Earth News: Philip Chien; Molniya Space Consultancy: Mr. Phillip Clark; JSC NASA: Dr. Nicholas Johnson; University of New Brunswick: Mr. Richard B. Langley; Havard-Smithsonian Center for Astrophysics: Jonathan McDowell; U.S. Space Command/ Public Affairs; Naval Space Command/Public Affairs; NASA NSSDC/WDC-A, Goddard Space Flight Center; and the *Satellite Times* staff.

'd' indicates that satellite is drifting — moving into a new orbital slot or at end of life. 'i' indicates an orbital inclination greater than 2 degrees and '#' indicates that the satellite has started into an inclined orbit.

Radio Frequency Band Key

VHF	136-138 MHz
P band	225-1,000 MHz
L band	1.4-1.8 GHz
S band	1.8-2.7 GHz
C band	3.4-7.1 GHz
X band	7.25-8.4 GHz
Ku band	10.7-15.4 GHz
K band	15.4 -27.5 GHz
Ka band	27.5-50 GHz
Millimeter	> 50 GHz

Satellite Service Key

BSS	Broadcast Satellite Service
Dom	Domestic
DTH	Direct to Home
FSS	Fixed Satellite Service
Gov	Government
Int	International
Mar	Maritime
Met	Meteorology
Mil	Military
Mob	Mobile
Reg	Regional

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
21140	1991-015B Meteosat 5 (MOP 2)	0.4E	Met (L)
24209	1996-044B Telecom 2D (France)	2.7E	Dom-FSS/Gov-Mil (C/X/Ku)
23730	1995-067A Telecom 2C (France)	2.9E	Dom FSS/Gov-Mil (X/C/Ku)
23712	1995-060A USA 115 (DFS-2/Milstar-2)	4.0E/i	Mil-Comm (P/S/K)
19919	1989-027A Tele X (Sweden)	4.9E	Reg DTH/FSS (Ku)
20193	1989-067A Sirius/Marcopolo 1(BSB R-1)	5.1E	Reg DTH (Ku)
22921	1993-076A USA 98 (NATO 4B)	5.9E/i	Mil-Comm (P/S/X)
20929	1990-095A DSP F-15 (USA)	6.6E#	Mil-Early Warning (S/X)
22028	1992-041B Eutelsat II F4	7.0E	Reg FSS (Ku)
21056	1991-003B Eutelsat II F2	9.9E	Reg FSS (Ku)
19596	1988-095A Raduga 22 (Russia)	11.3E/i	Dom FSS/Gov-Mil (X/C)
22557	1993-013A Raduga 29 (Russia)	11.6E#	Dom FSS/Gov-Mil (X/C)
22269	1992-088A Cosmos 2224 (Russia)	11.7E#	Mil-Earl Warning (X)
20777	1990-079B Eutelsat II F1	13.0E	Reg FSS (Ku)
21055	1991-003A Italsat F1 (Italy)	13.1E	Dom-Telephone (S/K/Ka)
23537	1995-016B Hot Bird 1 (Eutelsat II F6)	13.2E	DTH (Ku)
24665	1996-067A Hot Bird 2 (Eutelsat II F7)	132.E	DTH (Ku)
24208	1996-044A Italsat F2 (Italy)	13.2E	Dom-Telephone-Mob (S/K/Ka)
24307	1996-053A Inmarsat 3 F2	15.8E/i	Int Mar (L/C)
21803	1991-083A Eutelsat II F3	16.0E	Reg FSS (Ku)
19688	1988-109B Astra 1A	19.1E	Reg DTH (Ku)
23686	1995-055A Astra 1E	19.1E	Reg DTH (Ku)
21139	1991-015A Astra 1B	19.2E	Reg DTH (Ku)
22653	1993-031A Astra 1C	19.2E	Reg DTH (Ku)
23331	1994-070A Astra 1D	19.2E	Reg DTH (Ku)
23842	1996-021A Astra 1F	19.2E	Reg DTH (Ku)
14234	1983-077A Telstar 3A (301) (USA)	20.0E/i	Dom FSS-Saudi Arabia (C)
19331	1988-063B Eutelsat 1 F5 (ECS 5)	21.4E#	Reg FSS (VHF/Ku)
22175	1992-066A DFS 3 (Germany)	23.5E	Dom BSS (S/Ku/K)
18351	1987-078B Eutelsat 1 F4 (ECS 4)	25.5E/i	Reg FSS (VHF/Ku)
23948	1996-040A Arabsat 2A (Arabsat)	26.0E	Reg FSS/BSS (C/Ku)
20659	1990-054A Gorizont 20 (Russia)	26.3E/i	Dom/Gov FSS (C/Ku)
20706	1990-063B DFS 2/Kopernikus (Germany)	28.5E	Dom BSS (S/Ku/K)
21894	1992-010B Arabsat 1C (Arabsat)	31.0E	Reg FSS/BSS (S/C)
23200	1994-049B Turksat 1B (Turkey)	31.0E	Reg FSS (Ku)
24652	1996-062A Arabsat 2B (Arabsat)	32.0E	Reg FSS/BSS (C/Ku)
13595	1982-097A Intelsat 505	33.1E/i	Int FSS/Mar (L/C/Ku)
19765	1989-004A Gorizont 17 (Russia)	33.7E/i	Dom/Gov FSS (C/Ku)
21821	1991-087A Raduga 28 (Russia)	34.5E/i	Dom FSS/Gov-Mil (X/C)
22963	1993-002A Gals 1 (Russia)	35.9E	Dom BSS (Ku)
14128	1983-058A Eutelsat 1 F1 (ECS 1)	36.1/i	Reg FSS (Ku)
23717	1995-063A Gals 2 (Russia)	36.3E	Dom BSS (Ku)
23775	1996-005A Gorizont 31 (Russia)	39.6E#	Dom/Gov FSS (C/Ku)
23949	1996-040B Turksat 1C (Turkey)	42.1E	Reg FSS (Ku)
22981	1994-008A Raduga 1-3 (Russia)	48.9E#	Dom FSS/Gov-Mil (X/C)
23880	1996-034A Gorizont 32 (Russia)	52.8E	Dom/Gov FSS (C/Ku)
19687	1988-109A Skynet 4B (UK)	53.0E/i	Mil-Comm (P/S/X/Ka)
23305	1994-064A Intelsat 703	57.0E	Int FSS (C/Ku)
13040	1982-006A DSCS II E15 (USA)	57.0E/i	Mil-IOR reserve operational (S/X)
20203	1989-069B DSCS III A2 (USA 44)	57.0E/i	Mil-IOR primary operational (P/S/X)
20667	1990-056A Intelsat 604	59.9E	Int FSS (C/Ku)
22913	1993-074A DSCS III B10 (USA 97)	60.0E/i	Mil-IOR primary operational (P/S/X)
20315	1989-087A Intelsat 602	62.9E	Int FSS (C/Ku)
23839	1996-020A Inmarsat 3 F1	64.0E/i	Int Mar (L/C)
13636	1982-106A DSCS II F16 (USA 43)	64.9E/i	Mil-IOR reserve operational (S/X)
20918	1990-093A Inmarsat 2 F1	65.1E#	Int Mar-IOR (L/C)
23461	1995-001A Intelsat 704	66.0E	Int FSS (C/Ku)
23636	1995-040A PanAmSat 4 (PAS 4)	68.5E	Int FSS (C/Ku)
20083	1989-048A Raduga 1-1 (Russia)	70.2E/i	Dom FSS/Gov-Mil (X/C)
23448	1994-087A Raduga 32 (Russia)	70.7E#	Dom FSS/Gov-Mil (X/C)
22787	1993-056A USA 95 (UFO-2)	71.2E/i	Mil-IOR primary (P/S)
20410	1990-002B Leasat 5 (USA)	71.5E/i	Mil-IOR reserve (P/S/X)
12474	1981-050A Intelsat 501	72.1E/i	Int FSS (C/Ku)
23589	1995-027A USA 111 (UFO-5)	72.1E/i	Mil-IOR reserve (P/S/K)
13129	1982-031A Insat 1A (India)	72.6E/i	DOM FSS?Met (S/C)
22027	1992-041A Insat 2A (India)	73.9E	Dom FSS/BSS/Met (S/C)
23327	1994-069A Elektro 1 (Russia)	76.0E#	Met (L)
23680	1995-054A Luch 1-1 (Russia)	77.3E/i	Tracking & Relay SDRN-2 (Ku)
23314	1994-065B Thaicom 2 (Thailand)	78.4E	Reg FSS (C/Ku)
22931	1993-078B Thaicom 1 (Thailand)	78.5E	Reg FSS (C/Ku)
21759	1991-074A Gorizont 24 (Russia)	79.4E/i	Dom/Gov FSS (C/Ku)
23653	1995-045A Cosmos 2319 (Russia)	80.0E#	Data Relay (C)
24435	1996-058A Express 2 (Russia)	80.0E	Int FSS (C/Ku)
20643	1990-051A Insat 1D (India)	82.9E	Dom FSS/BSS/Met (S/C)
19548	1988-091B TDRS F3 (USA)	85.3E/i	Gov (C/S/Ku)
22836	1993-062A Raduga 30 (Russia)	85.5E#	Dom FSS/Gov-Mil (X/C)
18922	1988-014A PRC 22 DFH2-1(China)	87.9E/i	Dom FSS (C)
22880	1993-069A Gorizont 28 (Russia)	90.0E#	Dom/Gov FSS (C/Ku)
23765	1995-003A Measat 1 (Malaysia)	91.4E	Dom FSS/DTH (C/Ku)
22724	1993-048B Insat 2B (India)	93.5E	Dom FSS/BSS/Met (S/C)
23731	1995-067B Insat 2C (India)	93.5E	Dom FSS/BSS/Met (S/C)
23426	1994-082A Luch 1 (Russia)	95.4E#	Tracking & Relay CSDRN (Ku)
22245	1992-082A Gorizont 27 (Russia)	96.7E#	Dom/Gov FSS (C/Ku)
20263	1989-081A Gorizont 19 (Russia)	96.9E/i	Dom/Gov FSS (C/Ku)
20473	1990-011A PRC 26 DFH2A-1 (China)	98.1E#	Dom FSS (C)
22210	1992-074A Ekran 20 (Russia)	98.9E#	Dom BSS (P)
19683	1988-108A Ekran 19 (Russia)	99.1E/i	Dom BSS (P)
23723	1995-064A AsiaSat 2	100.5E	DTH (C/Ku)
21922	1992-017A Gorizont 25 (Russia)	102.7E/i	Dom/Gov FSS (C/Ku)
20558	1990-030A Asiasat 1	105.4E	DTH (C/Ku)
20570	1990-034A Palapa B2R	108.0E	Reg FSS (C)
23176	1994-040B BS-3N (Japan)	109.8E	Dom BSS (Ku)
21668	1991-060A BS-3B (Yuri 3B)(Japan)	109.9E	Dom BSS (Ku)
20771	1990-077A BS-3A (Yuri 3A)(Japan)	109.9E	Dom BSS (Ku)
19710	1988-111A PRC 25 DFH2-2 (China)	110.3E#	Dom FSS (C)
23864	1996-030A Palapa C2	113.0E	Reg FSS (C/Ku)
14985	1984-049A Chinasat 5 (Spacenet 1)	115.6E	Dom FSS (C/Ku)
23639	1995-041A Koreasat 1 (Mugunghwa 1)	115.8E	Dom FSS (Ku)
23768	1996-003A Koreasat 2 (Mugunghwa 2)	115.8E	Dom FSS (Ku)
21964	1992-027A Palapa B4	118.1E	Reg FSS (C)
20217	1989-070A GMS-4 (Himawari 4)	120.3E#	Met (P/L)
21132	1991-014A Raduga 27 (Russia)	127.2E/i	Dom FSS/Gov-Mil (X/C)
23649	1995-043A JCSAT 3 (Japan)	128.0E	Dom FSS (Ku)
22907	1993-072A Gorizont 29 (Rimsat 1)	130.1E#	Reg FSS (C/Ku)
23651	1995-044A N-Star A (Japan)	131.0E	Dom/Mob FSS (S/C/Ku/Ka)
18877	1988-012A CS 3A (Sakura 3A)(Japan)	132.0E	Dom FSS (C/K)
23943	1996-039A Apstar 1A (China)	133.9E	Reg FSS (C)
23781	1996-007A N-Star B (Japan)	135.6E	Dom/Mob FSS (S/C/Ku/Ka)
19508	1988-086A CS 3B (Sakura 3B) (Japan)	136.0E	Dom FSS (C/K)
23185	1994-043A APStar I (China)	138.0E	DTH (C)
23522	1995-011B GMS-5 (Himawari 5)	139.6E#	Met (P/L)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
20107	1989-052A Gorizont 18 (Russia)	140.1E/i	Dom/Gov FSS (C/Ku)
20953	1990-102A Gorizont 22 (Russia)	140.1E/i	Dom/Gov FSS (C/Ku)
23108	1994-030A Gorizont 30 (Rimsat 2)	142.1E#	Reg FSS (C/Ku)
17706	1987-029A Palapa B-2P	143.9E	Reg FSS (C)
20923	1990-094A Gorizont 21 (Russia)	144.4E/i	Dom/Gov FSS (C/Ku)
20066	1989-046A DSP F-14 (USA)	145.4E/i	Mil-Early Warning (S/X)
24653	1996-063B Measat-2 (Malaysia)	148.oE	Dom FSS/DTH (C/Ku)
19874	1989-020A JCSAT 1 (Japan)	150.0E	Dom FSS (Ku)
18316	1987-070A ETS V/Kiku 5 (Japan)	150.2E/i	Experimental (L/C)
23779	1996-006A Palapa C1	150.5E	Reg FSS (C/Ku)
18350	1987-078A Optus A3 (Aussat K3)	152.0E#	DTH (Ku)
20402	1990-001B JCSAT 2 (Japan)	154.0E	Dom FSS (Ku)
23227	1994-055A Optus B3 (Australia)	156.0E	DTH/Mob (L/Ku)
12994	1981-119A Intelsat 503	156.9E/i	Int FSS (C/Ku)
22253	1992-084A Superbird A1 (Japan)	158.0E	Dom FSS (Ku/K)
22087	1992-054A Optus B1 (Aussat B1)	160.0E	DTH/Mob (L/Ku)
21893	1992-010A Superbird B1 (Japan)	162.0E	Dom FSS (Ku/K)
16275	1985-109C Optus A2 (Aussat 2)	164.0E/i	DTH (Ku)
23175	1994-040A PanAmSat 2 (PAS-2)	169.0E	Int FSS (C/Ku)
12046	1980-087A OPS 6394 (FltSatCom F4)(USA)	172.0E/i	Mil-POR reserve (P-Bravo/S/X)
22871	1993-066A Intelsat 701	174.0E	Int FSS (C/Ku)
22719	1993-046A DSCS III B9 (USA 93)	175.0E/i	Mil-WPAC primary operational (P/S/X)
23124	1994-034A Intelsat 702	177.0E	Int FSS (C/Ku)
21814	1991-084B Inmarsat 2 F3	178.0E#	Int Mar-POR (L/C)
16117	1985-092C DSCS III B5 (USA 12)	180.0E/i	Mil-WPAC reserve operational (P/S/X)
15873	1985-055A Intelsat 511	179.9W/i	Int FSS (C/Ku)
08882	1976-053A Marisat 2	178.2W/i	Int Mar-IOR (P/L/C)
23467	1995-003A USA 108 (UFO-4) (USA)	177.6W/i	Mil-POR (P/S/K)
19121	1988-040A Intelsat 513	177.0W#	Int FSS (C/Ku)
21639	1991-054B TDRS F5 (USA)	174.2W	Int FSS/Gov (C/S/Ku)
23613	1995-035B TDRS F7 (USA)	171.3W#	Int FSS/Gov (C/S/Ku)
23967	1996-042A USA 127 (UFO-7)	170.5W/i	Mil-EPAC (P/S/K)
18631	1987-100A Raduga 21 (Russia)	170.4W/i	Dom FSS/Gov-Mil (X/C)
20499	1990-016A Raduga 25 (Russia)	170.1W/i	Dom FSS/Gov-Mil (X/C)
21392	1991-037A Satcom C5 (Aurora II)(USA)	139.0W	Dom FSS (C)
20945	1990-100A Satcom C1 (USA)	137.0W	Dom FSS (C)
22096	1992-057A Satcom C4 (USA)	135.0W	Dom FSS (C)
23581	1995-025A GOES 9 (USA)	135.3W#	Met (P/L/S)
21873	1992-006A DSCS III B14 (USA 78)	135.0W/i	Mil-EPAC primary operational (P/S/X)
23016	1994-013A Galaxy 1R (USA)	133.0W	Dom FSS (C)
22117	1992-060B Satcom C3 (USA)	130.9W	Dom FSS (C)
13637	1982-106B DSCS III A1 (USA)	129.8W/i	Mil-EPAC reserve operational (P/S/X)
21906	1992-013A Galaxy 5 (USA)	125.0W	Dom FSS (C)
16649	1986-026A Gstar 2 (USA)	124.9W#	Dom FSS (Ku)
23877	1996-033A Galaxy 9 (USA)	123.0W	Dom FSS (C)
19484	1988-081B SBS 5 (USA)	122.9W	Dom FSS (Ku)
22988	1994-009A USA 99 (DFS-1/Milstar 1)	120.0W	Mil-Comm (P/S/K)
15826	1985-048D Telestar 3D (USA)	119.9W#	Dom FSS (C)
24313	1996-055A Echostar 2 (USA)	119.1W	DTH (Ku)
23754	1995-073A EchoStar 1 (USA)	118.9W	DTH (Ku)
16274	1985-109B Morelos 2 (Mexico)	117.2W	Dom FSS (C/Ku)
13652	1982-110C Anik C3 (Canada)	114.8W/i	Dom FSS (Ku)
23313	1994-065A Solidardad 2 (Mexico)	112.9W	Dom FSS (L/C/Ku)
21726	1991-067A Anik E1 (Canada)	111.0W	Dom FSS (C/Ku)
22911	1993-073A Solidaridad 1 (Mexico)	109.1W	Dom FSS (L/C/Ku)
21222	1991-026A Anik E2 (Canada)	107.2W	Dom FSS (C/Ku)
23846	1996-022A MSAT M1 (Canada)	106.5W	Mobile (L/X)
23696	1995-057A USA 114 (UFO-6)	105.8W/i	Mil-CONUS (P/S/K)
03029	1967-111A ATS 3 (USA)	105.6W/i	Exp comm (VHF/C)
20946	1990-100B Gstar 4 (USA)	105.0W	Dom FSS (Ku)
08697	1976-017A Marisat 1	104.7W/i	Int Mar-AOR (P/L/C)
08747	1976-023B LES 9 (USA)	103.8W/i	Mil-Exp comm (P/Ka)
08746	1976-023A LES 8 (USA)	103.1W/i	Mil-Exp comm (P/Ka)
24315	1996-054A GE-1 (USA)	103.0W	DOM FSS (C/Ku)
15677	1985-035A Gstar 1 (USA)	102.9W	Dom FSS (Ku)
23435	1994-084A DSP F-17 (USA)	102.6W#	Mil-Early Warning (S/X)
22930	1993-078A DBS 1 (USA)	101.2W	DTH (Ku)
21227	1991-028A Spacenet 4 (USA)	101.0W	Dom FSS (C/Ku)
23553	1995-019A AMSC 1 (USA)	100.9W	Mobile (L/X)
23598	1995-029A DBS 3 (USA)	100.9W	DTH (Ku)
23192	1994-047A DBS 2 (USA)	100.9W	DTH (Ku)
22796	1993-058B ACTS (USA)	100.0W	Exp Comm (C/K/Ka)

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
17181	1986-096A USA 20 (FltSatCom F7)(USA)	99.9W/i	Mil-CONUS primary (P/S/X/K)
22694	1993-039A Galaxy 4 (USA)	98.9W	Dom FSS (C/Ku)
22927	1993-077A Telstar 401 (USA)	97.0W	Dom FSS (C/Ku)
23741	1995-069A Galaxy 3R (USA)	94.9W	Dom/DTH (C/Ku)
19483	1988-081A Gstar 3 (USA)	93.5W/i	Dom FSS/Mob (L/Ku)
16650	1986-026B SBTS 2 (Brazil)	92.0W	Dom FSS (C)
22205	1992-072A Galaxy 7 (USA)	91.0W	Dom FSS (C/Ku)
23670	1995-049A Telstar 402R (USA)	89.0W	Dom FSS (C/Ku)
18951	1988-018A Spacenet 3R (USA)	87.0W	Dom FSS (L/C/Ku)
15237	1984-093D Telestar 3C (302) (USA)	84.9W#	Dom FSS (C)
16482	1986-003B Satcom K-1 (USA)	84.9W	Dom FSS (Ku)
16276	1985-109D Satcom K-2 (USA)	80.9W	Dom FSS (Ku)
15561	1985-015B SBTS 1 (Brazil)	79.0W#	Dom FSS (C)
15235	1984-093B SBS 4 (USA)	77.0W/i	Dom FSS (Ku)
12309	1981-018A Comstar D4 (USA)	76.0W/i	Dom FSS (C)
14133	1983-059B Anik C2 (Argentina)	75.9W/i	Dom FSS (Ku)
23051	1994-022A GOES 8 (USA)	74.4W#	Met (P/L/S)
20873	1990-091B Galaxy 6 (USA)	74.0W	Dom FSS (C)
20872	1990-091A SBS 6 (USA)	73.9W	Dom FSS (Ku)
15642	1985-028B Anik C1 (Argentina)	71.8W	Dom FSS (Ku)
23199	1994-049A Brazilsat B1 (Brazil)	70.0W	Dom FSS (C)
15385	1984-114A Spacenet 2 (USA)	68.9W	Dom FSS (C/Ku)
23536	1995-016A Brasilsat B2 (Brazil)	65.0W	Dom FSS (C/X)
21940	1992-021B Inmarsat 2 F4	54.2W/i	Int Mar-AOR-W (L/C)
23571	1995-023A Intelsat 706	53.0W	Int FSS (C/Ku)
23628	1995-038A DSCS III B7 (USA)	52.5W/i	Mil-WLANT primary operational (P/S/X)
23915	1996-035A Intelsat 709	49.9W	Intl FSS (C/Ku)
13969	1983-026B TDRS F1 (USA)	49.1W/i	Gov (C/S/Ku)
22314	1993-003B TDRS F6 (USA)	47.0W/i	Gov (C/S/Ku)
19217	1988-051C PanAmSat 1 (PAS 1)	44.9W	Int FSS (C/Ku)
23764	1996-002A PanAmSat 3R (PAS 3R)	43.0W	Int FSS (C/Ku)
16116	1985-092B DSCS III B4 (USA 11)	42.5W/i	Mil-ATL reserve operational (P/S/X)
19883	1989-021B TDRS F4 (USA)	40.9W	Int FSS/Gov (C/S/Ku)
12089	1980-098A Intelsat 502	40.4W/i	Int FSS (C/Ku)
23413	1994-079A Orion 1 (USA)	37.5W	Int FSS (Ku)
20523	1990-021A Intelsat 603	34.5W	Int FSS (C/Ku)
20401	1990-001A Skynet 4A	34.0W/i	Mil-comm (P/S/X/Ka)
14077	1983-047A Intelsat 506	31.3W/i	Int FSS/Mar (L/C/Ku)
22116	1992-060A Hispasat 1A (Spain)	30.1W	Dom BSS/FSS (Ku)
22723	1993-048A Hispasat 1B (Spain)	29.9W	Dom BSS/FSS (Ku)
21765	1991-075A Intelsat 601	27.4W	Int FSS (C/Ku)
21653	1991-055A Intelsat 605	24.5W	Int FSS (C/Ku)
22112	1002-059A Cosmos 2209 (Russia)	23.8W#	Mil-Early Warning (X)
16101	1985-087A Intelsat 512	23.5W#/d	Int FSS (C/Ku)
20253	1989-077A USA 46 (FltSatCom 8)	22.7W/#	Mil-AOR primary (P-Charlie/S/X/K)
19772	1989-006A Intelsat 515	22.0W	Int FSS (C/Ku)
21989	1992-032A Intelsat K	21.4W	Int FSS (Ku)
15391	1984-115A NATO III D	20.9W/i	Mil-Comm (P/S/X)
20705	1990-063A TDF 2 (France)	18.8W	DTH (Ku)
23528	1995-013A Intelsat 705	18.0W	Int FSS (C/Ku)
21047	1991-001A NATO IV A	17.6W/i	Mil-Comm (P/S/X)
20391	1989-101A Cosmos 2054 (Russia)	16.0W/i	Tracking & Relay WSDRN (Ku)
21149	1991-018A Inmarsat 2 F2	15.5W/i	Int Mar-AOR-E (L/C)
15386	1984-114B Marecs B2	15.0W/i	Int Mar-AOR (L)
10669	1978-016A Ops 6391 (FltSatCom 1) (USA)	14.5W/i	Mil-AOR reserve (P-Alpha/S/X)
23132	1994-035A USA-104 (UFO-3)(USA)	14.3W/i	Mil-AOR primary (P/S)
23319	1994-067A Express 1 (Russia)	14.0W	Int FSS (C/Ku)
23267	1994-060A Cosmos 2291 (Russia)	13.3 W#	Data Relay (C)
22009	1992-037A DSCS III B12 (USA 82)	12.0W	Mil-ELANT primary operational (P/S/X)
22041	1992-043A Gorizont 26 (Russia)	11.2W#	Dom/Gov FSS (C/Ku)
22912	1993-073B Meteosat 6 (ESA)	9.7W#	Met (L)
21813	1991-084A Telecom 2A (France)	8.0W	Dom FSS/Gov-Mil (X/C/Ku)
21805	1991-080B DSP F-16 (USA)	6.9W#	Mil-Early Warning (S/X)
21939	1992-021A Telecom 2B (France)	5.0W	Dom FSS/Gov-Mil (X/C/Ku)
23865	1996-030B Amos 1 (Israel)	4.0W	Dom FSS (
23816	1996-015A Intelsat 707	1.0W	Int FSS (C/Ku)
20776	1990-079A Skynet 4C (UK)	0.9W#	Mil (P/S/X/Ka)
20762	1990-074A Thor 1/Marcopolo 2 (BSB R-2)	0.7W	Reg BSS (Ku)
20168	1989-062A TV Sat 2 (Germany)	0.4W	Dom BSS (Ku)

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

Satellite	Mode		Frequencies																
OSCAR 10 (AO-10) (Notes 1 & 12)	B (u/V)	Dn	145.825	835	845	855	865	875	885	895	905	915	925	935	945	955	965	145.975	
		Up	435.179	169	159	149	139	129	119	109	099	089	079	069	059	049	039	435.029	
	Bcn	145.810 (Steady unmodulated carrier)																	
RS 10/11 (Notes 2, 3, 4 and 12)		Dn	29.360	370	380	390	29.400					29.403							
		Up	145.860	870	880	890	145.900				(CW)	145.820							
	Bcn	29.357 (CW)																	
RS-12/13 (Notes 2, 5 & 6)		Dn	29.410	420	430	440	29.450					29.454							
		Up	21.210	220	230	240	21.250				(CW)	21.129							
	Bcn	29.408																	
RS-15 (Note 12)	A (v/a)	Dn	29.354	29.364	29.374	28.384	29.394												
		Up	145.858	145.868	145.878	145.888	145.898												
UoSat 11 (UO-II) (Note 13)	Bcns	Dn	145.826	435.025	2401.500														
		Up	None																
PACSAT (AO-16) (Notes 7, 8 & 10)	[a]	Dn	437.025 (Sec)437.050																
		Up	145.900	145.920	145.940	145.960													
DOVE (DO-17) (Notes 9 & 10)	[b,c]	Dn	145.825	2401.220															
		Up	None																
WEBERSAT (WO-18) (Note 10)	[a]	Dn	437.075	437.100 (Sec)															
		Up	None																
LUSAT (LO-19) (Notes 7 & 10)	[a]	Dn	437.125	437.150 (Sec)															
		Up	145.840	145.860	145.880	145.900													

NOTES

1. The AO-10 beacon is an unmodulated carrier. This satellite has suffered computer damage making it impossible to orient the satellite for optimum service or solar illumination. In order to preserve it as long an possible, do not transmit to it when you hear the beacon FMing.
2. RS-10/11 and RS-12/13 are each mounted on common spaceframes, along with comunication and navagation packages.
3. RS-10 has been in Mods A for some months, but also has capability for Mode T (21.160-21.200 Uplink, 145.860-145.900 Downlink), Mode K (21.160-21.200 Uplink, 29.360-29.400 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
4. RS-11 is currently turned off. If activated, it has capability for Mods A (145.910-145.950 Uplink, 29.410-29.450 Downink), Mode T (21.210-21.250 Uplink, 145.910-145.950 Downlink), Mode K (21.210-21.250 Uplink, 29.410-29.450 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
5. RS-12 has been in Mode K for some months, but also has capability for Mode A (145.910-145.950 Uplink, 29.410-29.450 Downlink), Mode T (21.210-21.250 Uplink, 145.910-145.950 Downlink) an well as combined Modes K/A and K/T using these same frequency combinations.
6. RS-13 is currently turned off. If activated, it has capability for Mode A (145.960-146.000 Uplink, 29.460-29.500 Downlink), Mode K (21.260-21.300 Uplink, 29.460-29.500 Downlink), Mode T (21.210-21.250 Uplink, 145.960-146.000 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
7. Transmitters on both AO-16 & LU-19 are currently using Raised Cosine Mode.
8. AO-16 users are encouraged to select 145.900, 145.920 and 145.940 for uploading and 145.960 for directory and/or file requests.
9. DOVE is designed to transmit digital voice messages, but due to hardware and software difficulties, it has not yet met this objective except for a few short tests. Recently, it has been transmitting telemetry in normal AX-25 AFSK packet.
10. Letters in [ ] represent digital formats, as follows:
    [a] 1200 bps PSK AX-25
    [b] 1200 bps AFSK AX-25
    [c] 9600 bps FSK
    [d] Digitized voice (Notes 8 & 9)
11. PO-28 is available to amateurs on an intermittent, unscheduled basis.
12. Modes of operation used include: CW,/USB/FAX/Packet/RTTY
13. Modes of operation used include: FM (AFSK) & PSK Data.
14. Modes of operation used include: Packet & FM Voice.

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

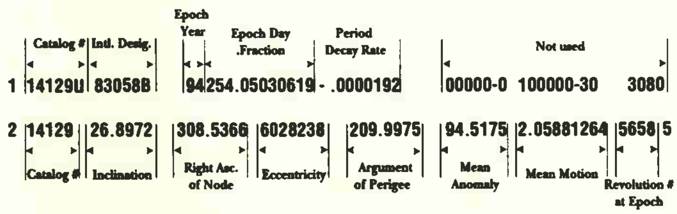
Satellite	Mode		Frequencies
JAS-Ib (FO-20) (Notes 10 & 12)	JA Linear	Dn	435.800 810 820 830 840 850 860 870 880 890 435.900
		Up	146.000 990 980 970 960 950 940 930 920 910 900
	Bcn		435.795 (CW)
	JD [a] Dgtl	Dn	435.910
		Up	145.850 145.890 145.910
OSCAR 22 (UO-22) (Note 10)	[c]	Dn	435.120
		Up	145.900 145.975
KITSAT A (KO-23) (Note 10)	[c]	Dn	435.173
		Up	145.850 145.900
KITSAT B (KO-25) (Note 10)	[c]	Dn	435.175 436.500
		Up	145.870 145.980
IT-AMSAT (IO-26) (Note 10)	[a,c]	Dn	435.820 (Sec.) 435.867
		Up	145.875 145.900 145.925 145.950
EYESAT /AMRAD (AO-27) (Note 10)	[b,a]	Dn	436.800
		Up	145.850
POSAT (PO-28) (Notes 10 & 12)	[c]	Dn	435.250 435.280
		Up	145.925 145.975
FUJI/ OSCAR 29 (FO-29) (Notes10 &12)	JA Linear	Dn	435.800 810 820 830 840 850 860 870 880 890 435.900
		Up	146.000 990 980 970 960 950 940 930 920 910 145.900
	JD Digtl (b,c)	Dn	453.910
		Up	145.850 145.870 145.890 145.910
MEXICO/ OSCAR 30 (MO-30) (Note 10)	(b)	Dn	437.138 (sec) 437.206 (pμ) BCN:
		Up	145.815 145.835 145.855 145.875 40.997 MHz
MIR (Note 14)	[b]	Up & Dn & FM voice	145.550
SHUTTLE (SAREX) (Note 14)	[b]	Dn	145.840
		Up	144.450 144.470

Compiled by
AMSAT
The Radio Amateur Satellite Corp.
PO Box 27 Washington, DC 20044

Amateur and Weather Satellite Two-Line Orbital Element Sets

Below is an example of the format for the elements sets presented in this section of the Satellite Service Guide. The spacecraft is named in the first line of each entry. Illustration below shows meaning of data in the next two lines.

OSCAR 10
1 14129U 83058B 94254.05030619 -.00000192 00000-0 10000-3 0 3080
2 14129 26.8972 308.5366 6028238 209.9975 94.5175 2.05881264 56585



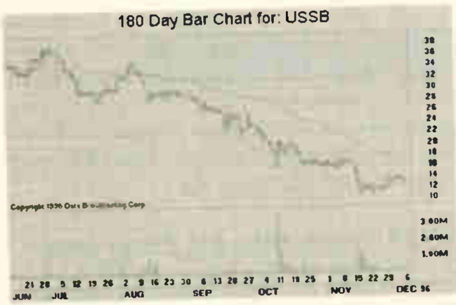
Notice that there is no decimal point printed for eccentricity. The decimal point goes in front of the number. For example, the number shown above for eccentricity would be entered into your computer tracking program as .6028238.

AMATEUR RADIO SATELLITES
OSCAR 10 (AMSAT OSCAR 10, AO-10)
1 14129U 83058B 96285.03170314 -.00000150 00000-0 10000-3 0 4581
2 14129 25.8858 184.9970 6048316 56.3073 347.4042 2.05879930 72258
OSCAR 11 (UoSAT 2, UoSAT 11, UOSAT OSCAR-11, UO-11)
1 14781U 84021B 96342.01958317 .00000139 00000-0 31257-4 0 9348
2 14781 97.8137 325.1947 0010758 260.0070 99.9921 14.69505446683038
Russian Mir Space Station
1 16609U 86017A 96345.31845887 .00002050 00000-0 28429-4 0 8620
2 16609 51.6525 316.0698 0013417 124.0920 236.1310 15.62583222617539
RS-10/11 (Radio Sputnik 10/11, Cosmos 1861)
1 18129U 87054A 96341.98767983 .00000015 00000-0 -23021-7 0 2901
2 18129 82.9279 20.8118 0013021 39.1330 321.0763 13.72372068473876
OSCAR 16 (PACSAT, AMSAT OSCAR-16, AO-16)
1 20439U 90005D 96342.25547733 .00000014 00000-0 22239-4 0 293
2 20439 98.5518 64.4849 0012150 55.9176 304.3157 14.29992224358804
OSCAR 17 (DOVE, DOVE OSCAR-17, DO-17)
1 20440U 90005E 96342.26053678 .00000034 00000-0 29789-4 0 307
2 20440 98.5547 65.2265 0012347 54.2410 305.9916 14.30134768358836
OSCAR 18 (WEBERSAT, WEBERSAT OSCAR-18, WO-18)
1 20441U 90005F 96342.25411242 .00000007 00000-0 19479-4 0 330
2 20441 98.5538 65.1395 0012786 55.3902 304.8484 14.30103067358831
OSCAR 19 (LUSAT, LUSAT OSCAR-19, LO-19)
1 20442U 90005G 96342.30657788 .00000030 00000-0 28279-4 0 293
2 20442 98.5564 65.7637 0013183 53.3873 306.8514 14.30214804358864
OSCAR 20 (JAS 1B, FUJI 2, FUJI OSCAR 20, FO-20)
1 20480U 90013C 96342.54871200 -.00000010 00000-0 41145-4 0 9269
2 20480 99.0224 334.4142 0541075 91.5399 274.7721 12.83235639320121
RS-12/13 (Radio Sputnik 12/13, Cosmos 2123)
1 21089U 91007A 96341.76333624 .00000020 00000-0 44304-5 0 9390
2 21089 82.9219 61.3627 0030330 111.0389 249.4015 13.74074888292738
OSCAR 22 (UoSAT-F, UoSAT-5, UOSAT OSCAR 22, UO-22)
1 21575U 91050B 96342.70251051 .00000036 00000-0 26447-4 0 7365
2 21575 98.3317 43.7434 0008253 102.9890 257.2218 14.37047855282985
OSCAR 23 (KITSAT-A, KITSAT-1, KITSAT OSCAR-23, KO-23)
1 22077U 92052B 96342.55708665 -.00000037 00000-0 10000-3 0 6253
2 22077 66.0783 186.4681 0015260 258.0302 101.9007 12.86299011203101
OSCAR 27 (EYESAT-A, EYESAT-1, AMSAT OSCAR-27, AO-27
1 22825U 93061C 96342.74083840 .00000012 00000-0 22344-4 0 5219
2 22825 98.5670 55.0264 0009435 79.0582 281.1660 14.27711602166750
OSCAR 26 (ITAMSAT, ITAMSAT OSCAR-26, IO-26)
1 22826U 93061D 96342.72392684 .00000002 00000-0 18353-4 0 5198
2 22826 98.5680 55.2124 0009949 79.4943 280.7360 14.27820602166768
OSCAR 25 (KITSAT-B, KITSAT-2, KITSAT OSCAR-25, KO-25)
1 22828U 93061F 96342.73394407 .00000041 00000-0 33895-4 0 4994
2 22828 98.5631 55.2915 0011165 64.5736 295.6591 14.28161937134881
OSCAR 28 (POSAT, POSAT OSCAR-28, PO-28)
1 22829U 93061G 96342.75283402 .00000008 00000-0 20442-4 0 5133
2 22829 98.5652 55.3837 0010938 69.0819 291.1533 14.28143249166808
RS-15 (Radio Sputnik 15)
1 23439U 94085A 96342.76084784 -.00000039 00000-0 10000-3 0 1826
2 23439 64.8119 102.3857 0155370 168.1618 192.3024 11.27529351 80353
OSCAR 29 (FUJI 3, FUJI OSCAR-29, FO-29)
1 24278U 96046B 96342.18966757 .00000000 00000-0 38924-4 0 420
2 24278 98.5687 43.3539 0351499 323.7050 34.0691 13.52627717 15163
OSCAR 30 (MEXICO OSCAR-30, MO-30)
1 24305U 96052B 96343.95862514 .00000204 00000-0 20364-3 0 503
2 24305 82.9227 135.1459 0031347 17.0445 343.1753 13.73088653 12950

WEATHER/IMAGING SATELLITES
Geostationary Satellites
GOES 7 (Standby Geostationary Spacecraft-USA)
1 17561U 87022A 96344.28406829 -.00000148 00000-0 10000-3 0 1792
2 17561 3.4071 68.1830 0000926 289.6419 88.0916 1.00279809 19063
GOES 8 (Operational East-USA)
1 23051U 94022A 96345.12294264 -.00000242 00000-0 10000-3 0 6254
2 23051 0.3842 87.8410 0004058 159.9354 160.8500 1.00278307 17131
GOES 9 (Operational West-USA)
1 23581U 95025A 96344.59584436 .00000100 00000-0 10000-3 0 2909
2 23581 0.0441 267.2107 0003809 4.7488 245.6697 1.00270314 5682
ELEKTRO (Operational-Russia)
1 23327U 94069A 96339.93105324 -.00000090 00000-0 00000+0 0 2310
2 23327 0.4007 101.3981 0001103 97.8386 286.2925 1.00272162 7719
Meteosat 5 (Operational ESA, aka MOP-2)
1 21140U 91015B 96345.19303771 .00000002 00000-0 00000+0 0 3076
2 21140 0.9066 78.7664 0002002 138.7238 290.9284 1.00270155 23375
Meteosat 6 (Operational-ESA)
1 22912U 93073B 96335.09544771 -.00000080 00000-0 00000+0 0 5872
2 22912 0.3053 65.9407 0003591 157.1427 230.7314 1.00271215 9520
GMS 4 (Standby-Japan, aka Himawari 4)
1 20217U 89070A 96337.70682601 -.00000358 00000-0 10000-3 0 5014
2 20217 2.1261 74.2804 0001640 253.2651 118.4152 1.00258080 27113
GMS 5 Operational-Japan, aka Himawari 5)
1 23522U 95011B 96344.57922028 -.00000273 00000-0 10000-3 0 1833
2 23522 0.4663 22.3288 0000659 176.2984 228.3692 1.00269116 6214

Near Polar/Polar Orbiting Imaging Spacecraft
NOAA 12 (Operational morning spacecraft-USA 137.500 MHz)
1 21263U 91032A 96344.82579341 .00000065 00000-0 47988-4 0 1908
2 21263 98.5475 358.8181 0013536 121.1407 239.1102 14.22675315289432
NOAA 14 (Operational afternoon spacecraft-USA 137.620 MHz)
1 23455U 94089A 96344.78429589 .00000034 00000-0 43378-4 0 8565
2 23455 98.9662 289.8993 0010175 101.9207 258.3107 14.11630493100226
Meteor 2-21(Off at last report)
1 22782U 93055A 96342.68375381 .00000065 00000-0 46182-4 0 5305
2 22782 82.5496 209.6343 0020842 211.3165 148.6746 13.83065345165117
Meteor 3-5 (Operational-Russia 137.850 MHz)
1 21655U 91056A 96342.13573429 .00000051 00000-0 10000-3 0 9392
2 21655 82.5541 198.3118 0014058 94.3664 265.9064 13.16849891255438
Meteor 3-6 (Off at last report)
1 22969U 94003A 96341.55573472 .00000051 00000-0 10000-3 0 3056
2 22969 82.5575 138.8886 0014756 164.9436 195.2135 13.16740100137730
DMSP B5D2-7 (DoD meteorological polar orbiter: downlink encrypted)
1 23233U 94057A 96344.79516592 .00000030 00000-0 39854-4 0 322
2 23233 98.8047 40.8102 0013297 44.6389 315.5853 14.12758424117627
DMSP B5D2-8 (DoD meteorological polar orbiter: downlink encrypted)
1 23533U 95015A 96344.65297716 -.00000008 00000-0 19401-4 0 7812
2 23533 98.8434 344.8928 0006667 283.8739 76.1685 14.12765159 88401

EARTH RESOURCES IMAGING SATELLITES
OKEAN 1-7 (Okean 4-Russia 137.400 MHz)
1 23317U 94066A 96345.18962370 .00000103 00000-0 12309-4 0 2046
2 23317 82.5428 257.1013 0024179 228.3717 131.5425 14.74060882116468
SICH-1 (Oceanographic satellite-Russia 137.400 MHz-off until March 97)
1 23657U 95046A 96342.22745032 .00000199 00000-0 27114-4 0 1299
2 23657 82.5333 41.2882 0026601 205.4231 154.5668 14.73515356 68319
IRS-1C (Remote Sensing-India)
1 23751U 95072A 96343.24512494 -.00000044 00000-0 00000+0 0 1414
2 23751 98.7136 55.0381 0001040 88.5801 271.5497 14.21631139 49167
IRS-B3 (Remote Sensing-India)
1 23827U 96017A 96343.21652064 -.00000044 00000-0 00000+0 0 1008
2 23827 98.7798 57.3509 0001105 113.4773 246.6521 14.21595129 37212
TOMS-EP (Total Ozone Mapping Spectrometer-USA)
1 23940U 96037A 96343.79900611 .00001529 00000-0 70591-4 0 658
2 23940 97.4333 247.0811 0014692 89.6189 270.6732 15.21646466 24188
ADEOS (Advanced Earth Observation Satellite-Japan 2200, 8150, 8250, and 8350 MHz)
1 24277U 96046A 96343.97132003 -.00000044 00000-0 00000+0 0 1199
2 24277 98.6170 58.3988 0001138 36.9838 323.1417 14.27645477 16225



Starting in August, the dishes were advertised for $199, counting the prepayment rebate.

Martin wrote that the largely ineffective pricing promotion, launched against one 'underfinanced' high-power direct broadcast competitor, EchoStar, will be difficult to discontinue."

Another One Bites the Dust....

Day & Date is dead. The daily hour-long afternoon newsmagazine which was syndicated by CBS-owned Eyemark Entertainment, was scheduled to pull the plug on production Dec. 3. Previously taped episodes of the show will air through Jan. 3, 1997.

ABC has announced that it will cancel the daytime soap *The City* on March 28 and replace it on June 2 with *GH2*, a new half-hour daytime drama, billed as a spinoff of ABC's *General Hospital*. The spinoff will "explore the entire town of fictional Port Charles, focusing on Port Charles University's Medical School, adjacent to General Hospital...where ideals clash with reality, where passion and ambition conflict with dreams and where goals are continually being redefined in the face of life-and-death situations." Where do they get this stuff...

Bryant Gumbel, who leaves NBC's *Today Show* in January, has been spotted with executives of rival network ABC. Rumor has it, says *New York* magazine that ABC has proposed an "edgy" talk show on Thursday nights for Gumbel. The talk show might be linked to Diane Sawyer's "flirtation" with CBS. If Sawyer left ABC, a source told the magazine, "Bryant would be a good guy for *PrimeTime*. He could even substitute for (Ted) Koppel." Gumbel's agent, Ed Hookstratten, said his client "does not and will not decide on anything before the first of the year."

Comedy Central and VH1 are out in many cities and a new nature channel is in as TCI rearranges its lineup for most subscribers. TCI said it was making the changes to strengthen its cable offerings. Also gone will be superstations WGN and WWOR (much to the chagrin of a lot of sports and movie fans). The Travel Channel and E! Entertainment Television will be eliminated in many areas. TBS and the Discovery Channel will be added to the basic service. Some cities will get the Sci-Fi Channel and others the History Channel because of channel availability and customer requests.

V-CHIP

Okay, okay, the TV programming writers have actual gotten together to get their V-Chip rating system put together (I admit it was sooner than I thought, but give me a break...are you really going to buy a new TV that locks out programs when your current TV works just fine?)

The *New York Daily News* reports that December 19 may mark the end to months of speculation about a television ratings system that would accompany the "V-chip." On the 19th, the television industry will release details of its new system by which producers and distributors will label shows based on their content. The system is the result of "V-chip" legislation, which urged the industry to develop a system that would work with the "V-chip" which must be installed in sets beginning in 1998.

If successful, the "V-chip," along with the ratings system, will assist parents in determining which shows are most suitable for their children's viewing. That's all well and good, but what some people seem to be forgetting is a key provision in the legislation: If the industry's "voluntary" system doesn't satisfy the Federal Communications Commission, the agency is authorized to come up with one of its own. Whether or not the system presented by the industry will be satisfactory remains to be seen. Read between the lines and you can see that I am not a big fan of more government intervention and regulation.

As reported in this column earlier, the industry's system is similar to that of the Motion Picture Association's system, which labels feature films. A recent report in the *Los Angeles Times* said the new system will rate shows as "G," "PG" or "PG" with an added age advisory. Shows with violent scenes and/or intense, "adult" situations may be rated "PG-17." In addition, ratings such as "PG-13" and "PG-9" would be implemented for shows like *Law & Order* which deal in mature themes but avoid violence, profanity, and nudity.

PROGRAMMING NOTES

The *Los Angeles Times* reports that Quentin Tarantino is in line to direct an episode of Fox's *The X-Files* that would air following the Super Bowl broadcast in January; however, his lack of Directors Guild of America membership could prevent him from doing so. Sources say the *Pulp Fiction* director is currently negotiating with the DGA for a waiver allowing him to direct *The X-Files* episode, and both sides hope to resolve the matter.

However, because the DGA granted Tarantino a similar waiver last year to direct an episode of *er*—and assumed that he would join the guild soon after—the DGA might be less permissive this time. Tarantino declined comment, but a spokeswoman said that he does plan to join the DGA at some point and is "not making a political statement" by delaying membership. A DGA spokesman declined to comment on the waiver, but said the guild looks forward to Tarantino joining its ranks.

International Note

INTELSAT and ENTEL have launched a new Ku-band satellite service which uses digital transmission technology to improve picture quality and signal strength to viewers in Chile.

ENTEL is leasing 36 MHz of capacity on the *INTELSAT 706* satellite at 307° East longitude. The network of the Catholic University of Chile and the Megavision network are the first Chilean broadcasters to use the service, with the signal being uplinked from the Longovilo earth station.

Chile is the first Latin American country to use Ku-band capacity for the distribution of TV programming from the main TV studio to distant transmitting sites (SMATV).

"Satellite transmission of broadcasting signals is uniquely adapted to Chile's geography," said Fernando Pavez, ENTEL Satellite Project Manager.

"We are pleased to offer this new high-quality, digital service to our customers and we anticipate that many other broadcasters and private network users will take advantage of this technology to further develop their business."

Can I get an Amen....

In a recent column I noted a new gospel music channel and admitted that I really wasn't sure what the difference was in different kinds of gospel music. I want to thank *Satellite Times* reader Mr. Paul Rawlings for enlightening me.

Mr. Rawlings wrote, "Gospel music has a great diversity. Bluegrass and country gospel music tend to focus on the instrumentation of the songs rather than the vocals and stick with familiar old songs. On the other hand is southern gospel music, not to be confused with what is sometimes called "black" gospel music. Southern gospel music focuses on the vocal arrangements; the smooth vocal harmonies of the male quartet style of the 30's, 40's and 50's is the backbone of this style of music."

Your comments are always welcome. The best way to get in touch with me is through the Internet at: **http://www.searcher.com/STcomments.html** ST

Satellite Launch Schedules

By Keith Stein

Space Transportation System (STS-NASA)

Space Shuttles are launched from the Kennedy Space Center, Florida.

Mission Number	Launch Date/ Orbiter	Inclination Altitude	Mission Duration	Mission/Cargo Bay/Payloads
STS-81	January 1997 Atlantis*	51.6/213	9+1 days	S/MM-05
STS-82	February 1997 Discovery**	28.5/313	10 days	HST SM-02
STS-83	March 1997 Columbia***	28.5/160	16 days	MSL-01

*Crew Assignment: CDR:Michael A. Baker, PLT:Brent W. Jett, MS:John E Blaha (D), MS:John M. Grunsfeld, MS:Marsha S Ivins, MS:Jerry M Linenger (U), MS:Peter J K Wisoff

**Crew Assignment: CDR:Kenneth D Bowersox, PLT:Scott J Horowitz, MS:Gregory J Harbaugh, MS:Steven A Hawley, MS:Mark C Lee, MS:Steven L Smith, MS:Joseph R Tanner.

***Crew Assignment: CDR:Jim Halsell, PLT:Susan Still, MS: (PLC):Janice Voss, MS:Mike Gernhardt, MS:Donald A Thomas, PS:Roger K Crouch, PS:Gregory T Linteris.

STS	Downlink Frequency Assignments:
VHF/UHF Voice	139.208 (Only while STS-81 is docking or undocking with MIR), 145.550 (amateur radio), 145.840 (amateur radio), 243.000 (AM), 259.700 (AM), 279.000 (AM), and 296.800 (AM) MHz.
UHF Boosters	240.0, and 242.0 MHz (recovery beacon data)
S-band TLM	2217.500, 2250.000, and 2287.500 MHz.
C-band TRK	5400-5900.000 MHz

Mir	Downlink Frequency Assignments:
VHF Voice	143.625, 145.200, 145.550, 145.800 MHz

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
January 1997	Delta II	CCAS	GPS II R1
January 1997	Titan IV	CCAS	DOD
January 1997	Pegasus XL	Spain	MINISAT
January 1997	Atlas	CCAS	JCSAT-4
February 1997	LMLV-1	VAFB	CLARK
February 1997	Delta II	CCAS	Thor-IIA
February 1997	Atlas	CCAS	TEMPO 2
March 1997	Delta II	VAFB	Iridium #2
March 1997	Pegasus XL	VAFB	SWAS
March 1997	Pegasus XL	VAFB	FORTE

Delta II	Downlink Frequency Assignments:
S-band TLM	2244.500, 2241.500, and 2252.500 MHz
C-band TRK	5765.000 MHz

GPS II R1	Downlink Frequency Assignments:
L-band	1227.600 MHz
S-band	2227.500 MHz

Titan IV	Downlink Frequency Assignments:
S-band TLM	2217.5, 2255.5, 2272.5, and 2287.5 MHz

L-1011 A/C	Downlink Frequency Assignments:
L-band	1480.5 and 1727.5 MHz
S-band	2250.5 MHz
C-band	4583.5 and 5765.0 MHz

Pegasus XL	Downlink Frequency Assignments:
S-band TLM	2269.5 and 2288.5 MHz
C-band TRK	5765.0 MHz

Atlas	Downlink Frequency Assignments:
S-band TLM	2202.5, 2206.5, 2210.5, 2211.0, & 2215.5 MHz
C-band TRK	5765.0 MHz

SWAS	Downlink Frequency Assignments:
S-band TLM	2215.0 MHz

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
January 1997	Ariane 44P	Kourou	INTELSAT 8-2
February 1997	Ariane 4	Kourou	HOT BIRD-3
March 1997	Ariane 4	Kourou	PAS-6

Ariane	Downlink Frequency Assignments:
S-band	2203.0, 2206.0 and 2218.0 MHz

Satellite Launch Schedules

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1997	Soyuz	Baikonur	Soyuz TM-25

Soyuz TM-25	Downlink Frequency Assignments:
VHF Voice	121.75 (WBFM)
VHF TLM	166.0 (WBFM)
L-band TLM	922.75 and 926.1 MHz

Japanese Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1997	M-V	???????	MUSES-B/VSOP

MUSES-B/VSOP	Downlink Frequency Assignments:
K-band	14.20 GHz

Brazil Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1997	VLS-1	Alcantara	SCD 2A

List of Abbreviations and Acronyms

C-band	3700 to 6500 MHz.
CCAS	Cape Canaveral Air Station, Fla.
CDR	Commander.
CLARK	This high resolution satellite will locate utility pipelines & cables, and help town planners at construction sites.
(D)	Crew member coming down from MIR.
DOD	Classified Department of Defense payload.
GHz	Gigahertz
GPS II R1	U.S. Air Force global positioning satellite for military and civilian navigation services.
HOT BIRD	Will provide direct TV programming to 45 cm dishes across Europe.
HST SM-02	Hubble Space Telescope Servicing Mission-02 is to replace science instruments or other orbital replacement units (ORU's).
INTELSAT	Satellite for the International Telecommunications Satellite Organization a non-profit group in Washington DC.
Iridium	The Iridium system is a planned commercial communications network comprised of 66 low earth orbiting satellites. The system will use L-band to provide global communications services through portable handsets.
JCSAT-4	A communications satellite for Japan Satellite Systems Inc., Tokyo and planned to enter geosynchronous orbit.
L-band	1400 to 1800 MHz
MINISAT	Program under the Interministerial Commission for Science & Technology (INTA). The spacecraft will carry a Extreme Ultraviolet Radiation Detector and Low Energy Gamma Ray Imager.
MIR	Current Russian orbiting Space Station.
MHz	Megahertz
MS	Mission Specialist.
MSL-01	Microgravity Science Laboratory-01 is a payload which remains attached to the Shuttle to perform materials processing experiments in low-g.
MUSES-B	A deep space mission managed by the Institute of Space and Astronautical Science (ISAS) in Japan.
PAS	U.S. telecommunications satellite for Pan American Satellite of Connecticut.
PLC	Payload Commander.
PLT	Pilot.
PS	Payload Specialist
S-band	2000 to 2300 MHz
S/MM-05	Shuttle MIR Mission-05 is a flight to the Russian Space Station MIR, to support design and assembly of the international space station.
Soyuz TM	Manned mission to carry replacement crew to the Russian space station Mir.
SWAS	Submillimeter Wave Astronomy Satellite will study how molecular clouds collapse to form stars and planetary systems.
TEMPO 2	A high power DTH satellite owned by Tempo, a subsidiary of Tele-Communications Inc.
TLM	Telemetry
TRK	Tracking
(U)	Crew member going up to MIR.
UHF	Ultra High Frequency (390 to 499 MHz)
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
WBFM	Wide-band FM

Satellite Launch Report

*By **Phillip Clark**, Molniya Space Consultancy*

How to Use the Satellite Launch Report

The "Satellite Launch Report" is a complete list of satellite launches which took place during September and October 1996. The format of the listing is as follows:

First line: launch date and time (UTC), international designation of the satellite, satellite name and satellite mass.

Second line: date and time (in decimals of a day, UTC) of the orbital determination, orbital inclination, period, perigee and apogee. In some cases where a satellite has manoeuvred, more than one set of orbital data will be listed.

This data is followed by a brief description of the satellite's planned mission, the launch vehicle, launch site, etc. '*' next to satellite's mass indicates that the mass has been estimated, and that no official information has been published.

The *Satellite Times* "Satellite Launch Report" is extracted from more detailed monthly listings, "Worldwide Satellite Launches", compiled by Phillip S. Clark and published by Molniya Space Consultancy, 30 Sonia Gardens, Heston Middx TW5 0LZ United Kingdom

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 4/0901	1996-051A		Cosmos 2333	3,250 kg?
1996 Sep 4.51	71.01 deg	101.94 min	849 km	852 km

"Tselina-2" ELINT satellite manufactured by NPO Yuzhnoye: no details of appearance. Orbital plane is 60 deg to the east of that of Cosmos 2322 (1995-058A), the previous launch in the series. Launched from Tyuratam using a Zenit-2 vehicle.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 5/1248	1996-052A		Cosmos 2334	825 kg?
1996 Sep 5.66	82.94 deg	104.80 min	970 km	1,000 km
1996 Sep 5/1248	1996-052B		UNAMSAT 2	17 kg
1996 Sep 5.66	82.93 deg	104.89 min	968 km	1,011 km

Cosmos 2334 is a "Parus" military navigation satellite, launched into the same orbital plane as Cosmos 2327 (1996-004A). UNAMSAT 2 is a science satellite, built by the Autonomous University of Mexico (UNAM) and replaces the satellite lost on the maiden flight of the Start launch vehicle (launched March 25, 1995). Satellite is to study micrometeors in orbit: reportedly the Russians charged $112,000 for the launch. Launched from Plesetsk using a Cosmos-3M vehicle.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 6/1737	1996-053A		INMARSAT-3 2	1,144 kg
1996 Sep 6.59	2.49 deg	1,461.68 min	36,260 km	36,312 km
1996 Oct 13.11	2.70 deg	1,436.06 min	35,766 km	35,806 km

Second commercial launch of the Proton-K (4) launch vehicle, flown from Tyuratam. Maritime communications satellite, to be operated by INMARSAT, London (UK). Compared with INMARSAT-3 1 (1996-020A), the second satellites did not require and therefore did not carry an apogee kick motor. Mass quoted is at launch: the dry mass of the satellite is 860.4 kg. Satellite was initially located over 28 deg E Sep 18, 1996, but approximately Sep 27, 1996, the satellite was manoeuvred off-station and drifted further to the west, reaching 344-345 deg E in October. Proton third stage discarded in a 51.59 deg, 89.01 min, 218-234 orbit: fourth stage (Block DM-1) not tracked by USSPACECOM through to mid-November 1996 but probably in an orbit similar to the first one listed for the satellite.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 8/2149	1996-054A		GE 1	2,764 kg
1996 Sep 8.56	25.02 deg	1,073.45 min	194 km	56,506 km
1996 Sep 30.95	0.01 deg	1,436.27 min	35,788 km	35,792 km

GE 1 is a telecommunications satellite, launched for GE American Communications Inc (GE Americom) and is the maiden flight of the Lockheed-Martin A2100 satellite. Mass of the satellite quoted is at launch and is taken from the GE 1 data sheet issued by Lockheed Martin (quoting 6,094 pounds, but converted to "2,770 kg" which is actually 6,107 pounds): the ILS AC-123 Mission Overview indicates an initial mass of 2,784 kg (quoted as 6,137 pounds). Mass on station is approximately 1,600 kg. Satellite located over 257 deg E. Launched by an Atlas-2A from the Eastern Test Range: second stage (Centaur) in an orbit similar to the first one listed for the satellite.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 11/0000	1996-055A		EchoStar 2	2,865 kg
1996 Sep 10.80	6.85 deg	640.60 min	150 km	36,326 km
1996 Oct 9.81	0.00 deg	1,436.13 min	35,781 km	35,794 km

EchoStar 2 is a direct broadcast satellite launched for the EchoStar Communications Corporation. Mass quoted is that at launch: in geosynchronous orbit the mass is 1,710 kg at the beginning of operations and the dry mass is 1,324 kg. Satellite located over 241 deg E. Launched from Kourou using an Ariane-42P: Ariane-42P third stage (H-10-3) left in an orbit similar to the first one listed for the satellite.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 12/0849	1996-056A		Navstar 27 (USA 128)	1,881 kg
1996 Sep 12.72	35.06 deg	355.55 min	180 km	20,313 km
1996 Sep 30.41	54.72 deg	717.98 min	20,057 km	20,307 km

Navigation satellite, launched as part of the Global Positioning System (GPS) network. Mass quoted is at launch: the dry mass is 930 kg. Launched by a Delta-2 (7925) from the ETR: Delta-2 second stage in a 35.54 deg, 95.45 min, 472-609 km orbit, third stage (PAM-D) in an orbit similar to the first one quoted for the satellite.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 16/0855	1996-057A		Atlantis (STS-79)	113,105 kg
1996 Sep 16.40	51.65 deg	89.01 min	158 km	293 km
1996 Sep 19.16	51.66 deg	92.19 min	376 km	388 km
1996 Sep 24.15	51.65 deg	92.16 min	373 km	388 km

Fourth Shuttle-Mir Mission (SMM-4) carried six astronauts: W F Readdy (commander), T W Wilcutt (pilot), J Apt (mission specialist, MS-1 and EVA crewman EV-2 if required), T Akers (MS-2), C E Walz (MS-3, EV-1) and J E Blaha (MS-4 prior to docking with Mir). Orbiter's payload bay carries a double SPACEHAB module (mass 7,056 kg), the docking system (mass 1,822 kg) and SAREX (Shuttle Amateur Radio Experiment, mass 12 kg): shuttle mass quoted is that projected for landing.

Atlantis docked with the Docking Module attached to the Kristall module of the Mir Complex Sep 19, 0313 UTC. The orbiter carried in excess of 2,100 kg of supplies to Mir. Blaha became an official member of the Mir resident crew, taking the place of Shannon W Lucid (MS-4 after undocking) who had been left aboard Mir during the STS-76 mission (1996-018A): he is due to return to Earth aboard the STS-81 mission, currently planned for January 1997. Atlantis undocked from Mir Sep 23, 2333 and landed at the Kennedy Space Center three days later at 1213. When she returned to Earth Lucid held the record for the longest flight by a non-Russian (non-Soviet) and the longest flight by a woman, with a mission duration of 188 days 4 hours 0 minutes.

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1996 Sep 26/1751	1996-058A		Ekspress 2	2,500 kg
1996 Sep 26.72	0.22 deg	1,419.00 min	35,063 km	35,840 km
1996 Oct 8.30	0.19 deg	1,435.94 min	35,774 km	35,793 km

Second launch of new-generation Ekspress telecommunications satellite. Some launch announcements called this satellite "Ekspress 12" which is the manufacturer's number for it: the NPO PM numbering for a satellite series appears to start with "11" rather than "1." Satellite located over 80 deg E. Launched from Tyuratam using a four-stage Proton-K launch vehicle - Proton-K (4): third stage discarded in a 51.63 deg, 88.28 min, 186-193 km orbit, fourth stage (Block DM-2) in an orbit similar to the first one listed for the satellite.

Launch Date/Time Epoch	 Incl	Int Des Period	Satellite Perigee	Mass Apogee
1996 Sep 20/0720		1996-059A	FSW-2 3	2,600 kg?
1996 Oct 20.41	63.04 km	89.64 min	171 km	342 km
Then: 1996-059A assigned to the FSW-2 3 equipment module				1,000 kg?
1996 Nov 4.15	63.04 km	89.54 min	171 km	332 km

Second generation Fanhui Shi Weixing ("Recoverable test Satellite"), launched for photoreconnaissance, remote sensing and microgravity work: in-orbit manoeuvres were completed. The re-entry module returned to Earth Nov 4, 1996, landing in Sichuan Province. The equipment module remained in orbit and retained the international designator 1996-059A. Launched from Jiuquan using a CZ-2D vehicle.

1996 Oct 24/1137		1996-060A	Molniya-3 48	1,750 kg?
1996 Oct 25.04	62.83 deg	735.87 min	612 km	40,632 km
1996 Oct 30.63	62.83 deg	718.27 min	610 km	39,768 km

Telecommunications satellite, co-planar with Molniya-3 36. Launched from Plesetsk using a Molniya-M vehicle: Molniya-M third stage (Block I) left in a 62.81 deg, 92.36 min, 216-565 km orbit, fourth stage (Block ML) in a 62.82 deg, 729.98 min, 607-40,348 km orbit.

Updates for Previous Launches

International Designation	Comment
1976-101A	MARISAT 3 was manoeuvred off-station over 182 deg E during Sep 25-27, 1996 and appears to have entered a retirement orbit. Add the following retirement orbital data: 1996 Sep 27.0 13.09 deg 1,495.17 min 36,426 km 37,444 km The Two-Line Orbital Elements isued via the Goddard Space Flight Center actually list this orbit for MARISAT 2 (1996-053A/8882), but the longitude of the satellite in the drift orbit indicates that the data are for MARISAT 3 and erroneously attributed to MARISAT 2.
1978-012A	The International Ultraviolet Explorer was finally shut down Sep 30, 1996 at 1842 UTC. The last set of orbital data to be issued prior to the shutdown was as follows: 1996 Sep 29.40 35.94 deg 1,437.04 min 29,992 km 41,618 km
1983-077A	Telstar 301 was manoeuvred off-station over 20 deg E approxi mately Sep 30, 1996.
1984-093C	LEASAT 2 was manoeuvred off-station over 182 deg E approxi mately 1996 Oct 1 and appears to have entered a retirement orbit. Add the following orbital data: 1996 Oct 10.59 10.25 deg 1,477.55 min 36,464 km 36,724 km
1985-028C	LEASAT 3 was manoeuvred off-station over 255 deg E approxi mately Sep 30, 1996, and appears to have entered a retirement orbit. Add the following orbital data: 1996 Oct 7.52 11.57 deg 1,485.07 min 36,378 km 37,102 km
1985-087A	INTELSAT 512 was manoeuvred off-station over 338-339 deg E approximately Sep 17, 1996.
1988-098A	TDF 1 had its longitude stabilised over 338-339 deg approximately Sep 10, 1996. The satellite was then manoeuvred off-station Oct 4, 1996, and appears to have entered a retirement orbit. Add the following orbital data: 1996 Oct 21.17 0.34 deg 1,451.63 min 36,082 km 36,098 km
1989-006A	INTELSAT 515 had its longitude stabilised over 338 deg E approxi mately Sep 12, 1996.
1989-084B	The Galileo Jupiter orbiter spacecraft performed a fly-by of the jovian satellite Ganymede, the minimum distance of 262 km being reached Sep 6, 1996. Subsequently it performed a fly-by of the jovian satellite Callisto on Nov 4, 1996, the minimum distance of 1,104 km being reached Nov 4 at 13.34 UTC.
1990-116A	The last station-keeping manoeuvre to be performed by Raduga-12 was during Jun 12-13, 1996, and by the end of September the satellite had drifted from its operational longitude over 49 deg E to 53 deg E. It appears that the satellite has "died" on station.
1991-060A	Yuri 3B had its longitude stabilised over 110 deg E approximately Sep 20, 1996. No orbital data were issued during Sep 15 and Sep 27 to allow the date of the manoeuvre to be estimated with any real accuracy.
1991-079A	It was earlier reported that Cosmos 2172 had drifted off-station and appeared to be dead. The satellite is still drifting without any sign of orbital manoeuvres, and therefore is assumed to be indeed dead.
1994-049A	TURKSAT 1B was manoeuvred off-station over 41 deg E approxi mately Sep 26-27, 1996 and was relocated over 31 deg E approximately Oct 10.
1995-004E	The final Report for the ODERACS 1 and ODERACS 2 experiments has now been published (JSC-27241) and this quotes a decay date of Feb 7, 1996.
1995-004H	After deployment from Discovery during the STS-63 mission, no orbital data were issued for ODERACS 2F and although the catalogue number 23476 was initially reserved for the object, this number was later re-assigned to 1983-075BC. The final Report for the ODERACS 1 and ODERACS 2 experiments has now been published (JSC-27241) and this confirms the deployment of an uncatalogued dipole during the mission. No orbital data are given, but a decay date of Feb 20, 1995 is quoted.
1995-013A	INTELSAT 705 had its longitude stabilised over 341-342 deg E approximately Aug 7, 1996.
1995-044A	A great deal of contradictory orbital data has been issued for N-STAR a, suggesting that it had been boosted off-station over 131 deg E at the end of May 1996. In October 1996 the orbital data settled down to indicate that the satellite was still located over 131-132 deg E, and was never manoeuvred off-station.
1995-051A	Cosmos 2320 was de-orbited Sep 28, 1996: if it was de-orbited close to a recovery opportunity (although these satellites are not recovered) then de-orbit would have been 1996 Sep 28.5. The recovery of this satellite means that there is no Russian photoreconnaissance satellite currently in orbit.
1995-071C	Add a newly-catalogued piece of debris from the Cosmos 2326 launch. Orbit: 1996 Oct 3.05 65.02 deg 92.80 min 403 km 420 km It has been suggested by the Kettering Group that this object might be the separated KONUS-A experiment, in which case the mass will be approximately 130 kg.
1996-006A	Palapa-C 1 had its orbital longitude re-stabilised over 150 deg E approximately Sep 12, 1996.
1996-011A	Soyuz-TM 23 with Russian cosmonauts Onufriyenko and Usachov and French spationaut Andre-Deshays (launched board Soyuz-TM 24) undocked from the Mir Complex Sep 2, 1996 at 0420 UTC and landed 100 km south-west of Akmola at 07.41 40 seconds.
1996-024	It has been reported that two calibration spheres have been separated from MSX (1996-024A): the first on Aug 24, 1996, and the second on Sep 12, 1996. Neither object has been catalogued by USSPACECOM.
1996-029E	The following orbital data for USA 123 are derived from unofficial visual observations: 1996 Sep 15.04 63.42 deg 107.44 min 1,056 km 1,161 km
1996-029F	USA 124 is reportedly the tethered satellite experiment, TIPS. The following orbital data are derived from unofficial visual observa tions: 1996 Sep 22.12 63.42 deg 105.59 min 1,018 km 1,026 km
1996-032D	PAM-STU decayed from orbit Oct 26, 1996.
1996-035A	INTELSAT 709 had its longitude stabilised over 309-310 deg E Jul 31, 1996.
1996-040B	TURKSAT 1C was manoeuvred off-station over 31 deg E approxi mately Sep 14, 1996, and was relocated over 41-42 deg E approximately Sep 26.
1996-043A	Progress-M 32 re-docked with the Mir Complex at the rear longitudinal port on Kvant 1 (-X) Sep 3, 1996 at 0935 UTC.
1996-044A	Add the following orbital data for ITALSAT 2: 1996 Sep 13.43 0.08 deg 1,436.09 min 35,774 km 35,799 km The satellite is located over 12-13 deg E.
1996-046A	ADEOS 1 has been renamed Midori ("Green") now that it is in orbit.

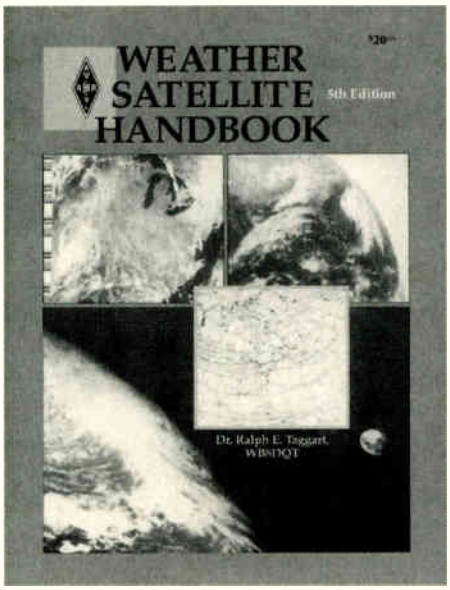
By Ken Reitz, KS4ZR

Getting Started in Weather Satellites

In the dark days of civilization, before the advent of computers and satellites—indeed, before The Weather Channel—there were those among our population with a certain penchant for weather. This curious throng had such a fascination with for weather that they were compelled to extraordinary lengths to know what was happening in the atmosphere. This compulsion led them to ferret out old weather service and military surplus reception equipment which were the size of home appliances and threw out almost enough heat to cook with. These hobbyists were receiving weather charts sent by various news services over radioteletype (RTTY) signals which choked HF bands all over the world.

While there are still a fair number of HF weather signals to be heard, the shift in interest over the last thirty years has been toward reception of polar orbiting and geostationary weather satellites. Although these satellites are from many countries around the world, they have very nearly standard transmission modes and may be received by equipment designed to receive only one type. The even better news is that you can cancel that trip to the government auction, because today's personal computers give excellent results. Combined with off-the-shelf or home-brewed antennas, down-converters, and programs, your pictures could look as good as those from the National Weather Service.

Now, as you might expect, weather satellite reception can be a little tricky and in no time at all you could find yourself spending your retirement savings on what's supposed to be a hobby. So to get started you'll need to do a little reading. There are two books and one periodical which are most useful and we'll be taking a closer look at all three in this edition of the *Beginner's Column.*



Weather Satellite Handbook

The *Weather Satellite Handbook* by Dr. Ralph Taggart, WB8DQT, now in its fifth edition, is essential reading to understand how weather satellites work, what it takes to receive image transmissions; how to track the polar orbiters; and advanced applications such as high-resolution and automatic acquisition. Taggart is a long-time amateur radio operator and a tireless experimenter. That's why the emphasis here is on doing-it-yourself. There are a great number of diagrams and details on building receiving antennas for both the polar orbiters and the S-band geostationary satellites. You can learn how to make your own S-band feed horn. There are also computer programs written in BASIC (three and a half pages long!) which can help track satellites, and a lengthy list of equipment suppliers.

One of the values of this book is that Taggart compares various receivers and antennas thus saving the reader untold money and time in duplicative searches. He also goes quite deeply in the technical side of things, which may prove to be a little daunting for some. Don't let this get you down. If you stick with it, you may find that things you didn't understand when you first began may start making sense.

Oddly enough, Taggart's PhD is in paleobotany and he is a full professor in the Department of Botany and Plant Pathology, as well as the Department of Geological Sciences at Michigan State University. Now, ordinarily this would seem off the mark, but it explains the excellent "teaching" style of writing and the textbook feel to the work. If one were to have a class in weather satellite technology, this is the only text you'd need. *The Weather Satellite Handbook* is published by the American Radio Relay League, costs $20 plus shipping and is available from the Grove catalog.

Viewing the Earth from Space

Viewing The Earth From Space is subtitled "The Complete Guide to Public Domain Radio-Based Imagery and Weather Services" and is written by James R. Buchanan K8WPI. This new book differs from the *Weather Satellite Handbook* in that it includes a fair amount of information on receiving weather satellite imagery via the HF bands. And, since it takes considerably less money and equipment to do so, it's a good place to start. It's also clear that once the WEFAX (weather facsimile) bug bites, it could easily turn into a terminal condition. And JeRB, as Buchanan is known to his friends, appears to be as close to a terminal condition as one gets. Outfitting his four wheel drive off-road vehicle with numerous antennas and racks of receiving equipment, he has roamed the continent for tens of thousands of miles in what he calls mobile weather reconnaissance missions.

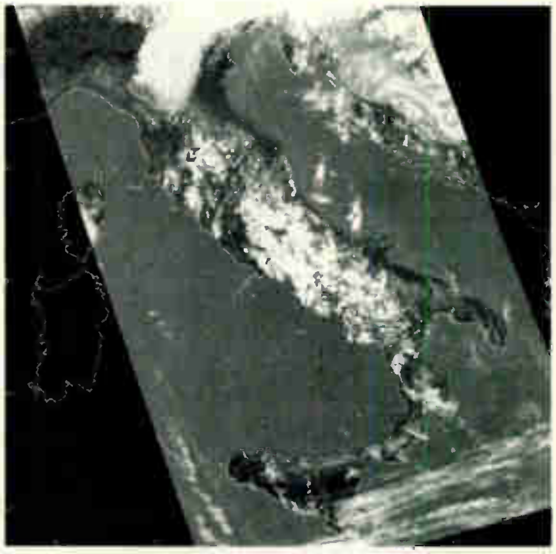
If you've ever been seized by an idea—I mean a really great idea—and somehow had the ability to follow it through to its great conclusion, logical or illogical, you'll appreciate the wit and writing of James Buchanan. His unbridled enthusiasm for the pursuit of weather satellite pictures leaks joyfully into his prose: "...As the moment of truth approached, I started the tracking program. My excitement climaxed as I felt the roof-top mass of sixty pounds of antenna and rotor spring to life, scanning the horizon in search of desired prey." Whew! Everybody should be this excited about their hobby!

Viewing the Earth from Space is a basic book which assumes that the reader needs the basics explained. In that way, this is a very accessible book which is made even easier to understand by the simple, uncomplicated language. The book is packed with interesting photos taken directly from the weather satellites or via HF broadcasts; diagrams for setting up various configurations of equipment; frequency lists of HF stations and their broadcasts; charts depicting expenses one may expect to incur when setting up various configurations (his all-band all-mode mobile facility is tagged at $26,000—less the four wheel drive vehicle). JeRB also reviews existing publications in the final chapter. Of *Weather Satellite Handbook* he says, "...No library is complete without this publication." And of *Satellite Times:* "...only...U.S. magazine which takes WX-SATs seriously." *Viewing the Earth From Space* is published by Woodhouse Communication and costs $24 plus $3 US priority mail from the address listed below.

Weather Satellite Report

Weather Satellite Report (WSR), subtitled "Devoted to Earth and atmospheric imagery," is an excellent quarterly publication also edited and published by James Buchanan and his wife, Pam. JeRB's literary thumb prints are all over this publication and the result is another easy read and back-to-basics style which makes it user-friendly to beginners and old hands alike. WSR's 24 pages are packed with timely and useful information regarding all aspects of weather satellite imagery.

Regular contributors include *Satellite Times*' and Dallas Remote Imaging Group's own Jeff Wallach. Also of note is Doug Burke's column of HF-WEFAX. Here late breaking news about frequencies and stations are given as well as interesting screen captures of images and charts. But the best part is the page called "Image Gallery" in which interesting images captured from weather satellite watchers from around the world are presented. Subscriptions are $25 for one year (four issues) or $30 Canada and $32 for the rest of the planet at the address below.

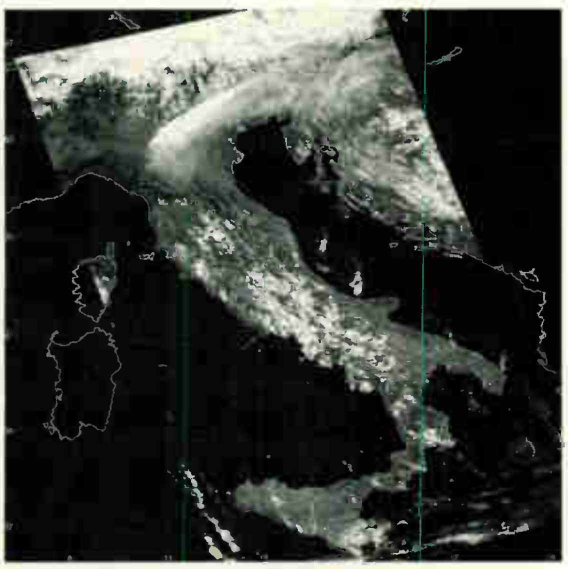


Visual image of Italy. (Courtesy of Dallas Remote Imaging Group)

It should also be noted that Woodhouse Communication has a product guide of specialty VHF antennas and accessories for weather satellite reception. Antennas include up to 16 elements circularly polarized or simple turnstile designs. And, of course, you won't want to pass up their offer to "...Let Woodhouse build your next mobile communication facility..." Address listed below.

Bottom Line

Comparing these two books would not be fair to either. Both are written by amateur radio operators whose passion for weather satellite reception has led them to extremes few of us could manage. However, we are the happy recipients of their hard work and dedication. I say, "Get 'em both!" I know, you're saying, "What? I'm going to spend $45 on this hobby and all I get are two books?" To which, I say, "In the WEFAX hobby you'll spend that much on printer paper alone by the time you've figured it out!" So, buy the *Weather Satellite Handbook* for the great construction projects, and buy *Viewing the Earth from Space* for its excellent guide to HF as well as satellite weather reception.



Infrared image of Italy. (Courtesy of Dallas Remote Imaging Group)

For More Information

So, what about satellite tracking? Well, unless you like the stab-in-the-dark method of WXSAT searching, you'll need a tracking program. For those who want to do it on the cheap, I refer you to the May/June 1996 issue of *ST* and this column "Tracking Those Elusive AMSATS (Cheaply!)" For those who want something a lot more sophisticated, and want to help a good cause, try AMSATs satellite tracking program, Orbits II, available from AMSAT, 850 Sligo Avenue Suite 600, Silver Spring, MD 20910-4703, Phone 301-589-6062.

Finally, a good (well, let's face it: cheap) way to get involved in reception of weather satellite imagery is by using one of the cheap FAX demodulators, your shortwave radio and the JVFAX program. For more information on this program and method of reception see John Catalano's *Computers & Radio* column in the January 1994 issue of *Monitoring Times* (this column is a classic and is recommended reading for anyone with an Earthly sense of humor). While the FAXCAP mentioned in the piece is no longer made, the program is the same and the demodulator is similar to other demodulators.

Also of interest is the article in the August 1996 *Monitoring Times* by Brian Webb, entitled *HF Fax on a Shoestring.* This piece tells how to build an HF demodulator and is complete with schematics, parts list, and block diagram. A source for the JVFAX program is also given. *MT* reprint articles are available for $2 and a SASE from Grove Enterprises. Now, see what you are missing?

The Weather Satellite Handbook is available from Grove Enterprises, 7540 Highway 64 West, Brasstown, NC 28902 or call 800-438-8155 (FAX) 704-837-2216.

Viewing the Earth from Space and subscription to WSR are available from Woodhouse Communication, P.O. Box 73, Plainwell, MI 49080 or call 616-226-8873 (FAX) 616-226-9073. ST

By Steve Dye, gpsyes@aol.com

The GPS Space Segment

This month we take a closer look at the Global Positioning System (GPS) space segment, which consists of 24 GPS satellites orbiting the Earth at an altitude of 10,900 nautical miles and an inclination angle of 55 degrees to the horizon. Twenty-one satellites provide the global service, with three satellites acting as spares.

Each satellite has a 12 hour orbital period and follows what is known as a non-geosynchronous orbit. This means the GPS satellites, unlike most communication satellites, move across the sky rather than appearing to be stationary above one point.

SVN	DATE
1	22 FEB. 78
2	13-May-78
3	06 OCT. 78
4	10-Dec-78
5	09 FEB. 80
6	26-Apr-80
7	NONE
8	14 JUL. 83
9	13 JUN. 84
10	08 SEPT. 84
11	09 OCT. 85

TABLE 1

Let's start by looking at the GPS satellite types, their launch history and what equipment they carry.

Each phase of development of GPS satellites is referred to as a block. The designations are as follows: Block I, Block II, Block IIA, Block IIR, and Block IIF. So far, three blocks have been deployed in space, with two more planned for the future.

The initial concept validation phase satellites are known as Block I; the last remaining Block I satellite was disposed of in the summer of 1995. Block II satellites are the initial production-phase satellites—Block IIA satellites being upgraded versions of the Block II. At this time, the current GPS constellation consists of 24 Block II/IIA satellites.

Replenishment satellites are designated as Block IIR, and are currently in production, with projected launch dates in the 1996 to 2004 time frame. Finally, "follow on" Block IIF satellites will be launched post-2004, and their advanced features are expected to provide a much better service to all users.

Block I satellites

Designated as Block I satellites, the first eleven GPS satellites were launched between 1978 to 1985 at Vandenberg Air Force Base (AFB), California. These initial concept satellites (as the name suggests) were used to validate the actual concept of GPS itself and to assess the overall accuracy, integrity, and reliability of the system. Block I satellites were positioned in the same orbital planes as the Block II, but at an inclination angle of 63 degrees.

Each Block I satellite contained one Cesium and two Rubidium atomic clocks. The design life of the Block I satellites was five years, but the high quality of their construction allowed the majority to perform well beyond their life expectancy.

Table 1 shows the launch history of Block I Satellites. The first column, entitled "SVN," is an abbreviation for Space Vehicle Number, the satellite designation. All the above satellites are now non-operational, and have been replaced by the Block II satellites.

Block II satellites

The Block II satellites are numbered 13 through 21, and were the first full-scale operational satellites to be deployed. These satellites were launched between February 1989 and October 1990. Block IIA satellites (22 through 40), are the second series of operational satellites, which were launched beginning in August 1993.

Each Block II/IIA satellite carries four atomic clocks—two Cesium and two Rubidium—and has a life expectancy of 7.3 years. These satellites also have the added capability of such features as selective availability (SA) and anti-spoofing (A-S).

The Block IIR replenishment satellites, numbers 41 through 62, are the operational replenishment satellites developed by General Electric which will provide us with a GPS service well into the next century. Block IIR satellites are designed for a life cycle of 7.8 years, and will contain three clocks: one cesium and two rubidium. The satellites will also feature selective availability and anti spoofing capabilities. Table 2 shows the launch history of the Block II/IIA satellites.

TABLE 2

Block	#	DATE
II	1	14 FEB. 89
II	2	10 JUN. 89
II	3	18 AUG. 89
II	4	21 OCT. 89
II	5	11-Dec-89
II	6	24-Jan-90
II	7	26 MAR 90*
II	8	02 AUG. 90
II	9	01 OCT. 90
IIA	10	26 NOV. 90
IIA	11	04 JUL. 91
IIA	12	23 FEB. 92
IIA	13	10-Apr-92
IIA	14	07 JUL. 92
IIA	15	09 SEPT. 92
IIA	16	22 NOV. 92
IIA	17	18-Dec-92
IIA	18	03 FEB. 93
IIA	19	30-Mar-93
IIA	20	13-May-93
IIA	21	26 JUN. 93
IIA	22	30 AUG. 93
IIA	23	26 OCT. 93
IIA	24	10-Mar-94
IIA	25	28-Mar-96
IIA	26	16 JUL. 96
IIA	27	12 SEPT. 96

* Satellite no longer in service.

Block IIF satellites

As Block IIR satellites will ultimately near the end of their design life cycle, more satellites will be required to maintain GPS service beyond the first decade of the 21st century. Block IIF—referred to as sustainment satellites—will take over at this juncture, continuing to provide the GPS service to the global community. The Block IIF sustainment satellites will offer a much improved level of service, meeting the more stringent demands for applications of the future in both private and commercial sectors. Such enhancements envisioned are :

- Improved timing
- Positioning
- Integrity
- Longer life span of 12.7 years
- Additional civilian access frequencies

The GPS satellite payload

The payload of a satellite can be defined as the total weight of the instruments, plus spacecraft systems for power generating, communications, and propulsion. The major systems and subsystems to be found on a GPS satellite are:

- Attitude and velocity control
- Mechanical structure.
- Navigation subsystem
- Electrical Power (battery and solar)
- Reaction and Thermal Control
- Tracking, telemetry, and control

Attitude and velocity control

Attitude can be defined as the orientation of a spacecraft relative to its direction of motion. For a GPS satellite, this ensures a correct orbital path, and, more importantly, ensures the antennas are optimally positioned for correct coverage of the earth. The attitude and velocity are controlled by a series of spinning wheels whose momentum is used to react against the spacecraft's motion, creating precise controlling torques.

Mechanical structure

The mechanical structure of the satellite is of critical importance; the extreme conditions under which a satellite works during launch demands that the satellite be of sound construction, to say the least. The mechanical structure protects and houses the delicate components and equipment that perform all communication and navigation functions from the harmful radiation and environment of space. The satellite's structure must be assembled from high quality materials of an equally high specification to assure reliable operation. The basic structure of a GPS satellite essentially consists of aluminum sheets bonded to a honeycomb-like structure which provides a solid, rigid construction.

Navigation subsystem

GPS calculates a receiver's position by measuring the time of arrival (TOA) of the signal from each GPS satellite. These timing signals are generated by four on-board atomic clocks. Two of these clocks are rubidium, the other two are cesium. These clocks work in a redundancy configuration, meaning that at any one time only one clock is providing the timing, while the other three remain on standby in the event the primary clock fails.

The navigation system also consists of the navigation code generator, signal modulator, and the power amplifiers that broadcast the L1 and L2 navigation signals and the S-band status signal received by the monitoring stations on the ground. Figure 1 illustrates the various component blocks in a GPS satellite's navigation sub-system.

The L1 and L2 navigation signals are transmitted using an array of helical wound antennas that illuminate the Earth's surface, forming a 28 degree cone pattern. This antenna configuration enables seamless, global coverage of the GPS signal.

Electrical power (battery and solar)

Two large solar arrays provide all electrical power for the GPS satellite systems and sub-systems. As the satellites orbit the Earth, there will be instances when the satellite is shadowed from the Sun. During these periods (approximately six months apart), power is drawn from three nickel cadmium batteries. The charge for each battery is maintained by the solar panels as they receive solar energy.

The solar panels are critical to the success of the launch; during launch, they are held in place by a spring mechanism, which prevents them from prematurely deploying to their operational position. Upon reaching orbit altitude, the mechanism is released to deploy the solar panels. The mechanism is not strong enough to support the weight of the panels on earth, but in the weightless environment of space, it provides sufficient strength.

Reaction and thermal control

The reaction controlling or steering of a GPS satellite is controlled by hydrazine propellants. From time to time it will be necessary to correct for orbit or ephermeris errors, and this can be accomplished by using the propellants to provide thrust to the satellite correcting the position appropriately.

The thermal control of a GPS satellite is essential, as it provides a constant operating environment for the electrical and mechanical components. The thermal control system is comprised of a thermostatically controlled system that opens and closes louvers, letting heat either in or out of the satellite. The louvers are closed or opened automatically by a bi-metallic strip that expands or contracts, appropriately controlling the louvers' position.

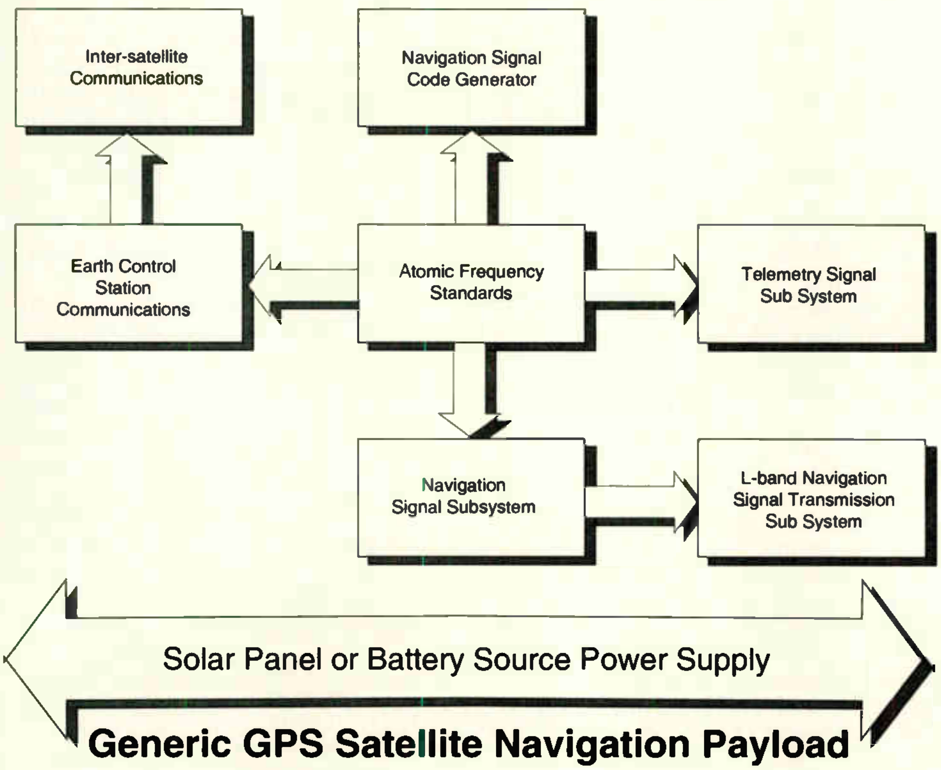
Additionally, heaters are placed in chosen areas of the satellite to assist in maintaining a constant temperature for such components as the atomic clocks and code generators.

Tracking and control telemetry.

This section enables the Earth-based ground control to communicate with the satellite so that clock and orbital correction factors can be up-linked to the satellite, processed, and verified by a confirmation sent back to the ground station. Two-way messaging takes place on two S-Band frequencies:

Uplink : 2.2275 GHz
Downlink : 1.78374 GHz

That wraps it up for this issue of *Satellite Times*: if you have any questions or comments, you can E-mail to me at gpsyes@aol.com. ST



By Dr. T.S. Kelso
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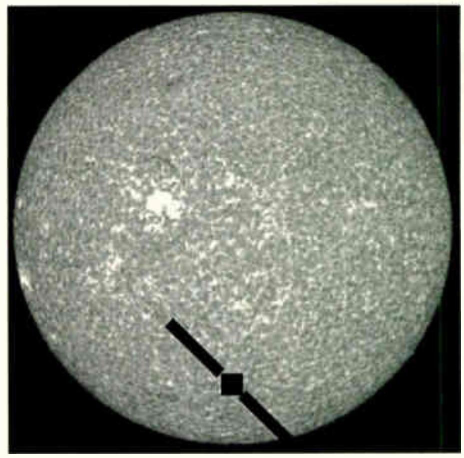
Tracking the Sun and Moon



From time to time, I'll get a question asking for two-line element sets for the moon (or the sun). This would seem to be a natural enough question. After all, the moon is a satellite of the Earth and its orbit is described by the same basic parameters as those contained in the two-line element sets.

The rub here is that the two-line element sets you find on the Celestial WWW are not generic element sets—they are specific to NORAD's SGP4 orbital model. In order to understand why this distinction is important, I'd like to begin by briefly reviewing the basics of orbital modeling and specifically address the assumptions made in the SGP4 orbital model. Once we've done that, it should become clear why this model can't be used for tracking the moon. Then, we'll move on to cover some simple ways to track both the sun and the moon and discuss an interesting new application.

While we have covered some of this material before, it is important to note it here to place the larger question in perspective. First and foremost, we must understand what a model is to fully appreciate the general limitations of any orbital model and the specific limitations of the SGP4 orbital model. According to Shannon, "a model is a representation of an object, system, or idea in some form other than that of the entity itself."[1]

Models can come in many forms from physical and scale models to mathematical and computer models. Regardless of the form, models serve one of two purposes: they are either *descriptive* (explain the system of interest) or *prescriptive* (predict the behavior of the system).[2] The orbital models we use for predicting the position of an Earth satellite (natural or artificial) fall in the latter category.

The reason for using a model, as Rosenblueth and Wiener note, is that no substantial part of the universe is so simple that it can be grasped and controlled without abstraction. Abstraction consists in replacing the part of the universe under consideration by a model of similar but simpler structure.[3]

This statement is certainly true of orbital mechanics. While the underlying principles of gravitational attraction are pretty simple, extending them to objects other than point masses can become complicated pretty quickly.

When developing a model, it is important to do several things. First, you should understand the *goal* of developing the model. For the SGP4 orbital model, the goal was to track large numbers of artificial satellites orbiting the Earth on a routine basis—the implication here being that the tracking needed to be computationally efficient to support daily operations. Of course, the speed of computation would have to be traded off against the accuracy (or fidelity) of the predictions, with some minimum level of performance.

The second thing that needs to be done is to define the *system* under investigation. Shannon defines a system as "a group or set of objects united by some form of regular interaction or interdependence," which for our case amounts to our satellites and anything which influences their orbits.[4] The range of influences would naturally include the gravitational influence of the Earth, moon, sun, and planets, as well as things like atmospheric drag and solar pressure.

We must define the system as part of the process of balancing the goals of computational speed against predictive accuracy. If we could model every influence on the motion of a satellite, our accuracy would be very good, but our computational speed would be low. If, however, we rank these effects by the magnitude of their influence, we find that some have no practical effect on the motion of a near-Earth satellite. For example, the effect of the Earth's gravity is much greater than that of Mars and, in fact, the gravitational pull of Mars has no practical influence on the orbits of these satellites. As such, there is no point in developing a model (and increasing the computational complexity) that includes such an effect.

When the predecessor to SGP4 (SGP or Simplified General Perturbation) was developed, most artificial satellites were in low-Earth, circular orbits where the primary effects were the Earth's gravity (including some of the major perturbations due to its non-spherical shape and non-uniform density) and atmospheric drag. Things such as solar and lunar gravitational effects and solar pressure had a negligible effect on these orbits. As a result, the model was developed incorporating only these effects. In addition, simplifications could be made since the mass of these artificial satellites is much much less than the mass of the Earth, and the effect of third bodies could be ignored.

To eliminate the need to numerically integrate the position of each satellite (a particularly time consuming computational process), an analytical model was developed that allowed the position to be calculated directly at the time of interest (for more information on numerical integration versus analytical models, see this column in the March/April 1995 issue of *Satellite Times*). This analytical model required a series expansion in terms of the orbit's eccentricity—a term that is usually small for the class of orbits being examined.

Both the reduction in the number of effects influencing the orbit of the satellite and the conversion from a numerical integrator to an analytical model served to considerably reduce the computational load of predicting the position of a given satellite. At the same time, however, it also reduced the accuracy of these predictions and placed some assumptions on the orbital characteristics being modeled to ensure the accuracy is maintained within reasonable limits.

These assumptions include the satellite having a negligible mass compared to that of the Earth, with no third-body gravitational effects, and having a near-Earth orbit—where the effects of the Earth's gravity and atmospheric drag dominate—with a small eccentricity. With the exception of the low eccentricity, neither the orbit of the moon or the Earth around the sun (to calculate the position of the sun) meet the remaining modeling assumptions. Since the orbital elements in the two-line element sets are generated by fitting observations to the SGP4 orbital model, trying to fit elements to orbits which do not satisfy our modeling assumptions will result in predictions which are likely to have large errors.

As can be seen from this development,

therefore, there can be no two-line element sets for the position of the moon or the sun (actually, the Earth's orbit around the sun). Equally important, it can be seen that predictions for orbits which have high values of eccentricity will likely be less accurate than those with small eccentricity.

Of course, as satellites began to be launched into higher orbits, other limitations in the SGP model's assumptions became apparent. In particular, above a certain altitude, effects such as solar-lunar gravity, solar pressure, and gravitational resonances with the spin of the Earth dominate over that of atmospheric drag. As a result, SGP was modified to become SGP4 (or really, SGP4 and SDP4). SGP4 is valid for *near-Earth* orbits with periods of 225 minutes (an altitude of roughly 5,000 km) or less while SDP4 is valid for *deep-space* orbits above that (well, at least out to geosynchronous altitude).

As would be expected, several tradeoffs had to be made in developing the SDP4 portion of the model. Of course, some additional effects are included in this new model while atmospheric drag is eliminated, increasing the overall computational load. In addition, since the series expansion in eccentricity modeled only the Earth's gravitational effect, some numerical integration was required to handle some of these new effects. The result is what is referred to as a semi-analytical model—again increasing the computational load. However, without these changes, the accuracy of predictions for orbits above the 225-minute cutoff would be significantly reduced.

Down to Business

Just as a separate model is required to handle deep-space orbits, separate models are needed to predict the position of the sun or the moon with reasonable accuracy. Astronomers have expended considerable effort in developing models to predict the position of these bodies with extremely high accuracy for use in calculating circumstances for solar eclipses. In fact, at the beginning of this century, E.W. Brown spent twenty years developing his theory of the motion of the moon—ten years to develop the equations and another ten years to check them!

In the case of the sun's motion, not only must theory account for the Earth-moon orbit about the sun but also the rotation rate of the Earth and the nutation and precession of the Earth's axis. The moon's orbit is influenced by the gravitational attraction of not only the Earth and the sun but also of the planets, together with interactions with the Earth's ocean tides. High accuracy predictions require equations with hundreds of terms to account for the various effects.

For more practical applications of predicting the position of the sun and the moon for calculating satellite eclipse circumstances or the rise and set times of these celestial bodies, an excellent source is Jean Meeus's *Astronomical Algorithms*. As the title suggests, this book covers a wide range of algorithms relating to astronomical circumstances—including how to calculate the position of the sun (chapters 24 and 25) and the moon (chapter 45).

For the sun, Meeus's algorithm—similar to the one in my SGP4 Pascal library—predicts the sun's position to 0.01 degrees (two percent of the solar diameter) by assuming a purely elliptical motion for the Earth and ignoring perturbations from the moon and planets. Each calculation only requires evaluation of eleven low-order polynomial equations with a dozen trigonometric evaluations. As seen in this column in the September/October 1996 issue of *Satellite Times*, this makes it possible to calculate when Earth satellites are visible to observers on the ground by calculating the elevation of the sun and the position of the Earth's shadow.[5]

Meeus's algorithm for the calculation of the position of the moon is considerably more complicated. The calculation is based on a summation of sine and cosine terms which, while significantly reduced from the hundreds of terms necessary for high accuracy computations, still requires ninety trigonometric evaluations. Using only these more significant terms, however, the algorithm is still able to provide accuracy of approximately 10 arcseconds in geocentric longitude and 4 arcseconds in geocentric latitude.[6]

An Interesting New Application

Back in August of this year, I received an e-mail message from Gary Eldridge wanting to know how to predict the position of the moon. Seems Gary has become hooked on watching satellites transit (cross the surface of) the moon's disk through his telescope. After relating his initial experiences, I can see why:

> Got a GREAT silhouette view of Mir last Saturday night and some other unknown satellite a few weeks prior. The detail was incredible while using an 8 inch reflector scope and 17mm eyepiece.

Of course, the real problem here is figuring out just when a satellite is going to transit the moon (or the sun) so as to know when to look. Up to now, he's been using something of a brute force approach—running a large catalog of objects against a star background and examining in detail those that come close to the sun or moon.

I think this problem would make an interesting project for an upcoming column(s) since it has several intriguing aspects. First, it will be necessary to develop code to predict the position of the moon (to go along with that for the sun) which can be used with the SGP4 orbital model. Then, it will be necessary to define the circumstances of a successful transit: (1) the sun or moon above the observer's horizon, (2) for lunar transits, a minimum phase for the moon and the sun being a certain distance below the horizon, and (3) the satellite crossing the illuminated portion of the object's surface.

The challenging part of this project will be to come up with efficient ways to reduce the number of cases examined. The intriguing part is two-fold. First, since the satellite will transit the sun or the moon's disk, it is trivial to know exactly where to point a telescope (and track) to watch the transit and the background should be bright enough to make it easy to photograph or videotape the event. Second, it will be interesting to see just how much detail can be discerned of the satellite as it transits since, according to Gary, there seems to be some disagreement:

> I seem to have caused some controversy among other astronomers as to whether an amateur telescope can resolve such detail on an orbital satellite. I would not have thought so either until I started seeing these things. It seems that when they cross in front of the Moon, the silhouette image reveals incredible detail. Solar panels and other structures can easily be seen.

Of course, observation and timing of these transits will also serve to visually demonstrate the overall accuracy of the orbital model, as discussed in our last column on "Real-World Benchmarking."

I hope you will join me on this journey. Not only will we be covering new ground, but the development of an efficient tool to predict satellite transits is likely to spark a new aspect of visual observing. And I, for one, am looking forward to seeing your best photographs so we can share them with the world.

If you have any questions or comments regarding this column, please feel free to contact me at **tkelso@grove.net**. Until next time, keep looking up!

[1] Robert E. Shannon, Systems Simulation: The Art and Science (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1975), p. 4.

[2] Ibid., p. 7.

[3] Quoted in Thomas H. Naylor et al., Computer Simulation Techniques (New York: John Wiley & Sons, 1966), p. 9.

[4] Shannon, p. 15.

[5] Jean Meeus, Astronomical Algorithms (Richmond, Va.: Willmann-Bell, Inc., 1991), pp. 151–153.

[6] Ibid., pp. 307–313.

ST SATELLITE PROFILE

By Phillip Chien

AMSAT OSCAR-13

One of the most productive amateur radio satellites has finally reached the end of its operating life—*AMSAT OSCAR-13 (AO-13)*. On December 5, 1996 it dipped below an altitude of 74 km, and burnt up on reentry into the Earth's atmosphere.

Before launch *AO-13* was called Phase 3C (P3C)—three for the third major increment in amateur satellites. Phase 1 satellites were simple, experimental, battery-powered beacons; Phase 2 satellites had active tranceivers and solar cells; and Phase 3 satellites are more sophisticated satellites launched into high altitude elliptical orbits. The *C* in Phase 3C indicates the third satellite in that series.

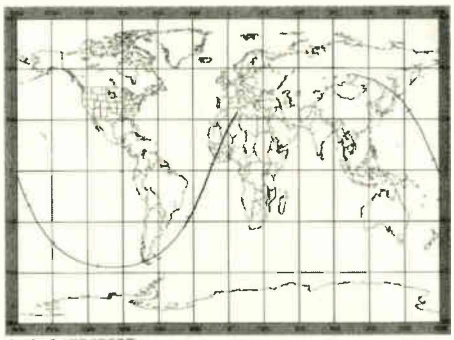
AMSAT's Phase 3D project was started in 1991, and the spacecraft is currently under construction. Launch of Phase 3D is anticipated in the first half of 1997.

All of the Phase 3 satellites have been international projects, with amateur radio operators from Germany, the United States, and other countries participating in the spacecraft's design and construction.

The first Phase 3 satellite, Phase 3A was lost due to the failure of its Ariane L02 launch vehicle (May 23, 1980).

Phase 3B was built as a replacement satellite, and was successfully launched on Ariane L06 on June 16, 1983. After it achieved orbit it was renamed OSCAR (Orbiting Satellite Carrying Amateur Radio)-10 or *AO-10*. Its early days were more exciting than any roller coaster ride. It turns out that the third stage of the Ariane launch vehicle accidentally hit AO-10, damaging one of the antennas.

Improper motor firings resulted in only one short engine firing, so the final planned orbit was not achieved. Still, it was successfully put into operation and happily welcomed by the ham radio community. *AO-10* has turned out to be an incredibly long-lived satellite, surviving well beyond its planned lifetime. As expected its batteries



have failed, and its computer eventually succumbed to the high radiation dosage. But it continues to work as long as its solar arrays generate enough electricity to power its transponders.

As Phase 3B was being prepared for launch the international AMSAT groups started to think about Phase 3C, a more sophisticated clone of Phase 3B.

The project was developed primarily by U.S. and German hams, but many other ham radio groups and individuals around the world also participated.

Phase 3C was a roughly triangular-shaped spacecraft 600 x 40 x 200 centimeters The center core of the spacecraft held the two-compartment tank which was filled with the monomethyl hydrazine and nitrogen tetroxide propellants and the German-built 400 Newton (90 pounds force) rocket engine.

The computer was centered around an RCA 1802—a 1970s era microcomputer. While extremely underpowered by today's standards, it was adequate for the task and capable of handling a fair amount of radiation.

Each of the three arms held several electronic boxes, including the battery charge regulator, integrated housekeeping unit, and radio frequency (RF) transponders. Both sides of each arm was covered with solar cells, for a total of six solar panels. The 'antenna farm' consisted of omnidirectional 2-meter and 70-cm monopoles, three two-element beams for 2-meters, three dipoles over reflectors for 70-cm, a 5 turn 23-cm helix, and an 8 turn 13-cm helix. The 2-meter and 70-cm directional antennas had phasing harnesses for right hand circular polarization.

AO-13 operated on the 2 meter, 70-cm, 23-cm, and 13-cm amateur radio bands. *AO-13*'s cross-band transponders were configured for Mode B—70 cm lower sideband (LSB) uplink and 2-meter upper sideband (USB) downlink; Mode S—70 cm uplink USB and 13 cm USB downlink; and Mode L—uplink 23-cm LSB, downlink 70-cm USB). Linear transponders permitted many users to operate simultaneously.

Phase 3C was launched on June 15, 1988, on Ariane 401, the first flight of the Ariane 4 launch vehicle (V22). The launch vehicle was flown in its 44LP configuration, two solid and two liquid boosters. P3C's sister satellites were *Panamsat 1* and *Meteosat P2*.

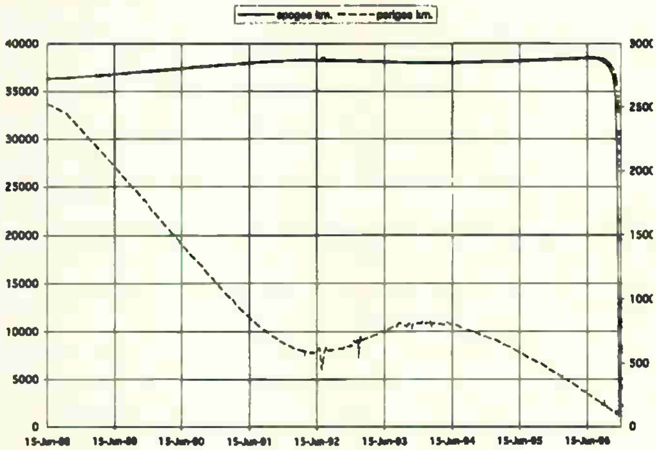
After Phase 3C successfully achieved orbit it was renamed *AMSAT-OSCAR 13*, since it was the thirteenth amateur satellite to reach orbit. Several firings of the rocket engine were required to convert the initial Ariane 4's geosynchronous transfer orbit of 223 x 36,077 kilometers with an inclination of 10 degrees into *OSCAR-13*'s operational orbit of 2,500 x 36,000 kilometers with an inclination of 57 degrees. The spacecraft controllers were especially nervous, since things didn't operate properly during the AO-10 engine burns. The burns went well, and by mid-July AO-13 had reached its operational orbit.

On July 22, 1988, *OSCAR-13* was officially opened for 'business' at 15:00 UTC. It had traveled around the Earth 80 times, with plenty of spacecraft testing by the ground control operators until that point. The first ham to use the satellite was Dick Jansson WD4FAB, who later became AMSAT-NA's vice president of engineering.

AO-13's elliptical orbit was designed to permit hams long periods of uninterrupted communications across very large distances. At apogee AO-13 viewed over a third of the Earth's surface. The orbital parameters combined to result in very favorable operating windows for most hams. Tri-continent nets and conversations were quite feasible due to *AO-13*'s orbit.

What wasn't suspected when *AO-13* was launched was the inherent instability in its orbit. At apogee the satellite is much closer

FIGURE 1 altitude vs. time



to the moon, which tends to 'pull' *AO-13* upward. Combined with the Sun's gravitational force, and to a lesser degree the Earth's non-uniform shape and gravitational influences from the other planets, an orbit gradually changes over time. Unfortunately, it turned out that *AO-13*'s orbit was inherently time-limited; within a decade its perigee would decrease until it hit the Earth's surface, unless something else happened first. Of course something else did happen—*AO-13* burned up in the Earth's atmosphere well before it reached the surface.

While it's possible to calculate with a fair amount of accuracy what orbit a satellite will end up in after several years, it's impossible to choose a final orbit and determine from that what orbit the satellite has to be in at the start.

AO-13's last days were calculated by James Miller G3RUH, one of the *AO-13* ground station operators. Several years earlier he predicted that *AO-13* would make its last orbit around the Earth in the first week of December 1996. What's especially amazing is the calculations were performed by a program written in BASIC on an 8 bit Acorn computer!

James Miller's analysis indicated that *AO-13* would encounter intense heating towards the end of its life. Every watt of energy which was used by the launch vehicle to put *AO-13* into orbit would be converted back into heat as *AO-13* scraped the Earth's upper atmosphere. It was obvious that the spacecraft's electronics would fail well before the spacecraft reentered; the only question was when and for what reason. His analysis is available on the Internet in AMSAT's archives at **ftp://ftp.amsat.org/amsat/satinfo/ao13/decaykep.zip**.

As *AO-13*'s altitude inexorably decreased, interest in *AO-13* increased, with many hams going to extra efforts to make one final contact through an old friend, and others eager to make their first contacts.

As *AO-13* made its last orbits around the Earth the Phase 3-D Integration Team successfully powered up its IHU. Originally, it had been hoped that Phase 3-D would be in orbit and operational before *AO-13*'s demise to provide uninterrupted coverage for amateurs, but delays to the Ariane 5 launch vehicle prevented that from happening.

On November 23, 1996, at 0306 UTC on orbit 6478, Peter Guelzow DB2OS reported that the current on panel 3 went to zero, indicating that either a solder joint melted or something else caused the solar panel to fail. In addition, telemetry indicated that the temperature jumped to over 80 degrees Celsius—much higher than the normal operating temperatures. Even with a lost array the transponders continued to operate and hams reported strong signals.

By this point it was quite clear that the end was coming quickly. With each perigee pass hams wondered—will this be the last operational orbit?

On orbit 6480 as *AO-13* came over Graham Ratcliff VK5AGR's horizon on Nov 23 2315 UTC, the telemetry indicated that four more solar panels had failed, leaving only solar panel 5 in operation. Graham sent the command to shut off all of the transponders to conserve power, finishing *AO-13*'s long service to the ham radio community. At this point only the engineering beacon was left on, transmitting spacecraft telemetry, including the rising temperature detected by its sensors.

One orbit later at 5:38:16 UTC on November 24, Graham reported that the *AO-13*'s engineering beacon ceased transmitting and *AO-13* was officially declared dead.

AO-13 remained in orbit as a dead hulk for another 12 days before its reentry. According to James Miller's best estimates AO-13 entered the Earth's atmosphere over North America on December 5 at 0900 UTC.

USSPACECOM feels that reentry occurred on the December 6 at 0157 UTC, which would place its reentry over Africa. In either case during AO-13's 3096 days in space it had traveled over 1.05 billion kilometers—almost the distance of the Sun to Saturn.

Figure 1 is derived from *ST* staffer Dr. TS Kelso's long-term archive of *AO-13* two line elements stored on his Grove Enterprises web page (**http://www.grove.net/~tkelso/**). I took all of the archival elements for *AO-13* since its launch and used a set of word processor string searches to edit it in to a format which could be loaded in to a spreadsheet. Simple physics formulas were used to convert the information in the two line element sets into real-world numbers. There are a couple of glitches in the data, due to the methods used by NORAD to calculate orbits for long term satellites. Note how rapidly the apogee decreases after June 1996, and how the perigee moves down towards the top of the Earth's atmosphere.

Shortly before the end, hams around the world were surprised by the following announcement in *AO-13*'s telemetry beacon from ground station:

Stacey Mills W4SM - "M QST de *AO-13* BIRTH ANNOUNCEMENT 1996 Nov 20 0240 EST

My child, P3D, began "thinking" today when its IHU was activated. I'm glad I lived long enough to learn of this wonderful event. I wish P3D a long, functional life. Do not grieve for me when I'm gone. I'm only metal, plastic, & sand. My "life" came from enriching the lives of those who built, commanded & utilized me, and it's been a good "life". Danke Karl, et al. No regrets. The baton will soon be passed. AO-13 signing off...."

Farewell old, friend. Your amateur radio friends here on Earth will miss you. ST

ST On The Air

By Steven J. Handler

WFMT Classics and Fine Arts Get No Finer

Like buried treasure for the mind, WFMT's radio signal lies hidden, piggybacked on WGN Television's signal carried on *Galaxy 5* channel 7. In stereo, using the 6.30 and 6.48 MHz audio subcarriers to deliver their programming, this unique fine arts radio station showcases the cultural life of Chicago and brings home to Chicago the best of other cultures from other corners of the United States and the world.

In 1051, more than 45 years ago, WFMT debuted its fine arts format which continues to this day. It brings listeners a mix of music, drama, poetry, and other unique programming. Located in studios in Chicago, Illinois, WFMT's over the air FM radio signal on 98.7 MHz reaches listeners in parts of four states, Illinois, Wisconsin, Michigan, and Indiana. However, through the use of satellite, its world class broadcasts are able to grace the homes of listeners throughout the United States and parts of Mexico and Canada.

WFMT's hallmark is live concert presentations found almost mowhere else. Live programming includes weekly chamber music concerts, presentations from the Chicago Cultural Center, opening night performances from the world renowned Lyric Opera of Chicago, and simulcasts with Chicago's public television station WTTV (Channel 11). In addition, an annual series of drama presentations is aired that showcases the talent of Chicago area theater companies. In addition to live performances, WFMT has more than 65,000 recordings, many of which they taped, in its library and available to be assembled into daily programming.

WFMT transmitters are atop the John Hancock Center in downtown Chicago, shown here adjacent to WFMT street banner.

WFMT was founded by Bernard and Rita Jacobs in 1951 and is now an operating division of Window To The World Communications, Inc, a not-for-profit organization. The Jacobs operated the station until 1968 when, because of Jacobs' long illness, they sold it to WGN Continental Broadcasting Company, the parent of Superstation WGN. In 1969, Continental donated WFMT to the Chicago Educational Television Association, the predecessor to Window To The World Communications, Inc.

Each year over 15,000 listeners donate $40 or more to become members of WFMT's Fine Arts Circle. Although supported in part by donations, WFMT is not a public radio station. It carries advertising. However, unlike almost any other radio station, all advertising copy is read by WFMT's announcers. Rather than the rat-tat-tat patter of commercials and advertisements found on other stations, WFMT's soothing announcers glide the advertisements across the airwaves to land gently in the listeners' ears, rather than assaulting their minds.

With a budget of about five million dollars a year, their staff of 37 full time and eight part time employees strives to air the finest of fine arts programming. Until 1995, WFMT operated from studios in Chicago's loop. To meet the superior quality required, a custom designed two-story high music studio was built. Isolated from all noise and vibration, it brought concert hall acoustics to live and recorded broadcasts. In addition to shielding the studio complex from the daily sounds of the six million plus people that call the Chicago area their home, the studio was specially shielded to minimize electrical interference. With almost an all out war mentality, their engineers used a fiber optic system to carry data within the studio complex to prevent computer generated noise from polluting the audio signals.

In 1995, WFMT moved from its loop location to its newly constructed facility on

Neotek Mixing Console

the near north campus of its sister station, WTTW-TV, the Chicago area public TV station, which is also owned by Window To The World, Inc. The ceiling in its current music performance studio is over 18 feet high to capture concert hall quality. Only the best components were used in the studio, lest a technical deficiency mar the quality of WFMT's broadcasts.

Technology Pioneer

Chicago may be known as the Second City, but WFMT has been the home to many technology firsts. In June of 1982, they conducted the North American broadcast premier of the CD (compact disc). Sony, a world leader in audio products, brought this technology to WFMT because of its audio excellence. This first was followed by WFMT's broadcasts premiering the DAT (digital audio tape cassette) and more recently, the SONY mini-disc reordable CD.

Along the way WFMT has experimented with ways to improve the audio quality enjoyed by listeners. It was one of the first stations to broadcast quadraphonic sound, although this format is no longer used. They experimented with technology by broadcasting Chicago's internationally famous Lyric Opera's opening nights live in four-channel sound, although it's now broadcast in stereo.

Bill of Fare

WFMT records live performances for their *Chicago Theaters On The Air* series. In 1996 they brought listeners great plays including *This Town, The Misanthrope, The Manchurian Candidate,* and *Escape from Paradise.* These performances included such renowned stars such as Stacy Keach, Paul Winfield, Matha Lavey, Gates McFadden and Ed Begley, Jr. The 1997 season, consisting of ten performances by Chicago drama companies, begins taping in January for broadcast beginning in April.

Weekly live solo and chamber music concerts emanate from WFMT's performance studio on Monday nights at 9 p.m. Eastern Standard Time (EST). 1997 will bring a special series of concerts beginning January 27th, celebrating the 200th anniversary of the birth of Franz Schubert. For those interested in exercising their gray matter, Chicago native and famed author Studs Terkel's program can be heard weeknights at 11:30 p.m. EST.

WFMT doesn't limit its live performances to Chicago. *Opera of the Week,* which airs at 1:30 p.m. EST each Saturday, includes live performances from the Metropolitan Opera in New York. In addition to cultural programming, on-air radio-thon events raise more than $500,000 a year for

98.7WFMT
CHICAGO'S FINE ARTS STATION

WFMT Fine Arts Network

Chicago Symphony Orchestra and $250,000 for the Lyric Opera of Chicago.

For the History Books

Recognizing that their fine arts programming needs to be accompanied by the genteel voices of refined announcers, many have backgrounds in music and theater. To say that their announcers are dedicated to fine arts is an understatement. One announcer's personal record collection exceeds the 60,000 LPs, CDs, and other recordings in the station's large sound recording vault.

Mike Nichols, of the comedy team May and Nichols and late of television fame, was an early WFMT announcer. Joining the staff in 1953, he started the *Midnight Special* program. The *Midnight Special* is an eclectic blend of folk music, comedy and show tunes. It currently airs on Saturdays from 10 p.m. to 1 a.m EST. Another little known historical note involves the famous song *City of New Orleans*. The late Steve Goodman is reported to have written the song while traveling on a train from New Orleans to Chicago. After arriving in Chicago, he proceeded to WFMT's studio and performed *City of New Orleans* for the first time, live on the *Midnight Special* program.

WFMT also established the Beethoven Satellite Network. Since 1986 this classical music format station has been distributed by satellite to radio stations around the country. It currently is broadcast to radio stations nationwide using digitally encoded signals on Galaxy 4 satellite, channel 3, with a SCPC audio of 72.0. On New Year's Day, 1997, the old 11 hour a day programming format changed to around the clock broadcasting.

WFMT goes far beyond other merely classical stations to bring the listener the highest quality programming whose rendition is extremely faithful to the original. Rest assured, if WFMT broadcast the sounds of a thunderstorm, you would need a raincoat to listen to the symphony of droplets and drumbeats of thunder. As Jon Kavanaugh, spokesman for WFMT, said in a recent interview, WFMT and its radio network are "More than a commercial radio station—WFMT and the radio networks operate as a fine arts institution." Don't just take my word for it: tune in to WFMT, one of the great things you'll find *On The Air*.

More Treasure of Satellite Mantra!

Not satisfied with any of the satellite TV guides that I reviewed in my column a year ago? Check out the *Superstar Entertainment Guide* which covers C-band programming.

A sample issue of this monthly graced my mailbox. Measuring about 8-3/8 inches wide by 10-3/4 inches in length, it contained over 330 pages. The eighteen full color pages included articles about satellite television and programming. The balance of the issue was printed on a paper similar to newsprint. Program listings were displayed in a grid format. Separate time bars (Atlantic, Eastern, Central, Mountain and Pacific) were displayed at the top of each page and were divided into half hour time blocks. Following down the page, the programs were listed by categories including the premium channels, music, religion, sports, basic/variety channels, superstations, Denver 5, PBS, PT East, PT West, Pay per view, and adult. Within each category the channels were listed alphabetically.

Other sections of the magazine include a three page wild feeds list, an alphabetic listing of movies with a brief description of the movie, a sports section with listings arranged chronologically for each sport, and a "specials" section. For each sport listed, a calendar was provided listing the specific sporting events, and including the satellite and transponder.

The "movie" section listed movies alphabetically, and included a movie rating, brief description about the movie, the stars' names, the movie length in minutes, and the day of the month, time, satellite and transponder on which the movie aired.

The color center section included a "directory" page with a channel lineup. It listed by category those stations covered by the guide. A two page satellite chart listed the C-band satellites in a grid, showing their transponders and the user broadcasting on each. The chart was color coded to indicate adult, networks/superstations, pay per view, premium, Spanish, sports, religious and variety stations. It also indicated whether the channel was available by subscription only. Information about each satellite included the name, whether the satellite uses normal or reverse polarity, and the exact position in the satellite arc.

BSN Around the Clock

Beethoven Satellite Network America's 24-hour classical music service

For more information contact Superstar at (800) 225-5772. ST

UNITED STATES POSTAL SERVICE

Statement of Ownership, Management, and Circulation

(Required by 39 USC 3685)

1. Publication Title: SATELLITE TIMES
2. Publication Number: 1 0 7 7 - 2 2 7 8
3. Filing Date: 10/31/96
4. Issue Frequency: BI-MONTHLY
5. Number of Issues Published Annually: 6
6. Annual Subscription Price: $19.95
7. Complete Mailing Address of Known Office of Publication: P. O. BOX 98, BRASSTOWN, NC 28902. Contact Person: KELLY T. DAVIS. Telephone: (704) 837-9200
8. Complete Mailing Address of Headquarters or General Business Office of Publisher: P. O. BOX 98, BRASSTOWN, NC 28902
9. Publisher: ROBERT B. GROVE, P. O. BOX 98, BRASSTOWN, NC 28902
Editor: LARRY VAN HORN, P.O. BOX 98, BRASSTOWN, NC 28902
Managing Editor:

10. Owner

Full Name	Complete Mailing Address
GROVE ENTERPRISES, INC.	P. O. BOX 98, BRASSTOWN, NC 28902
ROBERT B. GROVE	P. O. BOX 98, BRASSTOWN, NC 28902
JUDY A. GROVE	P. O. BOX 98, BRASSTOWN, NC 28902
KELLY T. DAVIS	P. O. BOX 98, BRASSTOWN, NC 28902

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box ☐ None

Full Name	Complete Mailing Address

12. Tax Status

PS Form 3526, September 1995

13. Publication Title: SATELLITE TIMES
14. Issue Date for Circulation Data Below: NOV/DEC 1996

15. Extent and Nature of Circulation	Average No. Copies Each Issue During Preceding 12 Months	Actual No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies (Net press run)	12,580	12,[illegible]
b. Paid and/or Requested Circulation (1) Sales Through Dealers and Carriers, Street Vendors and Counter Sales (Not mailed)	6,883	7,760
(2) Paid or Requested Mail Subscriptions	3,610	2,879
c. Total Paid and/or Requested Circulation	10,493	10,639
d. Free Distribution by Mail (Samples, complimentary, and other free)	2,064	2,000
e. Free Distribution Outside the Mail (Carriers or other means)	-0-	-0-
f. Total Free Distribution	2,064	2,000
g. Total Distribution	12,557	12,639
h. Copies not Distributed (1) Office Use, Leftovers, Spoiled	-0-	-0-
(2) Returns from News Agents	665	-0-
i. Total	13,222	12,639
Percent Paid and/or Requested Circulation	83.45	84.2[illegible]

16. Publication of Statement of Ownership: will be printed in the JAN/FEB 97 issue of this publication.
17. Signature and Title of Editor, Publisher, Business Manager, or Owner: EDITOR. Date: 10/31/96

Instructions to Publishers

PS Form 3526, September 1995 (Reverse)

By George Wood
wood@rs.sr.se

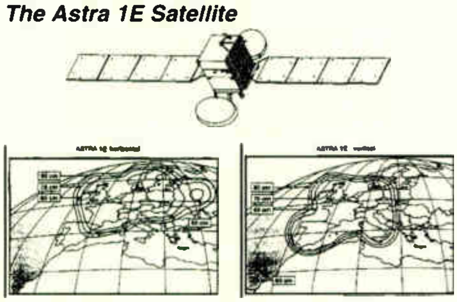
Murdoch's Adventures

BSkyB, in no hurry to get involved in digital broadcasting when it already dominates the analog market, has swapped digital transponders with its new friend, Germany's Kirch Group. The deal involves Sky handing over its four remaining (and unused) digital transponders on *Astra 1E* and *1F* in return for an unspecified number of transponders on the new Astra satellite that will be launched to 28.2 degrees East. The *1E* and *1F* transponders will now be used to boost the output of the German DF1 package in which Kirch and Sky are partners. DF1 was launched in July using seven transponders.

Sky will use its new transponders at 28 degrees East to increase the channel count for its own digital service, due to launch soemtime during 1997 with 200 to 300 channels. Sky had already booked half the transponders on the satellite. But there's some doubt as to what will happen when the package is launched.

Writing in a magazine called *What Satellite TV*, noted British media observer Barry Fox has observed that, since Sky and Astra both say the analog services will continue for the forseeable future, it will be very difficult to get the millions of current BSkyB viewers to buy new receivers. Virtually all of them have fixed dishes aimed at Astra's 19 degrees East, and it perhaps may be even to get them to move their antennas to the new position at 28 degrees.

The Astra 1E Satellite



The German alternative to DF1 has fallen apart. On September 19, Bertelsmann and its Luxembourg-based partner CLT announced they had abandoned plans for a digital pay-TV service. That was followed by the announcement that Deutsche Telekom is leaving MMBG, the group of broadcasters and companies once created to distribute digital TV in Germany.

But a few days later Bertelsmann said that the German cartel authorities view any involvement by Rupert Murdoch in the German pay-TV broadcaster Premiere critically. Murdoch's BSkyB has been promised a 25 percent stake in Premiere as part of Murdoch's alliance with German media mogul Leo Kirch. According to Bertelsmann board member Thomas Middlehoff, BSkyB's involvement with Kirch's DF1 is thus thrown into question.

Sometimes the moves and countermoves in the German media market seem to be based on *Dallas*, or perhaps *Alice in Wonderland*. Stay tuned.

BBC World Service radio has closed its satellite downlinks on *Hot Bird* and *Eutelsat II-F1*, which share 13 degrees East, on both the EBN and BBC World transponders. This is to provide bandwidth for a new digital control system for BBC relay stations and rebroadcasters. The BBC radio Astra relays continue.

The BBC is not abandoning 13 degrees East, however. BBC World has extended its contract on *Eutelsat II-F1* until 1999. The 24 hour TV news channel has also concluded a 12 year agreement until 2011 for carriage on *Hot Bird 5*, which is scheduled to replace II-F1 in 1999.

The owner of the Weather Channel, Landmark, has acquired 50 percent of Pelmorex, which owns the rival Weather Network. The deal will lead to the Weather Channel becoming Britain's (and presumably Europe's) sole TV weather channel from this spring onwards, as the Weather Network will be closing. The Weather Network has been cable only in Britain, while the Weather Channel has been part of the Sky Multichannels package, operating for a few hours every morning. sharing Astra transponder 60 with Sky Movies Gold.

Sister channel Travel TV ceases its analog broadcasts on *Intelsat 601* on January 1, 1997. They are being replaced with the clear MPEG-2 digital transmissions that began on Astra transponder 71 on November 1. The German children's channel Kindernet has also stopped analog transmissions on *Intelsat 601* in favor of digital

CNBC
FIRST IN BUSINESS WORLDWIDE

transmissions on Astra transponder 71.

Luxembourg-based CLT, now part of Bertelsmann, started a new satellite channel to Poland, called RTL 7, on December 7. CLT failed to win a Polish broadcasting licence two years ago.

Programming is being prepared by a 50 member team in Warsaw, sent to Luxembourg, and then beamed back to the 13.5 million Poles with access to cable and satellite TV. The station says it will abide by Polish bans on cigarette and alcohol advertising.

One of Europe's most exotic satellite channels, Thaiwave from Thailand, is back on *Eutelsat II-F3* on 11.163 GHz. Meanwhile, there's been a very strange screen on *Eutelsat II-F4* at 7 degrees East, which carries programming for the European Broadcast Union. They use a system called sound-in-sync, which results in a fuzzy picture with no sound for ordinary viewers.

There are devices on the market which can restore the picture, but not the sound. At any rate, just before the American election, while tuning in to 11.428 GHz on *II-F3*, I discovered the output of a BASYS news computer system on the screen. BASYS is one of the most popular newsroom systems, used by CNN, the BBC, and hundreds of other radio and television stations around the world. The screen on *Eutelsat II-F4* is a bit too fuzzy to work out what it is, but the language seems to be English. On one occasion, the BASYS screen was replaced by an "EBU Moscow" screen. It would be interesting to know who is putting their BASYS system on satellite.

Here are new channels on the Russian *GALS 1/2* (36 degrees East) (all SECAM):

11.766	NTV+ Sport
11.835	NTV+ Music
11.919	NTV+ Mir Kino (World of Cinema)
12.166	NTV+ Nashe Kino (Our Cinema)

Scandinavia

As I write, it's unclear whether Nethold managed to launch Scandinavia's first digital television package by Christmas.

The start, scheduled for the fall, has been delayed several times. This despite all-out production of the necessary digital receivers at Nokia's factory in Motala, in southern Sweden.

The service will initially include 19 TV channels and 40 CD-quality themed radio channels from DMX. The TV channels include:

Nethold's own Filmnet, SuperSport, and Hallmark Entertainment, along with Discovery, the Children's Channel, Bloomberg Information Television, NBC, CNBC, EBN, Country Music Television, the Weather Channel, the Travel Channel, Performance, and Sweden's Kanal 5 and Norway's TV Norge.

Later on, interactive home shopping, Internet access, movies-on-demand, and impulse pay-per-view will be added.

The TV channels have been available for several months on Nethold's digital transponders 73, 77, 93, and 97 on the Astra satellites, and Nethold launched a similar package to the Benelux countries this past summer.

The situation has been complicated by a German company that has been importing digital receivers into Sweden. These are intended for the German market, and, according to Nokia, after a short period they will no longer decode the Nethold signals.

TV1000 also made a mess of its launch to Finland in October. Its two film channels TV1000 and TV1000 Cinema broadcast uncoded during the launch weekend, and the centerpiece of the entire advertising campaign for subscribers, both in Finland and Sweden, was the broadcast of the film *Pulp Fiction*. Unfortunately, something happened during the uplink, and the screen went blank in the middle of the movie for an entire hour. Rather than stop the film and start it again when the trouble was fixed, TV1000 just kept rolling—a move that did not win it many friends. The uncoded broadcasts continued for several more days than initially announced, apparently in an attempt to mollify outraged viewers.

While TV1000's owner Kinnevik has no immediate plans for digital broadcasting, it has gotten involved in the digital domain in a different way. Kinnevik's general entertainment channel TV3 Sweden is now allowing viewers to surf the Worldwide Web for free, using teletext. This is the European system of providing hundreds of screen pages of information transmitted in the blank spaces at the top and bottom of TV screens. Teletext typically provides program guides; news, weather, business, and sports news; classified ads; and sometimes even extensive railroad schedules. (The BBC's teletext carries arrivals information from London's Heathrow Airport.)

TV3 viewers can punch up teletext page 801, and then dial a Stockholm telephone number. From then on they can use their telephone touch buttons to net surf. The system uses the Lynx text-only browser, as teletext offers only clunky images, so there aren't any graphics, but it does work, and it's free, at least except for the phone call.

Because TV3 is carried in D2-MAC on the *Sirius* satellite at 5 degrees East, anyone who can receive that satellite can actually watch other people net-surfing. On cable you need a teletext- equipped TV to view the pages, but D2-MAC includes built-in teletext, which works even if you don't have a subscription card to view the channel. The Web-surfers are allocated teletext pages between 780 and 799; thus if you check out some of those pages you can often find people using the system.

The only really major media news in Europe recently has been Kinnevik's new relay of a number of channels from Viacom from the Nordic satellite positions. On *Sirius*, at 5 degrees East, VH-1 is now on 11.785 GHz, and Nickelodeon is sharing 11.862 GHz with Kinnevik's youth channel Z-TV.

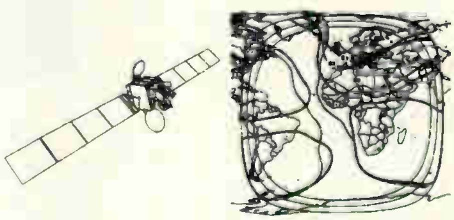
According to *What Satellite TV*, the German version of Nickelodeon, currently on Astra transponder 49, will move to the current Swedish Nickelodeon Astra transponder 27 soon.

MTV is supposed to be joining Kinnevik's offerings next year, but the station has already taken over the former Norwegian TV Plus transponder on 11.679 GHz on *Intelsat 707*, which shares 1 degree West with *TV-Sat* and *Thor*.

The Sci-Fi Channel had a strange launch.

The Intelsat 707 Satellite

Spacecraft in Orbit **Coverage Contour**



Originally Sci-Fi was reported to be coming to the *TV-Sat* satellite at 1 degree West.

Instead it started on the aging *Tele-X* at the other Nordic position at 5 degrees East, on 12.600 GHz. But within a couple of weeks, Sci-Fi started on *TV-Sat* too, on 12.054 GHz. According to Kinnevik's distribution subsidiary Viasat, the move is because of *Tele-X*'s weaker signal. Sci-Fi has been in the clear, but according to Viasat encoding in Eurocrypt starts on January 1, 1997.

Sci-Fi will not be included in the CTV package on *Thor* (CNN, Discovery, TCC, Eurosport Nordic, and MTV), instead it will be included in its own package with Nickelodeon and VH-1. Viasat has plans to include more channels in this new package, but rather than renting new transponders, they will use the Murdoch method of sharing existing transponders.

Ironically, because teletext is already included in D2-MAC, Kinnevik was initally unable to provide the well-known Dominion teletext pages for the Sci-Fi Channel. Kinnevik's subsidiary MTG and uplink partner Swedish Teracom lacked the equipment to convert teletext to the MAC format. Teletext has been gradually introduced on Sci-Fi, VH-1, and Nickelodeon.

There was also confusion over the appearance of the BBC's subscription entertainment channel BBC Prime at 5 degrees West. It was initially reported that it would take MTV's old transponder on *Thor* at 12.092 GHz. But instead Filmnet 1 moved to that transponder in mid-November, leaving *Intelsat 707* at the same position. BBC Prime took over Filmnet 1's *Intelsat 707* transponder on 11.133 GHz, as part of the CTV package.

Because Filmnet, like TV1000, shows hardcore pornography late at night—something that is completely banned in Britain in all forms, even video—there has been a major market for pirate Filmnet decoder cards. While *Intelsat 707* can be seen in Britain, Thor cannot, and one reason for the move must have been to make it harder for people outside Scandinavia watch the channel.

However, Filmnet is still available across Western Europe on Astra, where Nethold also has its new digital package. Nethold's subsidiary Multichoice has denied reports that it will soon leave analog transponder 11 on Astra to make room for Britain's new Channel 5. According to Ulf Persson, head of Filmnet Television AB, transmissions will continue as previously, and if the Filmnet 1 transponder is to be closed, this will be announced well ahead of time.

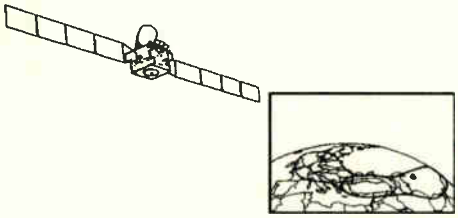
Chief Executive David Elstein says Channel 5 is likely to launch in late March 1997, three months later than planned. Elstein, who came to Channel 5 from British Sky Broadcasting, says he hopes the channel will be on satellite and cable from the start, and that its inclusion will strengthen Sky's satellite offerings.

More Murdoch

Outside of the Fox Network in the U.S. and British Sky Broadcasting in Europe, Rupert Murdoch is involved in satellite ventures to every continent. Here are some news tidbits from Planet Rupert.

The Saudi Arabian owned Middle Eastern satellite broadcaster Orbit has signed an agreement with Murdoch's Asian satellite broadcaster Star-TV, for a package of services to be carried on Orbit's digital radio and TV network. The deal came five months after the Saudi firm cancelled a contract for the BBC's Arabic news channel, after the BBC broadcast a program which criticised Saudi Arabia's human rights record. (Orbit and Murdoch seem to be on the same wavelength—Murdoch dropped BBC World from Star after similar protests from the Chinese authorities.)

The Turksat 1C Spacecraft

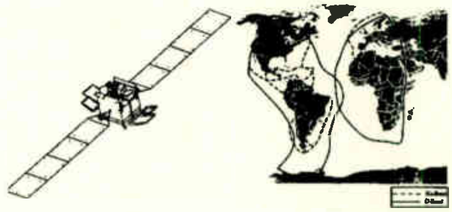


According to an Orbit spokeswoman, Star Movies, Star Sports, Sky News, CNBC, NBC, and a Filipino movie channel called Viva Cinema will be joining Orbit.

An English-language satellite channel from Star-TV will air Hindi programs to India at prime-time. A key part of Star Plus's new line-up will be news bulletins in Hindi and English focused on India. Gene Swinstead, Star TV's managing director for India, says the Indianization of Star Plus is part of a strategy by the channel across Asia to offer more local programming.

Murdoch's New Zealand news group, Independent Newspapers, announced in October it was in talks to buy a substantial shareholding in the country's largest pay-TV operator, Sky Network TV. Despite the name, Sky Network TV has had no connection with Murdoch's European operator, British Sky Broadcasting. That apparently is changing.

The PanAmSat 3 Satellite



October 30 saw the inaugural launch of the Sky Entertainment Services satellite direct-to-home service to Brazil, jointly owned by Organizacoes Globo, Murdoch's News Corp, and TCI. Sky will offer 40 channels, expanding to 140 later in 1997. Sky has made an initial purchase of 100,000 digital MPEG-2 DVB receivers from Pace, which will cost around USD 925 each, with an average monthly subscription fee of around USD 37. Initially the service uses four transponders on the *PAS-3* satellite (now owned by rival Hughes/DirecTV). In the longer term, the new *PAS-6* satellite is to devote 12 transponders for the Brazilian subscribers. (Unless Hughes puts a stop to it.)

Plans continue to launch Murdoch's new direct-to-home satellite ventures, Japan Sky Broadcasting and American Sky Broadcasting.

On the other hand, Israeli tax officials raided a hi-tech firm owned by Rupert Murdoch on October 20, confiscating files and computer data to gather evidence in a $150 million tax evasion case. Israeli Radio says 70 tax agents raided a factory in Haifa and offices in Jerusalem. The station reported that the Murdoch company News Datacom Research Ltd (NDR) had developed sophisticated technology what was created locally and smuggled abroad without reporting the transactions to the tax authorities. NDR has developed encryption systems for Murdoch's pay-TV satellite networks. The company issued a statement rejecting the charges as

being "without merit." A spokeswoman for the Income Tax Authority has denied reports the authority has petitioned the Jerusalem District Court to detain Murdoch if he enters Israel.

Middle East

Turksat 1C replaced *Turksat 1B* at 42 degrees East on 26 September, with a new channel line up, and with new frequencies for all channels.

The European beam is reported to be weaker than *1B* (which was pretty weak in Northern Europe, home of many Turkish immigrants), but it has several more channels now which only were on the Turkish beam before.

Here is the new TV channel line-up for *Turksat 1C*:

European Beam

10.965V	ATV
11.008V	Cine 5 (encrypted in Nagravision)
11.048V	Show TV
11.091V	Samanyolu TV
11.142V	Kanal 7
11.185V	Euro D
11.475V	TRT 1
11.500V	TRT 2/TRT Gap
11.568V	TRT 3
11.600V	TRT 4

Turkish Beam

10.975H	HBB
11.025H	Kanal D
11.075H	Kanal 6
11.126H	Cine 5
11.175H	Show TV
11.468H	Kanal 7
11.556H	TRT 1
11.592H	TRT 2/TV Gap
11.680H	TRT Avrasya

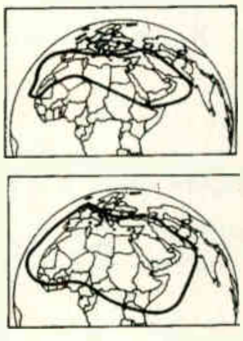
Turksat 1B is moving to 31 degrees East and probably be used for telephony and digital transmissions.

Several channels have started on *Arabsat 2A* at 26 degrees East. All are available in PAL, except Saudi TV.

3.720R	Sharjah TV
3.741L	LBC Sat promos
3.802	Nile TV International
3.823L	Bahrain TV
3.843R	CNN International
3.864L	Future TV test card
3.905L	Sudan TV
3.925R	Saudi Channel 1
3.946	CFI-Canal France International/MCM Euromusique
3.993R	Saudi Channel 2
4.058L	EDTV-Emirates Dubai TV
4.167	KTS (Kuwait)
4.180L	Yemen TV
4.410	Oman TV
12.521	Al Jazeera (Qatar)
12.578V	SRT (Syria)
12.620V	Abu Dhabi TV
12.720H	ART 4 Movies

The Arabsat IIA Spacecraft

Coverage Maps



Qatar's first satellite channel went on the air on November 1. Al Jazeera (the Arabic word for "island") will transmit for almost six hours a day. It is being operated by the private Qatar Satellite Channel Corporation, and features political, economic, and sports events, as well as talk shows and entertainment. It is broadcasting on *Eutelsat II-F3* 11.080 GHz and *Arabsat 2A* 12.521 GHz.

Arabsat has a WWW home page at **http://www.arab.net/arabsat/**

Arabsat has awarded a contract worth at least $90 million for its third second-generation satellite to France's Aerospatiale. The satellite, which may be called *Broadcasting Satellite System 1* (or *BSS1*), may be launched in 1998 or early 1999.

Asia/Pacific

Russia's *Express 6* has started transmitting at 80 degrees East. Strong signals have been monitored around the Arabian peninsuala on 3.725, 3.830, 4.025, 4.075, and 4.128 GHz.

The TV Shopping Network has started on Indonesia's *Palapa C2* on 3.880 GHz.

Malaysia launched a digital satellite service on September 25, including 22 TV channels and eight radio channels, using the *Measat-1* satellite. Subscribers will need 60 cm dishes and will pay around $32 a month for the service, which will be known as Astro. It includes Malay, Chinese, and Tamil program language channels. Hong Kong's TVB is supplying programs for the Chinese channel, and India's state-run Doordarshan will provide programming in Indian-languages.

International channels include CNN, NBC, CNBC, Asian Business News, Star Sports, Star Movies, Star Plus, ESPN, HBO, MGM Gold, Disney, Cartoon Network, and the Discovery Channel. Initially the service will only be available in Malaysia, but there are plans to expand into India, Indonesia, Taiwan, the Philippines, and eastern Australia.

Last, but not least, just a note that the World Radio Network has appointed Simon Spanswick as Director of Corporate Affairs. Like virtually everyone else at WRN Simon comes from the BBC (in this case the World Service), and has been host of the *Waveguide* program as well as the long-serving Assistant Secretary General of the European DX Council, the organization bringing together clubs for shortwave listeners in Europe. So he brings with him broadcast experience as both broadcaster and listener. Best of luck!

Thanks to Richard Karlsson, James Robinson, *SATCO DX Chart Update*, Curt Swinehart, and *Tele-satellit news* for their many contributions. All frequencies in this column are in GHz and all times in UTC.

ST

By Doug Jessop

Satellite Home Viewing Act: The FCC Response

In a recent issue, *Satellite Times* editor Larry Van Horn made comment about the Satellite Home Viewing Act. Based on the amount of attention that the subject has been receiving in DBS circles, I thought you might be interested in a letter that Saul Shapiro, Assistant Bureau Chief for Technology Policy, Mass Media Bureau, Federal Communications Commission, posted in a recent broadcasting related group discussion...

"On the topic of network programming on satellites, or more specifically local programming on Hughes' DSS or other direct-to-home (DTH) satellite video services:

The rules of retransmission are governed by the Satellite Home Viewing Act which was enacted by Congress to protect the local broadcast licensee's revenue stream by insuring that all viewers served by the local signal would only receive the network programming (and resultant advertising dollars) from the local over-the-air signal provider and to keep viewers watching the local affiliate as opposed to the distant one for non-network programming.

In the cable context, network-nonduplication rules ensure that local viewers receive national broadcast network programming via the local affiliate, although cable operators may carry, with appropriate retransmission consent, more than one affiliate of a broadcast network. Cable viewers thus may have side-by-side access to the non-network programming of more than one affiliate of the same network. These regulatory structures are designed to protect, supposedly, the values engendered by "localism," and certainly serve to protect the revenue streams of local licensees.

DTH satellite services have what is called a "compulsory license" which allows them to retransmit, to households unserved by a locally based signal affiliated with a network, (or an unaffiliated, non-network signal, such as superstations WTBS and WGN), without getting copyright clearance from the content producers. That is, the copyright holders are required (that's the compulsory part) to license their programming so that it might reach unserved households.

Satellite carriers pay a per-subscriber royalty to the U.S. Copyright Office, which distributes the pool directly to copyright holders.

Cable systems have a different compulsory license that permits them to retransmit television broadcast signals, subject to a different royalty schedule. Cable systems also are subject to the "must carry" and retransmission consent provisions of the Communications Act and to network nonduplication rules. Satellite carriers are generally subject to the statutory retransmission consent provisions, too, but there are exceptions for network stations and for non-network stations that were retransmitted by satellite as of May 1, 1991.

So when you sign up for DirecTV, PrimeStar, USSB, Echostar, AskyB, whatever, the only way they can legally supply you with a network feed is if you live in an unserved area (called "white areas," I guess because all you get is white static on your screen). Hughes's DirecTV has a deal with some network affiliates (they are not the Denver based affiliates or O&O) to provide their feed to unserved households for a small fee, to make up in part for the lack of their ability to supply a local signal.

The SHVA requires satellite carriers to furnish broadcast licensees with subscriber lists. The networks and stations may challenge the "unserved household" status of any subscriber. In response, the satellite carrier must either terminate service within 60 days or do a signal strength test at the subscriber's home."

New Satellite Service for Apartments

According to a report in the *Wall Street Journal*, Tele-Communications Inc. recently announced plans to invest $40 million in a joint venture with hotel-industry telecommunications concern LodgeNet Entertainment Corp. to provide direct-broadcast and interactive television services to apartment buildings. TCI Satellite Entertainment Inc., which was reportedly spun off to shareholders of TCI recently, will pay $5.4 million and then provide LodgeNet with $34.6 million in digital-satellite equipment in exchange for 37% of LodgeNet's ResNet Communications Inc. unit.

ResNet was created by the company this year to expand its hotel-based technology to apartment complexes. TCI Satellite president and Chief Executive Officer Gary Howard said the venture will help to target the six million apartments in buildings of 200 units or more in the US. According to LodgeNet, apartment complexes offer a market more than three times as large as the hotel room market.

Tele-Communications Inc.'s plan to offer stateside satellite television service using Canadian satellites was rejected by the Federal Communications Commission in November. Dig out the last issue of this column and you'll remember that the powers that be in the land up North are not exactly thrilled with the idea of U.S. broadcast influence into their country. In reaction to the FCC's decision, TCI announced that it would launch its own satellite, an option which will deliver less than half of the 200 channels the company originally envisioned. In the "no kidding" department, the FCC ruled that it can't grant a license to TCI and its partners without approval from the Canadian government, which it doesn't have.

TeleCommunications Inc., the nation's largest cable operator, announced that it is cutting 2,500 jobs, or 6.5% of its work force. In addition, it will freeze or reduce salaries for up to 100 senior managers, including Chairman John Malone. In an effort to cut costs TCI will also review expenses in its 1997 budget that aren't directly related to serving its 14 million cable TV customers.

According to analysts, TCI is making a serious effort to boost its cash flow in order to assure investors that the company can retain its customers—even in the face of subscriber rate increases.

"All this is indicative of serious problems at the company," said Hal Vogel, of Cowen & Co. in New York. LaRae Marsik, a TCI spokeswoman, said employees were notified in early December that they would be fired and receive a severance package. The moves are expected to save about $75 million in annual overhead costs for the company. The company posted a loss of $120 million on revenue of $5.1 billion in 1995.

The Discovery Channel and the British Broadcasting Corporation have announced a join investment of $500 million to make programs and launch new channels in the United States and elsewhere. According to the statement, parent Discovery Communications Inc. and BBC Worldwide Ltd., the commercial arm of the BBC, will create hundreds of hours of new programs.

Discovery will finance the venture with access to the vast program library of the BBC. Sure, the Canadian government doesn't want to have anything to do with U.S. programming, but the "old country" across the pond sees us as a lucrative market. (Sarcasm alert).

Two new cable sports channels hit television screens since our last issue, joining the already-crowded field of competitors in the sports channel biz. ESPNews rolled its service out to 1.5 million subscribers initially and Fox Sports Net to more than 20 million. In addition, by the time you read this Time Warner Inc., which owns Cable News Network and *Sports Illustrated* magazine, will launch CNN/SI (are swimsuit competitions coming to TV near you?). ESPNews and CNN/SI are both obviously going after young male demos. The big question is if people will really be willing to pay for another in a plethora of sports offerings already available.

As reported in an earlier column, Fox inaugurated a new live 24-hour news channel called....drum roll please....the Fox News Channel (FNC). The new news channel has found a home at DirecTV. "The Fox News Channel's diverse mix of breaking news, sports, entertainment and business news is a welcome addition to our programming lineup," said Stephanie Campbell, vice president of Programming for DirecTV. "We believe our existing and future subscribers will enjoy and benefit from FNC's original programming and its 24-hour service."

NBC and National Geographic Television have formed a joint venture to launch National Geographic channels throughout the world in 1997. The channels will carry documentary, drama, and children's shows, using National Geographic's library of nature programming as well as shows that will be acquired. NBC's US network and its European channel already carry programming produced by National Geographic. To start, the venture will launch cable- and satellite-delivered channels in Latin America, Europe and Asia, in cooperation with local partners in each territory.

The *Wall Street Journal* reports that Viacom Inc. will take another step to secure an outlet for its Paramount television studios, by exercising its option to buy half of United Paramount Network from BCH Communications Inc., a subsidiary of Chris-Craft Industries Inc., for $160 million. The purchase comes as the network has begun to show signs of competing with the major broadcast networks. Paramount launched the network in 1995 with three nights a week of programming. Nine of the 11 TV stations owned by Viacom's Paramount Television Group are UPN affiliates and the company recently began to reshape its station group to include more UPN affiliate stations.

News Corp and Time Warner's Latest Tiff

Big boy bravado continues between Rupert Murdoch's News Corp. and Time Warner . This time Time Warner wants the Federal Communications Commission to deny MCI Communications Corp.'s application for a U.S. direct-broadcast satellite license. According to Time Warner, if MCI is acquired by British Telecommunications PLC, it will not be eligible for the license. In a letter to FCC chairman Reed Hundt, Time Warner President Richard Parsons said MCI "would not be eligible to hold a DBS license under FCC rules" because it will soon be owned by a foreign corporation.

With the letter, Parsons took aim at Rupert Murdoch's News Corp., which is MCI's 50% partner in the planned satellite-TV service, American Sky Broadcasting. News Corp. is "an Australian company that, as a foreign entity, was already ineligible to bid directly for the DBS license," Parsons added. The letter is being viewed as the latest barrage in the very public battle between Time Warner which recently bought Turner Broadcasting Systems Inc., and News Corp.

Of course, this same kind of battle was fought a couple of years back when competing networks tried the same kind of argument against Aussie ownership of the FOX network. We all know what happened there: Rupert is still around and the network lawyers have new cars in the garage.

USSB Stock Hits All Time Low

The fierce battle for DBS supremacy continues. USSB, one of the original players in the DBS arena, hit an all-time low on the stock market in November ($10.75 a share). In a thrilling experience for the Hubbards, the stock market plunge happen to coincide with a shareholder's meeting.

An analyst for the lead underwriter of USSB's February 1996 initial public offering switched her rating on the company's stock from a "strong buy" to a "hold."

Chief Executive Stanley E. Hubbard pointed out to shareholders that retailers such as Target and Best Buy now offer 11 brands of the satellite dish system shared by USSB and the General Motors DirecTV unit, making it the industry standard. DirecTV, which offers more than 175 channels, is particularly strong in sports programming; USSB offers more than 25 channels, mostly movie channels. Hubbard said USSB's service is gaining greater acceptance, particularly in cable TV's stronghold urban and suburban areas.

But even though USSB's programming revenue grew from zero in 1994 to $192 million for the year ended June 30, CS First Boston analyst Laura Martin cited slower than anticipated growth in the direct satellite broadcast industry as a reason for downgrading the stock.

DirecTV, which shares a satellite with USSB, has revised its expected number of subscribers by year-end from a high of 3 million, which it predicted in August, to 2.3 million, an estimate it made in November. (USSB had slightly more than 1 million subscribers as of September.) At 2.3 million, DirecTV's subscriber base would have grown 86 percent from 1995, but it was less growth at a higher cost per customer, Martin wrote.

DirecTV offered a $200 consumer rebate on satellite dishes with prepayment of a year's programming. Along with USSB, which provided a subsidy of $40 per household to the manufacturers, DirecTV bought down the price of satellite hardware from $599 to $399.

Starting in August, the dishes were advertised for $199, counting the prepayment rebate.

Martin wrote that the largely ineffective pricing promotion, launched against one 'underfinanced' high-power direct broadcast competitor, EchoStar, will be difficult to discontinue."

Another One Bites the Dust....

Day & Date is dead. The daily hour-long afternoon newsmagazine which was syndicated by CBS-owned Eyemark Entertainment, was scheduled to pull the plug on production Dec. 3. Previously taped episodes of the show will air through Jan. 3, 1997.

ABC has announced that it will cancel the daytime soap *The City* on March 28 and replace it on June 2 with *GH2*, a new half-hour daytime drama, billed as a spinoff of ABC's *General Hospital*. The spinoff will "explore the entire town of fictional Port Charles, focusing on Port Charles University's Medical School, adjacent to General Hospital...where ideals clash with reality, where passion and ambition conflict with dreams and where goals are continually being redefined in the face of life-and-death situations." Where do they get this stuff...

Bryant Gumbel, who leaves NBC's *Today Show* in January, has been spotted with executives of rival network ABC. Rumor has it, says *New York* magazine that ABC has proposed an "edgy" talk show on Thursday nights for Gumbel. The talk show might be linked to Diane Sawyer's "flirtation" with CBS. If Sawyer left ABC, a source told the magazine, "Bryant would be a good guy for *PrimeTime*. He could even substitute for (Ted) Koppel." Gumbel's agent, Ed Hookstratten, said his client "does not and will not decide on anything before the first of the year."

Comedy Central and VH1 are out in many cities and a new nature channel is in as TCI rearranges its lineup for most subscribers. TCI said it was making the changes to strengthen its cable offerings. Also gone will be superstations WGN and WWOR (much to the chagrin of a lot of sports and movie fans). The Travel Channel and E! Entertainment Television will be eliminated in many areas. TBS and the Discovery Channel will be added to the basic service. Some cities will get the Sci-Fi Channel and others the History Channel because of channel availability and customer requests.

V-CHIP

Okay, okay, the TV programming writers have actual gotten together to get their V-Chip rating system put together (I admit it was sooner than I thought, but give me a break...are you really going to buy a new TV that locks out programs when your current TV works just fine?)

The *New York Daily News* reports that December 19 may mark the end to months of speculation about a television ratings system that would accompany the "V-chip." On the 19th, the television industry will release details of its new system by which producers and distributors will label shows based on their content. The system is the result of "V-chip" legislation, which urged the industry to develop a system that would work with the "V-chip" which must be installed in sets beginning in 1998.

If successful, the "V-chip," along with the ratings system, will assist parents in determining which shows are most suitable for their children's viewing. That's all well and good, but what some people seem to be forgetting is a key provision in the legislation: If the industry's "voluntary" system doesn't satisfy the Federal Communications Commission, the agency is authorized to come up with one of its own. Whether or not the system presented by the industry will be satisfactory remains to be seen. Read between the lines and you can see that I am not a big fan of more government intervention and regulation.

As reported in this column earlier, the industry's system is similar to that of the Motion Picture Association's system, which labels feature films. A recent report in the *Los Angeles Times* said the new system will rate shows as "G," "PG" or "PG" with an added age advisory. Shows with violent scenes and/or intense, "adult" situations may be rated "PG-17." In addition, ratings such as "PG-13" and "PG-9" would be implemented for shows like *Law & Order* which deal in mature themes but avoid violence, profanity, and nudity.

PROGRAMMING NOTES

The *Los Angeles Times* reports that Quentin Tarantino is in line to direct an episode of Fox's *The X-Files* that would air following the Super Bowl broadcast in January; however, his lack of Directors Guild of America membership could prevent him from doing so. Sources say the *Pulp Fiction* director is currently negotiating with the DGA for a waiver allowing him to direct *The X-Files* episode, and both sides hope to resolve the matter.

However, because the DGA granted Tarantino a similar waiver last year to direct an episode of *er*—and assumed that he would join the guild soon after—the DGA might be less permissive this time. Tarantino declined comment, but a spokeswoman said that he does plan to join the DGA at some point and is "not making a political statement" by delaying membership. A DGA spokesman declined to comment on the waiver, but said the guild looks forward to Tarantino joining its ranks.

International Note

INTELSAT and ENTEL have launched a new Ku-band satellite service which uses digital transmission technology to improve picture quality and signal strength to viewers in Chile.

ENTEL is leasing 36 MHz of capacity on the *INTELSAT 706* satellite at 307° East longitude. The network of the Catholic University of Chile and the Megavision network are the first Chilean broadcasters to use the service, with the signal being uplinked from the Longovilo earth station.

Chile is the first Latin American country to use Ku-band capacity for the distribution of TV programming from the main TV studio to distant transmitting sites (SMATV).

"Satellite transmission of broadcasting signals is uniquely adapted to Chile's geography," said Fernando Pavez, ENTEL Satellite Project Manager.

"We are pleased to offer this new high-quality, digital service to our customers and we anticipate that many other broadcasters and private network users will take advantage of this technology to further develop their business."

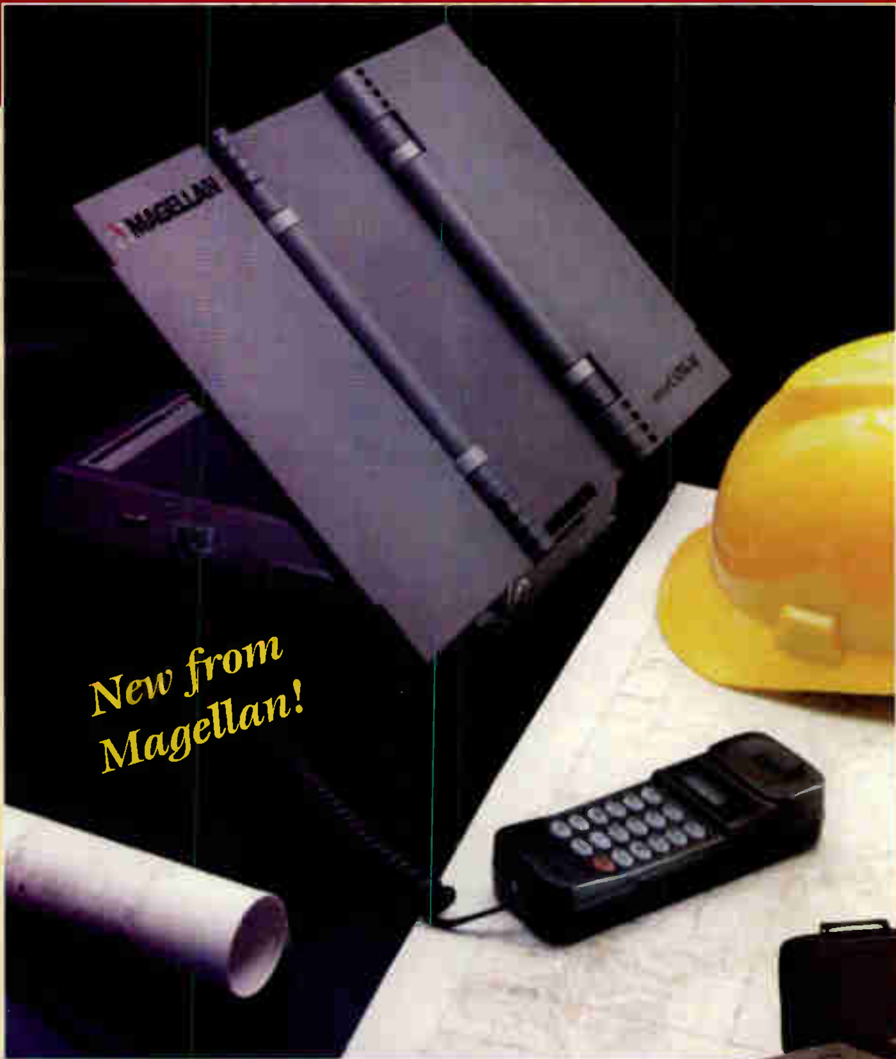
Can I get an Amen....

In a recent column I noted a new gospel music channel and admitted that I really wasn't sure what the difference was in different kinds of gospel music. I want to thank *Satellite Times* reader Mr. Paul Rawlings for enlightening me.

Mr. Rawlings wrote, "Gospel music has a great diversity. Bluegrass and country gospel music tend to focus on the instrumentation of the songs rather than the vocals and stick with familiar old songs. On the other hand is southern gospel music, not to be confused with what is sometimes called "black" gospel music. Southern gospel music focuses on the vocal arrangements; the smooth vocal harmonies of the male quartet style of the 30's, 40's and 50's is the backbone of this style of music."

Your comments are always welcome. The best way to get in touch with me is through the Internet at: **http://www.searcher.com/STcomments.html** ST

Telephone from Anywhere in the World, Via Satellite!



Ships complete with satellite telephone, handset with 7 feet of cable, 12 VDC power cable with cigarette lighter adaptor, soft carrying case, quick start guide, and user manual with compass.

Just imagine, this ultimate communications device, the world's smallest portable satellite telephone, allows you to communicate anywhere, anytime, via the powerful Inmarsat satellites. Just unfold the flat, side-panel antenna panels from this compact, lightweight radiotelephone, and guide it easily toward the closest satellite by watching the LED light bar.

IDEAL FOR DISASTER COMMUNICATIONS! When all other wire and radio communications circuits are down, your portable terminal can instantly summon and coordinate rescue and relief teams. From the arid desert to the bleak antarctic, from an Andean mountain peak to a life raft in the Pacific, worldwide telephone access is at your fingertips with the microCOM-M.

Whether voice or optional data or fax is required, the microCOM-M is the world's smallest, lightest, and lowest-priced Inmarsat telephone terminal, providing instant and reliable global telephone communications.

Crystal-clear primary or backup communications from remote outposts and field parties are assured for survivalists, contractors, paramilitary units, marine operations, missionaries, scientific expeditions, industrial explorations, fleet management, clandestine operations, emergency response teams, rescue operations, relief agencies—any application requiring reliable, failsafe communications on a moment's notice.

Measuring only 6.8" x 11.3" x 2.8"—just 1/8 cubic foot—and weighing in at a scant 5.5 pounds, the rugged microCOM-M is housed in a durable, impact-resistant, compolymer and diecast aluminum case. The potent 50 watt transmitter can be powered by 10-16 VDC with its cigarette lighter power cord, AC adaptor, or accessory battery pack. **Order PHN01, only $7999.95.**

We powered our test unit with the Grove PWR01 Portable Power Station (at right), only $59.95.

Bob Grove personally tested the Magellan MicroCOM-M at our Brasstown, N.C. offices recently. "This is a class act," he said. "Zeroing in on the Inmarsat satellite took only a few seconds using the LED light bar. And the connection was great. After traveling several thousand miles to the Inmarsat satellite and back to Earth again, the signal was loud and clear."

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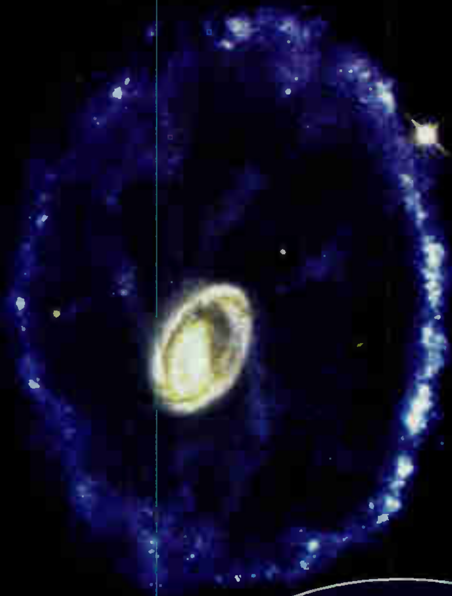
Best of Hubble: 1996 Picture Gallery

Hubble Space Telescope evokes a new sense of awe and wonder about the infinite richness of our universe in dramatic, unprecedented pictures of celestial objects. Like a traveler sharing their best snapshots, *ST* presents a selection of Hubble's most spectacular images for 1996. These images are courtesy of the Space Telescope Institute and NASA.

This colorful image from the Hubble shows the collision of two gases near a dying star. Astronomers have dubbed the tadpole-like objects in the upper right-hand corner "cometary knots" because their glowing heads and gossamer tails resemble comets. Although astronomers have seen gaseous knots through ground-based telescopes, they have never seen so many in a single nebula.

Hubble images reveal supersonic comet-like objects in heart of galaxy.

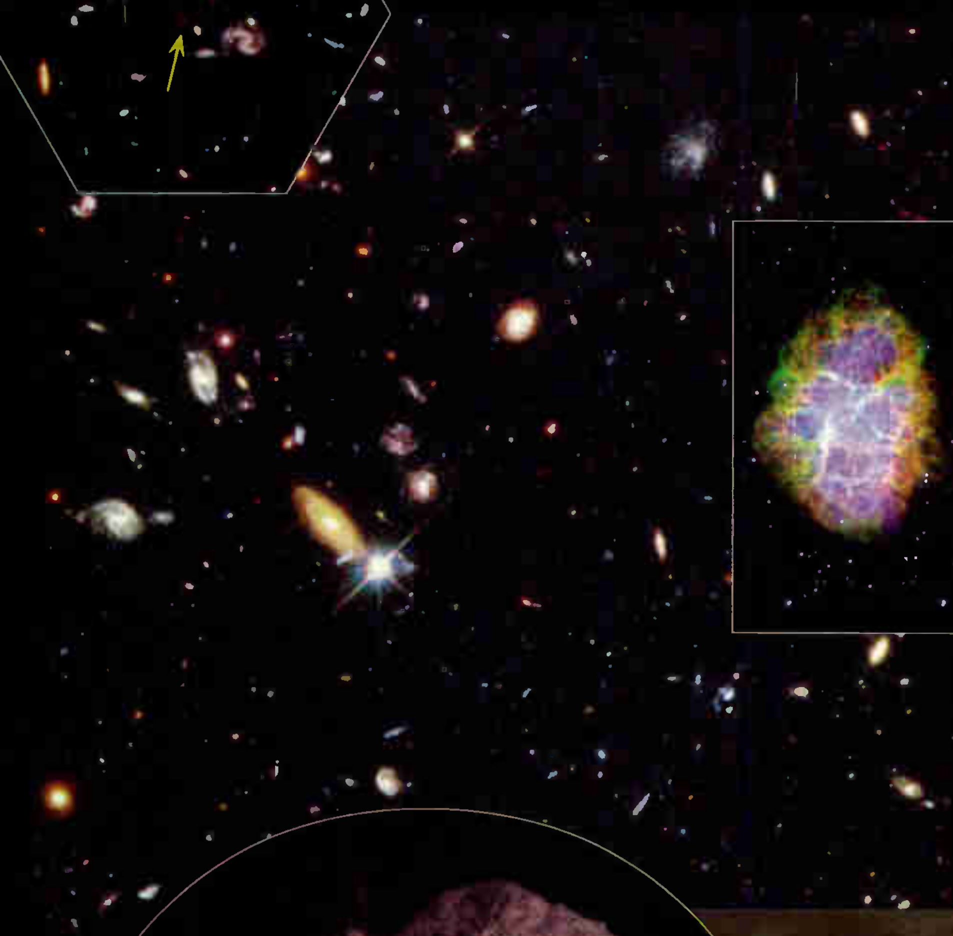


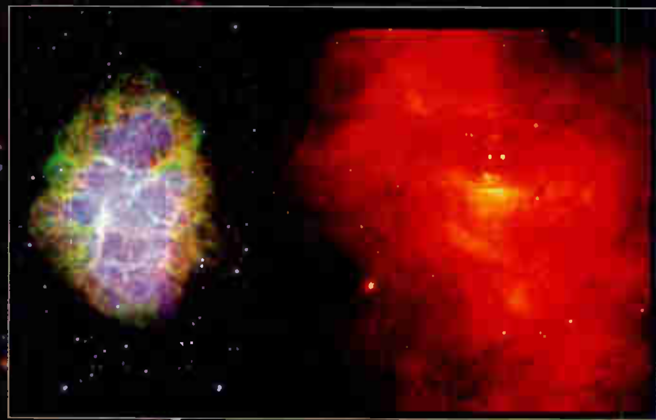
Left, this Hubble Telescope image reveals stellar death process (Planetary Nebula NGC 7027).

Below, Hubble detects searchlight beams and multiple arcs around a dying star (Egg Nebula (CRL 2688).

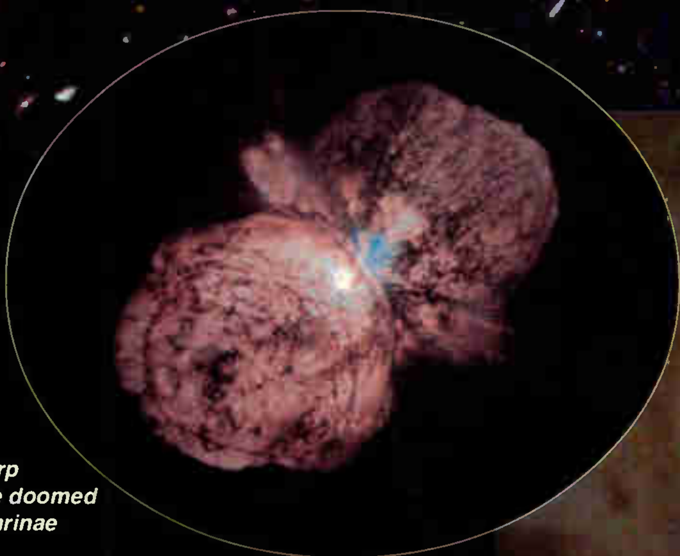
Hubble finds an hourglass nebula around a dying star.

Below, Hubble's deepest-ever view of the universe unveils myriad galaxies back to the beginning of time. Inset at left shows a small portion of the Hubble deep field image. Arrow points to a very faint galaxy that appears to be more distant than any known previously. Other galaxies in the image are at smaller distances.





Hubble captures dynamics of Crab Nebula (right). The photo at left is a ground-based telescope image from Mount Palomar.



Super-sharp view of the doomed star Eta Carinae

The Hubble Space Telescope has snapped this view of several star generations in the central region of the Whirlpool Galaxy (M51), a spiral region 23 million light-years from Earth in the constellation Canes Venatici (the Hunting Dogs).

Namibia Sand Dunes

By Larry Van Horn

This spaceborne radar image shows part of the vast Namibia Sand Sea on the west coast of southern Africa, just northeast of the city of Luderitz, Namibia.

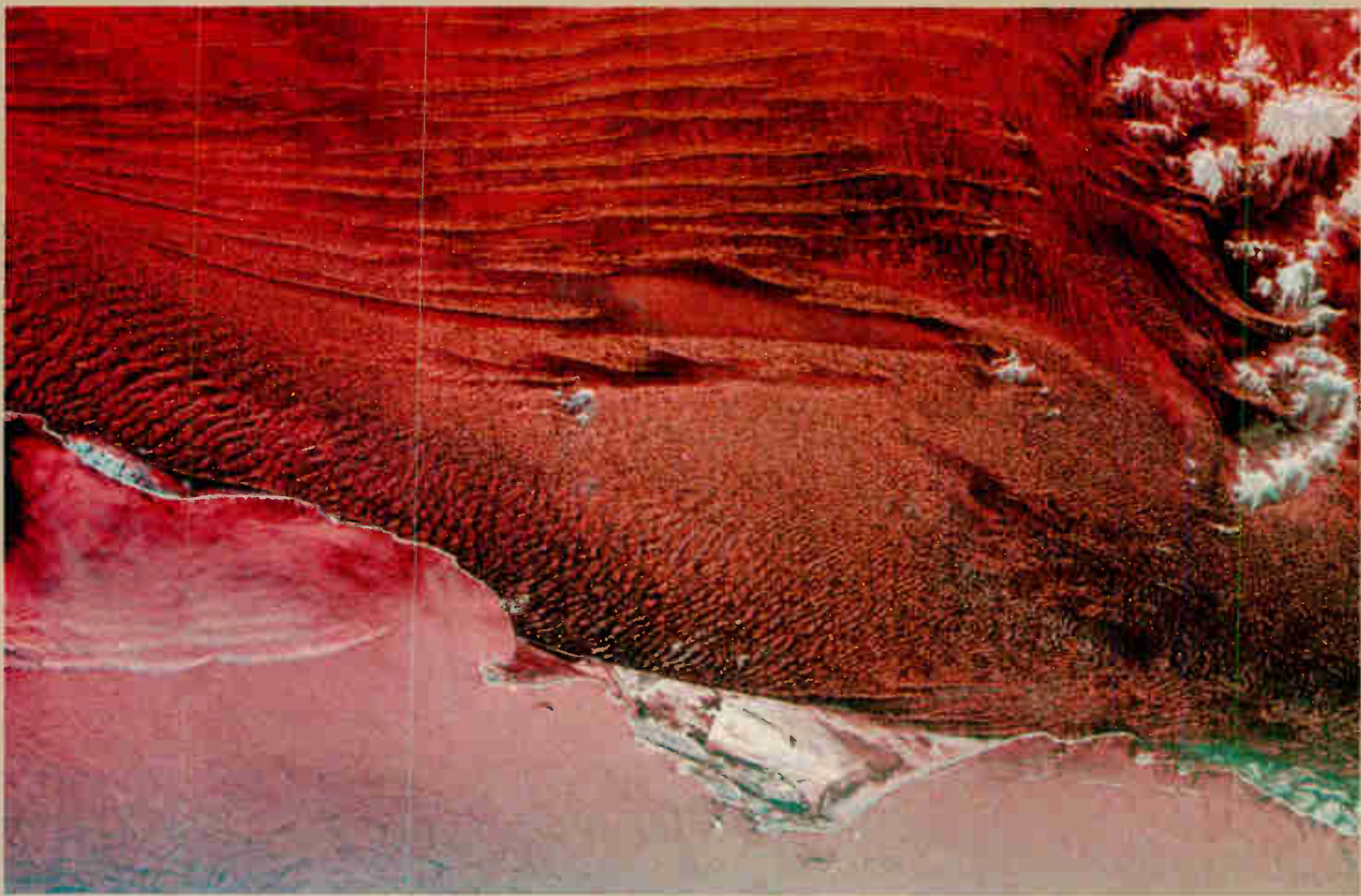
The magenta areas in the image are fields of sand dunes, and the orange area along the bottom of the image is the surface of the South Atlantic Ocean. The region receives only a few centimeters (inches) of rain per year. In most radar images, sandy areas appear dark due to their smooth texture, but in this area the sand is organized into steep dunes, causing bright radar reflections off the dune "faces." This effect is especially pronounced in the lower center of the image, where many glints of bright radar reflections are seen.

Radar images of this hyper-arid region have been used to image sub-surface features, such as abandoned stream courses. The bright green features in the upper right are rocky hills poking through the sand sea. The peninsula in the lower center, near Hottentott Bay, is Diaz Point; Elizabeth Point is south of Diaz Point.

This image was acquired by Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR) onboard the space shuttle *Endeavour* on April 11, 1994. The image is 54.2 kilometers by 82.2 kilometers (33.6 miles by 51.0 miles) and is centered at 26.2 degrees South latitude, 15.1 degrees East longitude. North is toward the upper left.

The colors are assigned to different radar frequencies and polarizations of the radar as follows: red is L-band, horizontally transmitted and received; green is L-band, horizontally transmitted, vertically received; and blue is C-band, horizontally transmitted, horizontally received.

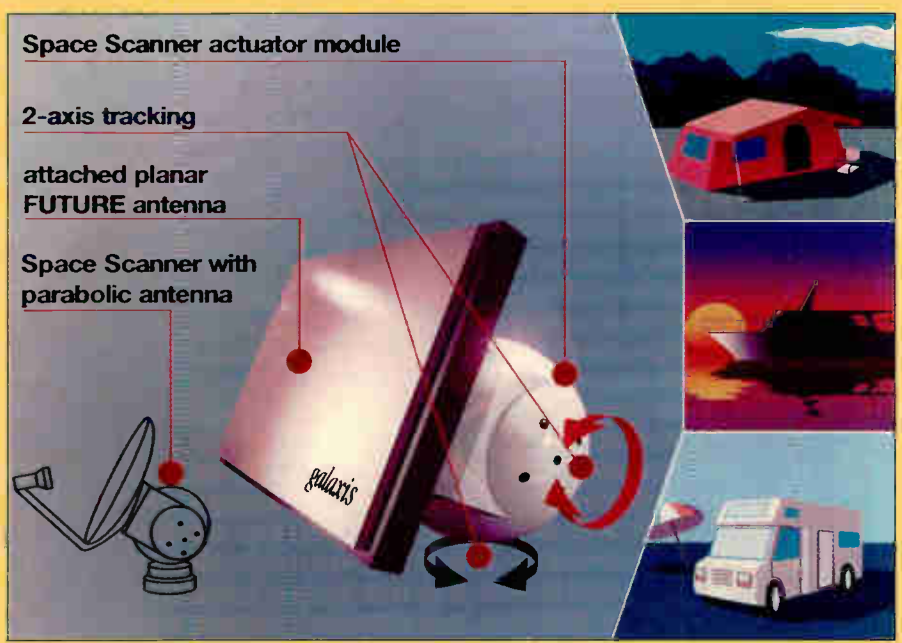
The radars illuminate Earth with microwaves allowing detailed observations at any time, regardless of weather or sunlight conditions. SIR-C/X-SAR uses three microwave wavelengths: L-band (24 cm), C-band (6 cm) and X-band (3 cm). The multi-frequency data is used by the international scientific community to better understand the global environment and how it is changing. SIR-C/X-SAR, a joint mission of the German, Italian, and United States space agencies, is part of NASA's Mission to Planet Earth.



What's New

by Wayne Mishler, KG5BI
email: mishler@ipa.net

Smallest Satellite Antenna?



And you thought the 18-inch dish was small. The galaxis (spelled in lower case) company would like you to take a look at their new antenna. It measures 15-1/2 x 8-/2 x 1-1/2 inches. Yet it pulls in over 100 analog and digital television and radio stations with maximum reception performance, says its creators.

As antennas go, smaller is bigger.

The new galaxis Future 1 Planar Satellite Antenna, which the manufacture says is the smallest in the world (we've heard of none smaller), was unveiled at a press demonstration and luncheon in Manhattan on October 8. It promises to simplify and enhance satellite and microwave reception for millions of consumers. The weatherproof design makes it ideal for both home and mobile installations including recreational vehicles and boats.

The Future 1 is the first in a family of new products designed by galaxis to compete in the growing demand for direct satellite delivery systems. That demand is expected to grow from 5 to 15 million units by the turn of the century. Other galaxis products in the new family will include a converter that can receive signals from two or more orbital positions and a two-way, bi-directional antenna that can support local loop networks.

"We're working on distribution agreements and manufacturing partnerships to ensure that we can deliver the highest quality technology at the most economic price levels to really move satellite communications into the 21st century," says Jim Clingham, galaxis senior vice president.

The galaxis USA Ltd. firm is a subsidiary of European-based galaxis Holding GmbH, Lubeck, Germany, which develops, manufactures, and markets innovative solutions in satellite reception and communication. Their 1997 sales are expected to exceed $500 million worldwide.

For more information on the Future 1 you can call Scott Treibitz or Madelyn Smith at galaxis USA ltd., telephone 703-276-2772.

TV Antennas for Jetliners, Baseball at 30,000 Feet

There is a new type of antenna on the horizon that you probably won't rush out and buy. It will cost upwards of $50,000. But you may be using one sooner than you think, if you fly on passenger jets.

Several companies are developing versions of this new antenna system which will allow high speed vehicles such as aircraft to lock onto satellite signals. Hughes and Datron, working in a partnership, have already installed such a system on the Delta 767 *Spirit of Delta* airliner.

"Passengers love it," says a spokesperson for Hughes. They were treated to coverage of the 1996 World Series between the Atlanta Braves and New York Yankees, delivered by DirecTELEVISION as an in-flight service aboard the Spirit. DirecTELEVISION has been providing live digital broadcast television to that aircraft since August. Other airborne programming available to *Spirit of Delta* passengers includes CNN, Headline News, Discovery Channel, and CNBC.

More companies, including Boeing, In-Flight Phone Corp., and Harris Corp., are expected to follow suit in the next few months. Currently there are plans to install the systems on 300 Continental Airlines next summer. Delta and Continental are considering a merge, which may affect the deal.

But sooner, rather than later, you can expect to see a screen and a telephone at every seat aboard all airliners, enabling you to watch your favorite satellite television programs while airborne. But be prepared to pay $5 or so for the service. Those antennas don't come cheap.

Gateway 2000 Offers Free Satellite System

Planning to buy computer? You might want to take a close look at Gateway 2000. At press time they were offering a free EchoStar DISH Network digital satellite system with the purchase of certain computer models and convergence PC-television sets.

For a limited time, when you buy a qualifying package from Gateway, you will receive a coupon for a free DISH Network system with the purchase of a one-year subscription to America's Top 40 programming package which sells for $300.

The satellite system includes a state-of-the-art fully MPEG-2/DVB compliant digital receiver, an 18-inch satellite dish, and an infrared remote control.

The plan targets customers interested in accessing digital entertainment via their PC computers. "This is a win-win situation for EchoStar, Gateway, and, most of all, consumers who gain exceptional value from our programming, hardware and accessories," says Carl Vogel, president of EchoStar.

For details telephone 800-Gateway.

Sports Fans: Watch for ESPNEWS

ESPN, Inc., will soon debut its ESPNEWS 24-hour sports news service via the Hughes Communications, Inc., Galaxy 9 satellite, transponder 21. The service will be transferred to Galaxy 10 when that satellite is launched in 1998. This will give ESPNEWS a long-term home in the nation's newest cable community located at 123 degrees West longitude.

"With ESPNEWS on our Galaxy 9 satellite, more than 14,000 cable head-ends in the United States can easily find top sports news from the worldwide leader in sports," says Carl Brown, senior vice president of Galaxy Satellite Services.

ESPNEWS™ NETWORK FROM THE WORLDWIDE LEADER IN SPORTS

L. Patrick Mellon, ESPN senior vice president, predicts the new service will become one of the fastest growing cable networks launched in the 1990s.

Golf Channel Expands to Asian Viewers

The PanAmSat Corporation says The Golf Channel is now being distributed in the Asia-Pacific region via the PAS-2 satellite.

"Demand for The Golf Channel has grown exponentially since it began broadcasting in the United States less than two years ago, and we share the belief that the channel will be particularly popular in Japan," says David Berman, senior vice president of PanAmSat.

"Digital technology and our unparalleled satellite and teleport facilities allowed us to help the channel reach the eager Asia market and become an international player virtually overnight," he adds.

The Golf Channel is transmitted in digital form via the PAS-2 C-band Pacific Rim Beam, which provides extensive coverage of Asia. The service is being transmitted from PanAmSat's temporary earth station in Sylmar, Calif. In December, digital transmission was to have been transferred to the firm's newly constructed Pacific Ocean Region teleport in Napa, Calif.

Featuring Arnold Palmer, The Golf Channel began broadcasting in the U.S. in January 1995. It offers a variety of golf-related programming including how-to programs, interviews, and extensive tournament coverage.

Andrew Corporation Announces Product Line

The Andrew Corporation, an S&P 500 company supplying communications equipment and services from its base in Orland Park, Ill., offers a variety of products for PCS operators.

Their new TA1915 Tower Top System includes both a tower top amplifier and ground unit which adds a 15 decibel boost to low power and distant PCS signals. A full PCS bandpass filter eliminates signals outside the band before sending them to the base station.

The company's ACCESS 1700 series fiber optic fed, bi-directional amplifier for PCS systems enables operators to centralize base-station equipment and use less fiber optic microcells to distribute RF signals.

A new cable tap makes it fast and easy to extend the coverage of in-house RF systems. The taps can be installed anywhere along the length of a main feeder cable. This increases coverage without the need for expensive power dividers or directional couplers.

Numerous other amplifiers, connectors, and PCS accessories are available in the Andrew product line. For more information on what the company offers you can contact their customer support center at 800-255-1479.

Flight & Space Family Magazine Debuts

A new general interest family publication, entitle *Flight & Space*, edited specifically for middle school students, parents and teachers will be distributed to students at the beginning of the 1997 school year.

The magazine is being published by Don Fink, the former editor-in-chief of *Aviation Week and Space Technology*. "Aerospace activities represent a powerful and inspirational force that appeals to young and old alike," he says. "With *Flight & Space* we've designed an editorial product that will stimulate interest in math, science and physics among middle school youngsters. It will help parents and teachers mentor their children's learning process. The magazine's mission is to offer real life learning experiences that will show young readers how these disciplines relate to their daily lives and what prospects they offer for the future."

The magazine is being sponsored by Rockwell Aerospace and Defense. "We decided to support *Flight & Space* because their efforts are focused on the kind of broad visionary goals that we have long supported as a corporation," says John McLuckey, president and CEO of Rockwell.

By spelling out "high-tech" concepts in layman's terms, *Flight & Space* plans to fill an information void for young and adult readers, and inspire next generation aerospace pioneers.

Flight & Space has joined with the 4H organization, the Air Force Association's Aerospace Education Foundation, the Civil Air Patrol, the Experimental Aircraft Association, and space oriented groups including the Challenger Center and Young Astronauts. The magazine will be a part of the coordinated program these groups are forming to foster interest in aviation and space. ST

FINAL FRONTIER

By Philip Chien

STS-82: the *Hubble* Servicing Mission—Take 2

When the *Hubble* Space Telescope was approved by Congress in 1974, it was with the understanding that the spacecraft would have to be serviced by the space shuttle. This limited the spacecraft to a relatively low orbit which could be reached by the shuttle on a rendezvous mission.

Hubble excels as a technology tool. With over 600 hours of spacewalks necessary to assemble the International Space Station, *Hubble* is an excellent real-world training tool where astronauts and flight controllers can develop the skills they will need to assemble space station. During the first *Hubble* servicing mission (STS-61), astronauts spent over 71 person-hours on five EVAs replacing *Hubble*'s components.

Surprising many outsiders—but not those who knew the shuttle program and how well the crew was trained—the first service mission followed the flight plan almost perfectly. One of *Hubble*'s old solar arrays had to be tossed overboard, following the exact procedure which the astronauts had trained for in their simulations. In the end, the successful mission seemed almost anti-climactic.

For the past three years astounding images from *Hubble*'s repaired optics have stunned the world, making magazine covers and the evening news. Project Scientist Ed Weiler put it best, "Twenty years from now spherical aberration will just be a minor footnote in *Hubble*'s long and distinguished career."

This time around, the pressure isn't on the STS-82 mission, unless something goes wrong. NASA's already proven that astronauts can repair *Hubble* in orbit without damaging it. Now the object is to service it and improve *Hubble*'s capabilities.

Two new, second-generation science instruments—the near infrared camera and multiobject spectrometer (NICMOS) and the space telescope imaging spectrograph (STIS)—were officially approved in 1984, well before *Hubble* was even launched. They had been planned for installation on the 1993 servicing mission, but got delayed three years due to the spherical aberration. In addition, most of the budget for the corrections to *Hubble*'s optics were taken out of the funding for these instruments, reducing their capabilities.

NICMOS extends *Hubble*'s capabilities into the infrared wavelengths. *Hubble* was designed primarily as an ultraviolet telescope, with some instruments also observing visible light. There have been a couple of previous infrared space observatories, most notably the *Infrared Astronomy Satellite* (IRAS), *Cosmic Background Explorer* (COBE), and *Infrared Space Observatory* (ISO). Infrared instruments have to be cooled to cryogenic temperatures so they're limited by the amount of liquid helium which can be carried. NICMOS's primary advantage over previous infrared spacecraft is resolution. *Hubble*'s extremely large mirror permits more photons to be collected, permitting dimmer objects to be viewed than as possible by previous spacecraft.

However, NICMOS is cooled by a dewar filled with solid nitrogen at 58 degrees Kelvin (-355 F). NICMOS operates at a higher temperature than previous infrared telescopes in space, which will limit some types of observations. 100 kilograms of solid nitrogen are carried in NICMOS's dewar, enough for about three years of observations. It's conceivable that NASA may decide to develop an on-orbit 'refueling' system which can reload NICMOS with a new load of nitrogen on a future *Hubble* servicing mission.

STIS is the first imaging spectrograph in space. Spectrographs use prisms or gratings to spread light into rainbows. Most spectrographs consist of one row of detectors, similar to the scanner in a fax machine which reads a page one line at a time. Dark or bright lines in the spectra indicate the presence of elements within the light source, or between the light source and observer.

While cameras take pretty pictures, spectrographs can provide much more useful numerical science, determining the chemical makeup of a star, or measuring its rotation, or the speed it's moving relative to the Earth.

Unlike conventional spectrographs like *Hubble*'s existing faint object spectrograph (FOS) and Goddard high resolution spectrograph (GHRS), the STIS has a two dimension detector, like the CCD chip in a home camcorder or digital camera. It can view an entire galaxy at once—showing how the chemical composition varies from the core to the outer regions. Investigations which take many separate observations with *Hubble*'s existing spectrographs can be done in a single STIS observation.

In addition to the two science instruments, seven secondary tasks are scheduled for the four planned STS-82 EVAs.

Hubble has three fine guidance sensors (FGS). Two need to be replaced, but NASA only has one spare available. The FGS are used to aim *Hubble* precisely on target, and at least two must be operating properly to perform science.

Ground controllers are fairly certain that at least one of the two sick FGS will fail before the next *Hubble* servicing mission in 1999, so they're anxious to replace the FGS which is more likely to fail. The failed unit will be returned to Earth to be repaired and refurbished, and will almost certainly be flown up to *Hubble* on the 1999 servicing mission.

Hubble has three engineering and science tape recorders (ESTR). These are 1970s technology mechanical data recorders and prone to failure. ESTR #1 will be replaced with a new solid state recorder (SSR). The SSR can store 12 gigabits of information in its 36 memory modules—ten times the capacity of the existing ESTR.

In addition, ESTR #2 will be replaced with a ground spare unit. ESTR #3 remains in good operating condition.

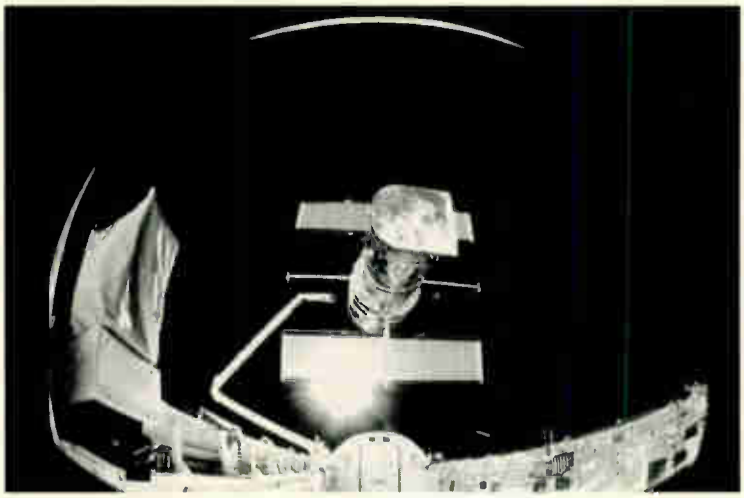
During the first servicing mission something extremely strange happened. Ground controllers got some strange readings which seemed at first glance to indicate that *Hubble* was no longer attached to the shuttle. They asked the astronauts to take a peak out of the window, just to verify that *Hubble* was still there!

It turned out that one of the data interface units (DIU#2) was fried when power was applied directly to the A side. It was switched to the alternate B side and has been functioning for the past three years.

Initially it was felt that it wouldn't be a problem, since most of the telemetry channels could be monitored through software. But it turns out that there are 60 to 80 lost telemetry channels which can't be supported by the malfunctioned "A" side if the "B" side were ever to fail. The replacement unit has the proper buffering circuits to prevent another accidental over voltage.

The optical control electronics enhancement (OCE) is a simple electronics box which will enhance the performance of the fine guidance sensors.

During the first servicing mission the astronauts noticed some loose insulation around the magnetic sensing system units which they installed. So ground controllers improvised and came up with a method of manufacturing a cover for the loose insulation in space.



The spacewalkers were asked to tear off a piece of spare Kapton insulation and bring it into the crew cabin. Pilot Ken Bowersox was faxed instructions on how to cut the Kapton into the proper shape to make a cover for the MSS insulation. He commented that the best training he had for building the MSS covers was *Cut and Paste* class in kindergarten! Well, cut and paste class, an excellent career in the Navy, and three other shuttle missions gave him the experience he needed to be assigned as the commander of the STS-82 *Hubble* repair mission.

The other members of the STS-82 mission will include pilot Scott Horowitz who previously flew on the STS-75 mission, flight engineer Steve Hawley, who previously flew on the 41-D, 61-C, and STS-31 missions and returned to active astronaut status after many years in management, and spacewalkers Mark Lee (STS-30, STS-47, STS-64), Greg Harbaugh (STS-39, STS-54, STS-71), Steve Smith (STS-68), and Joe Tanner (STS-66). Lee and Harbaugh have EVA experience earlier spaceflights; Smith and Tanner will be making spacewalks for the first time.

Originally Mark Lee had been scheduled to fly on the first *Hubble* servicing mission as a spacewalker, but was rejected by NASA headquarters due to his lack of EVA experience. So he was assigned to the STS-64 mission where he got EVA experience by testing out the experimental SAFER (simplified aid for EVA rescue) jet backpack: he was subsequently assigned as the payload commander for the STS-82 mission. Steve Hawley's most recent spaceflight, STS-31 in 1990, was the mission which launched *Hubble* in to orbit.

NASA's minimum success criteria for the STS-82 mission is to install at least one of the two new science instruments, replace the fine guidance sensor, and install the solid state recorder. So the priority order for the servicing mission is NICMOS, FGS, SSR, STIS, DIU#2, ESTR#2, OCE, SADE#2, and MSS. NICMOS gets higher priority than STIS because it expands *Hubble*'s capabilities into a new wavelength region.

Just in case, *Discovery* is also carrying a spare reaction wheel assembly and gyroscope, even though there are now current plans to replace them. And like any good repairman, the *Hubble* crew will have spare fuses and an extremely comprehensive tool kit.

In some ways the STS-82 mission will be more difficult than STS-61. Engineers don't want to retract the solar arrays to minimize the chance for damage. So the astronauts will have to work around the arrays, and whenever *Hubble* needs to be rotated on its lazy-susan turntable it will have to be tilted forward to give additional clearance between the arrays and the shuttle's tail.

A reboost to raise *Hubble*'s orbit by 5 to 8 kilometers is desirable if possible. Since the solar arrays will be open they'll tend to shake during the reboost, and NASA has experimented with how to do the reboost in as gentle a manner as possible. The plan is to use the shuttle's smallest, lowest power thrusters to gently rock the shuttle back and forth—similar to rocking a large refrigerator back and forth to move it. In terms of fuel it's an extremely inefficient way of increasing a spacecraft's altitude, but it's expected to be the gentlest on the arrays.

If things go well on the servicing mission, *Hubble* will return to science gathering within a week or so after the servicing's completed. The existing instruments will continue their scientific programs while the new instruments are calibrated and adjusted. NASA is hoping that the first scientific results from the new science instruments will become available within five to six months after the STS-82 servicing mission. ST

Jeff Lichtman

Arecibo Upgrade (Part 1)

At the July 1996 meeting of the Society of Amateur Radio Astronomers at NRAO, we had the pleasure hearing from the director of the famous Arecibo Radio Observatory, Dr Paul F. Goldsmith. Dr. Goldsmith also heads the National Astronomy and Ionospheric Center based at Cornell University.

Dr. Goldsmith touched on the history of the Arecibo observatory and its recent upgrade. In this two part article, I would like to tell our readers a bit about this world famous antenna. I will be using information generated by Dr Goldsmith and the Cornell staff.

For more than 30 years, the 305 meter diameter radio telescope at the Arecibo Observatory has been a very unique observational tool. The facilities and equipment have been used for studying the atmosphere, distant galaxies, radio and radar astronomy, asteroids, and even beaming a signal towards M13 (Galaxy in the constellation of Leo). The antenna has some special features, such as possessing the largest collecting area and the highest sensitivity of any present radio telescope facility.

Researchers at the Arecibo facility have been hampered by the necessity of using line feeds to properly illuminate the spherical aperture of the antenna. While effective at low frequencies, a line feed offers only a narrow bandwidth at an essentially fixed frequency. Observations have thus been restricted to very narrow frequency bands at a few specific frequencies between approximately 100 and 2400 MHz. A combination of factors is now permitting a major enhancement of the facility's capabilities. The new ingredients include a much improved capability for numerical analysis and optimization of reflector antenna systems, advances in structural engineering, and computer control of complex systems. With these new capabilities, an all reflective corrector system has been developed for the Arecibo Telescope, which will allow observations with significantly enhanced sensitivity over the frequency range from 300 MHz to at least 10 GHz.

Historical Background

Originally the telescope was developed to study the Earth's ionosphere. Professor William Gordon of the School of Electrical Engineering at Cornell envisioned using a radar reflection to measure the density of electrons, as well as other properties of the atmosphere between 100 and 1,000 kilometers above the Earth's surface. This technique, called incoherent radar scatter radar (ISR), was proposed by Gordon in the late 1950's, when there was very little data on this part of the Earth's surroundings.

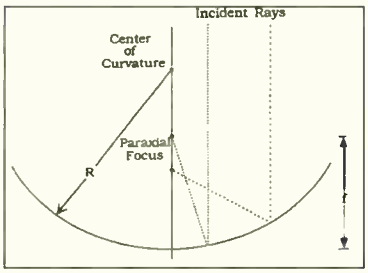


Figure 1. Schematic of Rays

His initial calculations suggested a very large antenna would be required for ISR, and a nominal diameter 305 m (1000 feet) was agreed upon. In discussion with federal agencies, in particular the newly formed ARPA (Advanced Research Project Agency), the suggestion was made that the antenna should be steerable that is, be able to point to different directions of the sky rather than simply looking vertically, which at that time was thought to be all that was required for research in atmospheric physics.

While attractive in principle, this might seem to pose an unmanageable technical problem, since the pointing of a 1000 foot diameter antenna in various directions is hardly a simple task. The technique suggested was to make a spherical primary reflector, rather than a parabolic reflector, as would normally have been used. The great advantage of a spherical reflector is that it has no preferred direction, so it can be steered by moving the feed only. A spherical antenna also has a major drawback, in that instead of focusing incident radiation to a point, it brings it to a focal line.

Coincidence would have it that ARPA had been funding engineers to study both how to use spherical antennas and the concept of the line feed that had been developed. It was suggested to Gordon that by making the Arecibo antenna a steerable spherical system rather than a fixed pointing parabolic system, it would not only be more useful for atmospheric science, but could also play an important role in radio astronomy. This far-reaching concept certainly was one of the key factors that has contributed to Arecibo's remaining a productive scientific facility for over three decades.

Understanding line feeds is critical to the appreciation of the success of Arecibo, as well as the motivation for the upgrade presently underway.

Figure 1 shows a diagram of rays from a distant source which has been reflected by the spherical surface of the primary reflector and the approaching focal region. As is well known to amateur telescope makers (among others), rays that have passed not too far from the center of curvature of a sphere are brought to a focus at a distance equal to half the sphere's radius, called the paraxial focus. Rays passing further from the center of the curvature do not come to a focus at this same point, but cross the axis closer to the surface of the sphere. This is a geometrical property of a spherical mirror, and is independent of wavelength.

The 305 meter diameter primary reflector of the Arecibo telescope has a radius of curvature of R=265 meters, and its paraxial focus is located 132.5 meters (435 feet) from the surface of the antenna. The inability to focus all the rays to a point is called spherical aberration, which is sometimes a nuisance for optical telescope makers (such as Hubble before the repair). For the Arecibo telescope, rays striking the edge of the primary reflector cross the focal line approximately 29 meters (96 feet) below the paraxial focus. Thus, what one must do to illuminate efficiently the entire antenna, is to provide a means of collecting radiation along a line this almost 30 meters long.

We can use the reciprocity principle to consider how a line feed and the spherical Arecibo primary work together as a transmitting system. This is more than a convenience, since the telescope is regularly used in exactly this fashion.

In the transmit mode, the feed has to illuminate each part of the primary reflector with amplitude and phase such that after reflection from the spherical primary, a plane wave in the aperture plane of the antenna is produced. The inner part of the antenna is illuminated by the energy radiated from the top of the line feed, while radiation from near the tip of the feed illuminates the outer part of the antenna. In order to achieve the required phase distribution across the aperture plane, the phase velocity in the line feed must increase from the top to the bottom.

For a full length Arecibo feed, the phase velocity is approximately three time the speed of light at the tip of the feed. This variation is accomplished by having the line feed be a sequence of sections of waveguide with gradually reduced dimensions. The propagation of a wave in a metallic guide has a characteristic cutoff frequency, f_c, below which propagation is not possible. As the frequency approaches the cutoff frequency in the propagating range, (i.e., frequency just greater than f_c) the phase velocity increases above its value in free space, the speed of light. By arranging the taper of the line feed size, the phase velocity of the propagating wave, and thus its phase shift, can be controlled. Rays which travel a certain distance down the feed, then to the reflector, and finally to the aperture plane, end up in phase as desired.

The design of the line feed is complicated by the need to control the amount of energy radiated at each position along it. Radiation occurs through apertures cut in the waveguide wall. In practice, the amount of radiation depends on the aperture size, but the apertures themselves in turn affect the phase velocity of the wave. Thus, the final design of the line feeds is an elaborate and tricky business.

Line feeds have been built and operate satisfactorily up to 2.4 GHz, but only the one at 430 MHz frequency is a full length line feed which illuminates the entire aperture of the antenna. This feed achieves the maximum gain when pointing at the zenith, but suffers from vignetting due to the fact that as the feed is moved from pointing at the zenith, part of the illuminating pattern spills over past the edge of the primary reflector. The gain of the antenna thus varies significantly with angle from zenith. At higher frequencies, shorter feeds (typically 13 m long) have been used, which illuminate the central 214 meters (700 feet) of the primary antenna.

Line feeds suffer the severe drawback of very restricted bandwidth. The origin of the problem is the dispersive nature of the propagation in the waveguide, which results in the radiation from the feed no longer having the desired phase outside of a relatively narrow frequency range. The useful bandwidth of a full length Arecibo line feed is approximately 10 MHz, while shorter feeds have approximately 45 MHz bandwidth. Over the years, a fairly large number of line feeds have been constructed, but it's obvious that to exploit fully the several gigahertz bandwidth of the antenna, an unreasonably large number of feeds would be needed, since each has a fixed center frequency.

The beam direction of the antenna is varied by moving the line feed along a circular arc centered on the center of the curvature of the primary reflector. The arc has a radius of curvature equal to the 132.5 meters paraxial focal length. On the Arecibo telescope, this arc is defined by an elevation track, which covers angles up to 20 degrees away from the zenith. The elevation track is located on the bottom of an arm which rotates in azimuth. The arm is held by a system of trolleys which run on a zenith rail. There is also a bearing at the center of the azimuth track which provides lateral location. The entire steerable feed section, including the arm and tracks, is supported on a large triangular platform, which in turn is suspended by cables from three concrete towers located around the perimeter of the primary reflector, as shown in figure 2.

Figure 2. View of Arecibo

Moving the feed does give the Arecibo antenna the ability to point in any direction within 20 degrees of the zenith. This is, however, somewhat limited for radio astronomical studies. It was one of the factors leading to the siting of the telescope in Puerto Rico, which is at a relatively low latitude of 18 degrees. By putting the telescope there, a relatively large fraction of the sky can be seen even with a limited pointing range. In particular, the plane of the elliptic, in which the sun and the planets orbit, is readily accessible by Arecibo.

From the early days of the observatory, it was anticipated that radar studies of objects in the solar system would be of interest, and this held true. Another factor was the terrain found in Puerto Rico, where a large limestone sinkhole provided a natural starting point for construction of the 305 meter reflector.

The antenna's location is approximately 15 km south of the city of Arecibo, Puerto Rico. Construction of the site began in 1960. The project was managed by Cornell University under contract with the Air Force Cambridge Research Laboratory and was funded by ARPA. Despite the advantage afforded by a natural sinkhole of karst terrain, some 200,000 cubic meters of soil had to be excavated, and approximately 160,000 cubic meters of compacted fill was used to shape the spherical cavity.

The original antenna surface consisted of a half inch square mesh suspended on steel cables in a rectangular grid. The first line feed was installed in August 1993. One of the earliest significant scientific accomplishments of the observatory was the determination of the rotation rate of the planet Mercury, which turned out to be 59 days rather than the previously thought 88 days. This work published in 1965 was the first of Arecibo's many scientific contributions.

In the next part of this article, we will be talking about astronomy research at Arecibo and the upgrade in progress.

If any of you are planning to vacation in Puerto Rico, a side trip to Arecibo promises something you won't forget; just the size alone is overwhelming. ST

World Radio Network Schedules

WRN 2- N. American Multi-lingual Service

Galaxy Five (125 deg West) transponder 6-3.820 GHz (TBS) vertical polarization, audio subcarrier 6.2 MHz. Please note that programs listed below with an asterisk (*) are subject to pre-emption without notice. All times Eastern (UTC +5 hours)

0030 - *WRN Announcements, until....
0255 - *YLE, Church Service (Sunday only)
0400 - *WRN Announcements, until....
0600 - [YLE Radio Finland], News in Finnish
0625 - YLE, News in Swedish
0630 - YLE, News in English
0700 - *WRN Announcements, until....
0800 - RTE News in Irish
0900 - Radio Prague in Czech
0927 - *WRN Announcements, until....
1000 - YLE, Radio Finland, News in Finnish
1005 - YLE, Regional News
1030 - YLE, News in Finnish
1100 - YLE, News in Swedish
1130 - YLE, Easy Listening Music and Chat in Finnish
1200 - *Vatican Radio, news in French, English, Albanian, Slovene, Croatian, Hungarian, Czech, and Slovak
1400 - *WRN Announcements, until....
1500 - *Radio Vlaanderen International in Dutch
1530 - *Radio Netherlands in Dutch
1625 - *WRN Announcements, until....
1645 - *YLE, News in French
1700 - *Polish Radio Warsaw in Polish
1800 - Radio Budapest in Hungarian
1830 - YLE Radio Finland, Devotional Music
1855 - YLE, News in Swedish
1900 - YLE, News in Finnish
1930 - YLE, Easy Listening Music and Chat in Finnish
2010 - YLE, Current Affairs in Finnish
2030 - YLE, Documentaries in Finnish
2030 - YLE, New Classical releases in Finnish (Sun)
2130 - YLE, Easy Listening Music in Finnish
2230 - YLE, News in Finnish
2300 - YLE, News in Finnish
2310 - YLE, Devotional Programming in Finnish
2320 - YLE, News in Swedish
2323 - YLE, Programme Information in Finnish
2330 - ORF Radio Austria International in German

WRN1- European English Service

Astra 1B (19 deg East) transponder 22-11.538 GHz (VH-1) vertical polarization, audio subcarrier 7.38 MHz.
WRN is also available on cable and local radio stations. WRN program information can be heard daily at 0125 and 1025 BST. It is also available on VH-1 text pages 222, 223, 224. All times UTC (Central European Time +1 hour)

0000 - Radio Budapest
0030 - Radio Netherlands
0127 - *Earth and Sky* (Daily Science Series)
0130 - ORF Radio Austria International
0200 - NPR *All Things Considered* (repeat)
0300 - CBC *As It Happens* (Tue-Sat)
RCI News, and Features (Sun and Mon)
0400 - Polish Radio Warsaw
0430 - *BBC Europe Today* (Mon-Fri)
Glenn Hauser's *World of Radio* (Sat)
UN Radio From New York (Sun)
0500 - PRI *Market Place* (Tue-Sat)
Radio Romania International (Sun)
SABC Channel Africa-Johannesburg (Mon)
0530 - YLE Radio Finland
0600 - Voice of America World Wide (Mon-Fri)
VoA Saturday (Sat)
VoA Sunday (Sun)
0700 - NPR *All Things Considered* (repeat)
0800 - ABC Radio Australia
0900 - Polish Radio Warsaw (Mon-Sat)
C-Span Weekly Radio Journal (Sunday)
0930 - Radio Canada International (Mon-Fri)
UN Radio (Sat)
1000 - Radio Prague
1030 - Radio Netherlands
1127 - *Earth and Sky* (Daily Science Series)
1130 - SABC Channel Africa-Johannesburg (Mon-Sat)
Glenn Hauser's *World of Radio* (Sun)
1200 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekly Edition* (Sat)
NPR *Weekly Edition* (rpt) (Sun)
1300 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekend Edition* (Saturday and Sunday)
1400 - Radio France International
1500 - Voice of Russia (Mon-Fri)
Radio Romania International (Sat)
Voice of America-*Communications World* (Sun)
1530 - KBS Radio Korea International
1600 - ABC Radio Australia
1700 - ORF Blue Danube Radio (Monday-Friday)
Glenn Hauser's *World of Radio* (Sat)
SABC Network Africa (Sun)
1730 - Radio Austria International
1800 - RTE *News at Six*
1830 - Radio Netherlands
1925 - News in Esperanto from Polish Radio Warsaw
1930 - YLE Radio Finland
2000 - RTHK-News from Hong Kong (Mon-Fri)
UN Radio from New York or Radio Denmark (alternate Sat)
2015 - Health Watch (Sat)
Radio Romania International (Sun)
2030 - Radio Vlaanderen International
2100 - Radio Sweden
2130 - Polish Radio Warsaw
2200 - Voice of America *World Report* (Mon-Fri)
VoA *Today* (Sat and Sun)
2300 - PRI *The World* (Mon-Fri)
NPR *All Things Considered* (Sat and Sun)

WRN2- European Multi-lingual Service

Eutelsat II-F1 (13 deg East) transponder 25-10.987 GHz (NBC) vertical polarization, audio subcarrier 7.38 MHz. Please note that programs listed below with an asterisk (*) are subject to pre-emption without notice. All times UTC (Central European Time +1 hour)

0309 - Vatican Radio
0745 - *WRN1 (NPR and ABC Radio Australia)
0830 - Vatican Radio (Sun) until 1130
0930 - Vatican Radio (Mon-Sat) until 1130, except Wed to 1200
1130 - *WRN1 (SABC Channel Africa) except Wed
1200 - Radio Studio Delta (Mon-Fri) until 1300
1200 - *WRN1 (NPR Sat and Sun)
1300 - Vatican Radio
1530 - Radio Studio Delta (Mon-Fri)
1530 - *WRN1 (Sat and Sun Radio Vlaanderen-Brussels and ABC Radio Australia)
1630 - Vatican Radio
2230 - Radio Studio Delta (Mon-Fri)
2230 - *WRN1 (Sat and Sun)
2330 - *WRN1 (Mon-Fri)

WRN- Asia-Pacific English Service

AsiaSat-2 (100.5 deg East) 4.000 GHz, vertical polarization, MPEG2 DVB, Symbol Rate 28.125 Mbaud, FEC 3/4, Select WRN1 from audio menu. AET-Australian Eastern Time (UTC +11 hours and for Hong Kong +8 hours to UTC).

UTC... AET
0000...1100 - YLE Radio Finland (Mon-Fri)
UN Radio (Sat)
Radio Romania (Sun)
0030...1130 - ORF Radio Austria International (Mon-Fri)
Radio Sweden (Sat)
Polish Radio Warsaw (Sun)
0100...1200 - PRI *The World* (Tue-Sat)
NPR *Weekend All Things Considered* (Sun and Mon)
0200...1300 - RTE Dublin
0300...1400 - CBC *As It happens* (Tue-Sat)
0300...1400 - Radio Canada International (Sun and Mon)
0400...1500 - Polish Radio Warsaw
0430...1530 - Radio Budapest
0500...1600 - PRI *Market Place* (Tue-Sat)
UN Radio from New York (Sun)
UN Radio Romania (Mon)
0530...1630 - ORF Radio Austria International
0600...1700 - NPR *All Things Considered* (repeat)
0730...1830 - Radio Canda International
0800...1900 - RTE Dublin
1000...2100 - Radio Prague
1030...2130 - SABC Channel Africa (Mon-Fri)
SABC Network Africa (Sat)
Radio Romania International (Sun)
1100...2200 - RTHK Hong Kong
United Nations Radio (Sat)
Glenn Hauser's *World of Radio* (Sun)
1130...2230 - KBS Radio Korea International
1200...2300 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekly Edition* (Sat)
NPR *Weekly Edition* (re-peat) (Sun)
1300...0000 - Radio Canada International
1400...0100 - RTE Dublin
1500...0200 - Voice of Russia
1530...0230 - ORF Radio Austria International
1600...0300 - Radio France International
1700...0400 - ORF Blue Danube Radio (Tue-Sat)
Glenn Hauser's *World of Radio* (Sun)
SABC Network Africa (Mon)
1730...0430 - KBS Radio Korea International
1800...0500 - RTE Dublin
1830...0530 - Radio Netherlands
1927...0627 - *Earth and Sky*
1930...0630 - YLE Radio Finland
2000...0700 - RTHK Hong Kong (Tue-Sat)
Radio Romania International (Sun)
UN Radio and *Health Watch* (Mon)
2030...0730 - Radio Vlaanderen International
2100...0800 - RTE Dublin
2230...0930 - ORF Radio Austria International
2300...1000 - Radio Netherlands
2357...1057 - *Earth and Sky* (Daily Science Series)

WRN- Middle East and Africa English Service

Intelsat 707 (1 deg West) 3.9115 GHz, right-hand circular-polarization, Symbol Rate 8.022 Mbaud, FEC 3/4, MPEG2 Audio Stream. CAT-Central African Time (UTC +2 hours).

UTC... CAT
Next four hours can be heard in South Africa on SAfm 104-107
2300...0100 - Radio Netherlands
2357...0157 - *Earth and Sky* (Daily Science Series)
0000...0200 - YLE Radio Finland (Mon-Fri)
UN Radio (Sat)
Radio Romania (Sun)
0030...0230 - ORF Radio Austria International (Mon-Fri)
Radio Sweden (Sat)
Polish Radio Warsaw (Sun)
0100...0300 - PRI The World (Tue-Sat)
NPR *Weekend All Things Considered* (Sun and Mon)
0200...0400 - RTE Dublin
0300...0500 - CBC *As It Happens* (Tue-Sat)
Radio Canada International (Sun and Mon)
0400...0600 - Polish Radio Warsaw
0430...0630 - Radio Budapest
0500...0700 - PRI *Market Place* (Tue-Sat)
UN Radio from New York (Sun)
UN Radio Romania (Mon)
0530...0730 - ORF Radio Austria International
0600...0800 - NPR *All Things Considered* (repeat)
0730...0930 - Radio Canada International
0800...1000 - RTE Dublin
1000...1200 - Radio Prague
1030...1230 - SABC Channel Africa (Mon-Fri)
SABC Network Africa (Sat)
Radio Romania International (Sun)
1100...1300 - RTHK Hong Kong (Mon-Fri)
United Nations Radio (Sat)
Glenn Hauser's *World of Radio* (Sun)
1130...1330 - KBS Radio Korea International
1200...1400 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekly Edition* (Sat)
NPR *Weekly Edition* (repeat) (Sun)
1300...1500 - Radio Canada International
1400...1600 - RTE Dublin
1500...1700 - Voice of Russia
1530...1730 - ORF Radio Austria International
1600...1800 - Radio France International
1700...1900 - ORF Blue Danube Radio (Tue-Sat)
Glenn Hauser's *World of Radio* (Sun)
SABC Network Africa (Mon)
1730...1930 - KBS Radio Korea International
1800...2000 - RTE Dublin
1830...2030 - Radio Netherlands
1927...2127 - *Earth and Sky*
1930...2130 - YLE Radio Finland
2000...2200 - RTHK Hong Kong (Mon-Fri)
Radio Romania International (Sat)
UN Radio and *Health Watch* (Sun)
2030...2230 - Radio Vlaanderen International
2100...2300 - RTE Dublin
2230...0030 - ORF Radio Austria International

GOES 9 WEFAX Broadcasts Schedules

The following WEFAX broadcasts schedule was provided by the Dallas Remote Imaging Group.

West WEFAX (GOES-9) Schedule Effective October 10, 1996

Time (UTC)	Product
0000	H 0000Z IR NW PS GMS
0005	I 0000Z VS NW PS GMS
0010	A 0000Z IR NW GMS
0015	B 0000Z IR NE GMS
0020	C 0000Z IR SW GMS
0025	D 0000Z IR SE GMS
0030	GOES-9 2300Z NH IR
0035	GOES-9 2300Z NH VS
0040	W484 PG-WDS & TEMP FL50
0045	W486 48HR 1000 STM/ ISOTACHS
0050	W487 48HR 1000 STM/ ISOTACHS
0055	W482 SIG WX PROG 400-70MB
0100	W483 SIG WX PROG 400-70MB
0105	W273 PG-WDS & TEMP FL100
0110	W473 PG-WDS & TEMP FL50
0118	GOES-9 0000Z NH IR
0122	GOES-9 0000Z NW IR
0126	GOES-9 0000Z SW IR
0130	GOES-9 0000Z NE IR
0134	GOES-9 0000Z SE IR
0138	GOES-9 0000Z FD IR
0142	GOES-9 0000Z NH VIS
0146	GOES-9 0000Z US IR
0150	GOES-9 0000Z NH WV
0154	GOES-9 0000Z NW WV
0158	GOES-9 0000Z SW WV
0202	GOES-9 0100Z NH IR
0206	GOES-9 0000Z NE WV
0210	GOES-9 0000Z SE WV
0214	GOES-9 0000Z FD WV
0218	GOES-8 2345Z NH IR
0222	GOES-8 2345Z FD IR
0226	GOES-8 2345Z FD WV
0230	POLAR DIR NH 010E-080W W028
0240	ICE CHART
0245	ICE CHART
0250	ICE CHART
0255	ICE CHART
0300	H 0300Z IR NW PS GMS
0305	I 0300Z VS NW PS GMS
0310	A 0300Z IR NW GMS
0315	B 0300Z IR NE GMS
0320	C 0300Z IR SW GMS
0325	D 0300Z IR SE GMS
0330	GOES-9 0200Z NH IR
0334	POLAR DIR SH 010E-080W W029
0338	POLAR DIR MER 010E-060W W030
0342	POLAR VIS MER 040W-110W W031
0346	POLAR NIR MER 140E-070E W032
0350	POLAR DIR MER 040W-110E W033
0354	GOES-8 0245Z NH IR
0358	GOES-8 0245Z FD IR
0402	GOES-9 0300Z NH IR
0406	GOES-9 0300Z NW IR
0410	GOES-9 0300Z SW IR
0414	GOES-9 0300Z NE IR
0418	GOES-9 0300Z SE IR
0422	GOES-9 0300Z FD IR
0426	GOES-9 0300Z US IR
0430	D2 0430Z IR METEOSAT
0434	D1 0430Z IR METEOSAT
0438	D3 0430Z IR METEOSAT
0442	E6 0430Z MOIST METEOSAT
0446	E7 0430Z MOIST METEOSAT
0450	E8 0430Z MOIST METEOSAT
0454	E9 0430Z MOIST METEOSAT
0458	GOES-9 0400Z NH IR
0502	POLAR VIS NH 080W-170W W034
0506	POLAR VIS SH 080W-170W W035
0522	POLAR NIR NH 080E-010E W036
0526	POLAR NIR SH 080E-010E W037
0530	POLAR VIS MER 100W-170W W038
0534	POLAR NIR MER 080E-010E W039
0538	POLAR DIR NH 080W-170W W040
0542	POLAR DIR SH 080W-170W W041
0554	GOES-9 0500Z NH IR
0600	H 0600Z IR NW PS GMS
0605	I 0600Z VS NW PS GMS
0610	A 0600Z IR NW GMS
0615	B 0600Z IR NE GMS
0620	C 0600Z IR SW GMS
0625	D 0600Z IR SE GMS
0630	D2 0630Z IR METEOSAT
0634	C02 0630Z VS METEOSAT
0638	C03 0630Z VS METEOSAT
0642	C3D 0630Z VS METEOSAT
0646	GOES-8 0545Z NH IR
0650	GOES-8 0545Z FD IR
0654	GOES-8 0545Z FD WV
0702	GOES-9 0600Z NH IR
0706	GOES-9 0600Z NW IR
0710	GOES-9 0600Z SW IR
0715	W301 ANAL 1000 STM/WDS
0720	W302 ANAL 1000 STM/WDS
0725	W303 ANAL 1000 STM/WDS
0730	W304 ANAL 1000 STM/WDS
0735	W305 ANAL 1000 STM/WDS
0740	W306 ANAL 1000 STM/WDS
0745	W307 ANAL 1000 STM/WDS
0750	W308 ANAL 1000 STM/WDS
0755	W309 PG-WDS & TEMP FL340
0800	GOES-9 0700Z NH IR
0805	W311 PG-WDS & TEMP FL240
0810	W210 PG-WDS & TEMP FL240
0818	GOES-9 0600Z NE IR
0822	GOES-9 0600Z SE IR
0826	GOES-9 0600Z FD IR
0830	GOES-9 0600Z US IR
0834	GOES-9 0600Z FD WV
0850	POLAR DIR MER 100W-170W W042
0854	GOES-9 0800Z NH IR
0900	H 0900Z IR NW PS GMS
0905	I 0900Z VS NW PS GMS
0910	A 0900Z IR NW GMS
0915	B 0900Z IR NE GMS
0920	C 0900Z IR SW GMS
0925	D 0900Z IR SE GMS
0930	POLAR DIR NORTH POLE W043
0934	POLAR DIR SOUTH POLE W044
0950	GOES-8 0845Z NH IR
0954	GOES-8 0845Z FD IR
0958	GOES-9 0900Z NH IR
1002	GOES-9 0900Z NW IR
1006	GOES-9 0900Z SW IR
1010	GOES-9 0900Z NE IR
1014	GOES-9 0900Z SE IR
1018	GOES-9 0900Z FD IR
1022	GOES-9 0900Z US IR
1030	W214 PG-WDS & TEMP FL100
1035	W215 PG-WDS & TEMP FL50
1040	W216 PG-WDS & TEMP FL50
1045	W217 PG-WDS & TEMP FL340
1050	W218 PG WDS & TEMP FL340
1055	W219 PG WDS & TEMP FL340
1100	GOES-9 1000Z NH IR
1105	W420 PG WDS & TEMP FL240
1110	W221 PG WDS & TEMP FL240
1115	W421 PG WDS & TEMP FL180
1120	W222 PG WDS & TEMP FL180
1125	W422 PG WDS & TEMP FL100
1130	W223 PG WDS & TEMP FL100
1135	W423 PG WDS & TEMP FL50
1140	W430 24HR 1000 STM/ ISOTACHS
1145	W431 24HR 1000 STM/ ISOTACHS
1150	W432 PG-WDS & TEMP FL50
1155	W440 SIG WX 400-70MB
1200	GOES-9 1100Z NH IR
1205	J 1200Z IR NW PS GMS
1210	A 1200Z IR NW GMS
1215	B 1200Z IR NE GMS
1220	C 1200Z IR SW GMS
1225	D 1200Z IR SE GMS
1230	POLAR VIS NH 170W-100E W001
1234	POLAR VIS SH 170W-100E W002
1238	POLAR NIR NH 010E-080W W003
1242	POLAR NIR SH 010E-080W W004
1246	POLAR VIS MER 170W-120E W005
1250	GOES-8 1145Z NH IR
1254	GOES-8 1145Z FD IR
1258	GOES-8 1145Z FD WV
1302	GOES-9 1200Z NH IR
1306	GOES-9 1200Z NW IR
1310	GOES-9 1200Z SW IR
1314	GOES-9 1200Z NE IR
1322	GOES-9 1200Z SE IR
1326	GOES-9 1200Z FD IR
1330	GOES-9 1200Z US IR
1334	GOES-9 1200Z NH WV
1338	GOES-9 1200Z NW WV
1342	GOES-9 1200Z SW WV
1346	GOES-9 1200Z NE WV
1350	GOES-9 1200Z SE WV
1354	GOES-9 1200Z FD WV
1358	POLAR NIR MER 020E-050W W006
1402	GOES-9 1300Z NH IR
1422	TBUS NOAA-12
1426	TBUS NOAA-14
1430	SCHEDULE FILE PART-1
1434	SCHEDULE FILE PART-2
1438	WEFAX MESSAGE FILE
1442	POLAR DIR NH 170W-100E W007
1446	POLAR DIR SH 170W-100E W008
1450	POLAR DIR MER 170W-120E W009
1454	GOES-9 1400Z NH IR
1500	H 1500Z IR NW PS GMS
1505	J 1500Z VS NW PS GMS
1510	A 1500Z NW IR GMS
1515	B 1500Z NE IR GMS
1520	C 1500Z SW IR GMS
1525	D 1500Z SE IR GMS
1530	POLAR VIS MER 130E-060E W010
1534	POLAR NIR MER 040W-110W W011
1538	POLAR DIR MER 130E-060E W012
1550	GOES-8 1445Z NH IR
1554	GOES-8 1445Z FD IR
1602	GOES-9 1500Z NH IR
1606	GOES-9 1500Z NW IR
1610	GOES-9 1500Z SW IR
1614	GOES-9 1500Z NE IR
1618	GOES-9 1500Z SE IR
1622	GOES-9 1500Z FD IR
1626	GOES-9 1500Z US IR
1634	GOES-9 1500Z NH VS
1646	GOES-9 1500Z NE VS
1650	GOES-9 1500Z SE VS
1702	GOES-9 1600Z NH IR
1706	GOES-9 1600Z NH VS
1715	W263 SIG WX 400-70MB
1720	W463 SIG WX 400-70MB
1730	W350 ANAL 1000 STM/WDS
1735	W351 ANAL 1000 STM/WDS
1740	W352 ANAL 1000 STM/WDS
1745	W353 ANAL 1000 STM/WDS
1750	W354 ANAL 1000 STM/WDS
1755	W355 ANAL 1000 STM/WDS
1800	H 1800Z IR NW PS GMS
1805	J 1800Z VS NW PS GMS
1810	A 1800Z IR GMS
1815	B 1800Z IR GMS
1820	C 1800Z IR GMS
1825	D 1800Z IR GMS
1830	GOES-9 1700Z NH IR
1835	GOES-9 1700Z NH VS
1840	W358 ANAL 1000 STM/WDS
1845	W359 PG WDS & TEMP FL340
1850	W360 PG WDS & TEMP FL340
1855	W361 PG WDS & TEMP FL340
1902	GOES-9 1800Z NH IR
1906	GOES-9 1800Z NW IR
1910	GOES-9 1800Z SW IR
1914	GOES-9 1800Z NE IR
1918	GOES-9 1800Z SE IR
1922	GOES-9 1800Z FD IR
1926	GOES-9 1800Z US IR
1930	GOES-9 1800Z NH VS
1934	GOES-9 1800Z NW VS
1938	GOES-9 1800Z SW VS
1942	GOES-9 1800Z NE VS
1946	GOES-9 1800Z SE VS
1950	GOES-8 1745Z NH IR
1954	GOES-8 1745Z FD IR
1958	GOES-8 1745Z FD WV
2002	GOES-9 1800Z FD WV
2006	GOES-9 1900Z NH IR
2010	GOES-9 1900Z NH VS
2014	POLAR VIS NH 100E-010E W013
2018	POLAR VIS SH 100E-010E W014
2022	POLAR NIR NH 080W-170W W015
2026	POLAR NIR SH 080W-170W W016
2030	POLAR VIS MER 070E-000E W017
2034	POLAR NIR MER 100W-170W W018
2038	POLAR DIR NH 100E-010E W019
2042	POLAR DIR SH 100E-010E W020
2046	POLAR DIR MER 070E-000E W021
2050	POLAR VIS NH 010E-080W W022
2054	POLAR VIS SH 010E-080W W023
2100	H 2100Z IR NW PS GMS
2105	I 2100Z VS NW PS GMS
2110	A 2100Z IR NW GMS
2115	B 2100Z IR NE GMS
2120	C 2100Z IR SW GMS
2125	D 2100Z IR SE GMS
2130	GOES-9 2000Z NH IR
2134	GOES-9 2000Z NH VS
2146	POLAR NIR NH 170W-100E W024**
2150	POLAR NIR SH 170W-100E W025
2154	GOES-8 2045Z NH IR
2158	GOES-8 2045Z FD IR
2205	W268 PG-WDS & TEMP FL340
2210	W269 PG-WDS & TEMP FL340
2215	W270 PG WDS & TEMP FL240
2220	W470 PG WDS & TEMP FL240
2225	W271 PG WDS & TEMP FL240
2230	W471 PG WDS & TEMP FL180
2235	W272 PG WDS & TEMP FL180
2240	W474 PG WDS & TEMP FL100
2246	GOES 9 2100Z NH IR
2250	GOES-9 2100Z NW IR
2254	GOES-9 2100Z SW IR
2258	GOES-9 2100Z NE IR
2302	GOES-9 2200Z NH IR
2306	GOES-9 2100Z SE IR
2310	GOES-9 2100Z FD IR
2314	GOES-9 2100Z US IR
2318	GOES-9 2100Z NH VS
2322	GOES-9 2100Z NW VS
2326	GOES-9 2100Z SW VS
2330	GOES-9 2100Z NE VS
2334	GOES-9 2100Z SE VS
2338	GOES-9 2200Z NH VS
2350	POLAR DIR NH 010E-080W W026**
2354	POLAR DIR SH 010E-080W W027**

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SPACE GLOSSARY

The following are some terms used in the satellite business and are described in layman's terms.

ALTITUDE (ALT): The distance between a satellite and the point on the earth directly below it, same as height.

AQUISITION OF SIGNAL (AoS): The time at which a particular ground station begins to receive radio signals from a satellite.

APOGEE: The point in a satellite's orbit farthest from the Earth's center.

ARGUMENT OF PERIGEE: This value is the number of degrees from the ascending node the perigee point occurs. The perigee point is the point where the satellite is the closest to the earth (assuming an orbit which is elliptical to some degree). This number may be entered as a real value between 0.0 and 360.0.

ASCENDING NODE: Point at which the satellite crosses the equatorial plane from the southern hemisphere to the northern hemisphere. (See RIGHT ASCENSION OF THE ASCENDING NODE.)

AZIMUTH (AZ): The angle measured in the plane of the horizon from true North clockwise to the vertical plane through the satellite.

CATALOG NUMBER: A 5-digit number assigned to a cataloged orbiting object. This number may be found in the NASA Satellite Situation Report and on the NASA Two Line Element (TLE) sets.

COORDINATED UNIVERSAL TIME (UTC): Also known as Greenwich Mean Time (GMT). Local time at zero degrees longitude at the Greenwich Observatory, England. Uses 24 hour clock, ie. 3:00 pm is 1500 hrs.

CULMINATION: The point at which a satellite reaches its highest position or elevation in the sky relative to an observer. (Known as the Closest Point of Approach)

DECAY RATE: This is the rate of decay of the orbital period (time it takes to complete one revolution) due to atmospheric friction and other factors. It is a real number measured in terms of Revolutions per Day (REV/DAY).

DECLINATION (DEC): The angular distance from the equator to the satellite measured positive north and negative south.

DIRECT BROADCAST SATELLITE (DBS): Commerical satellite designed to transmit TV programming directly to the home.

OOPPLER SHIFT: The observed frequency difference between the transmitted signal and the received signal on a satellite downlink where the transmitter and receiver are in relative motion.

DOWNLINK: A radio link originating at a spacecraft and terminating at one or more ground stations.

DRAG: The force exerted on a satellite by its passage through the atmosphere of the Earth, acting to slow the satellite down.

EARTH-MOON-EARTH (EMR): Communications mode that involves bouncing signals off the moon.

ECCENTRICITY (ECC): This is a unitless number which describes the shape of the orbit in terms of how close to a perfect circle it is. This number is given in the range of 0.0 to less than 1.0. An perfectly circular orbit would have an eccentricity of 0.0. A number greater than 0.0 would represent an elliptical orbit with an increasingly flattened shape as the value approaches 1.0.

ELEMENT SET: (See ORBITAL ELEMENTS.)

ELEVATION (EL): Angle above the horizontal plane.

EPHEMERIS: A tabulation of a series of points which define the position and motion of a satellite.

EPOCH: A specific time and date which is used as a point of reference; the time at which an element set for a satellite was last updated.

EPOCH DAY: This is the day and fraction of day for the specific time the data is effective. This number defines both the julian day (the whole number part of the value) and the time of day (fractional part of the value) of the data set.
The julian day figure is simply the count of the number of days thatparticular date is from the beginning of the year. (January 1 would have a julian day of 1. Feb 28 would be 59.) This number may range from 1.0 to 366.999999999 (taking into account leap years).

EPOCH YEAR: This is the year of the specific time the rest of the data about the object is effective.

EQUATORIAL PLANE: An imaginary plane running through the center of the earth and the Earth's equator.

EUROPEAN SPACE AGENCY (ESA): A consortium of European governmental groups polling resources for space exploration and development.

FOOTPRINT: A set of signal-level contours, drawn on a map or globe, showing the performance of a high-gain satellite antenna. Usually applied to geostationary satellites.

GROUND STATION: A radio station, on or near the surface of the earth, designed to receive signals from, or transmit signals to, a spacecraft.

INCLINATION (INC): The angle between the orbit plane and the Earth's equatorial plane, measured counter-clockwise. 0 (zero) degrees inclination would describe a satellite orbiting in the same direction as the Earth's rotation directly above the equator (orbit plane = equatorial plane). 90 degrees inclination would have the satellite orbiting directly over both poles of the earth (orbit plane displaced 90 degrees from the equatorial plane). An inclination of 180 degrees would have the satellite orbiting again directly over the equator, but in the opposite direction of the Earth's rotation. Inclination is given as a real number of degrees between 0.0 and 180.0 degrees.

INTERNATIONAL DESIGNATOR: An internationally agreed upon naming convention for satellites. Contains the last two digits of the launch year, the launch number of the year and the piece of the launch, ie. A-indicates payload, B-the rocket booster, or second payload, etc.

LATITUDE (LAT): Also called the geodetic latitude. the angle between the perpendicular to the Earth's surface (plane of the horizon) at a location and the equatorial plane of the earth.

LONGITUDE (LONG): The angular distance from the Greenwich (zero degree) meridian, along the equator. This can is measured either east or west to the 180th meridian (180 degrees) or 0 to 360 degrees west. For example, Ohio includes 85 degrees west longitude, while India includes 85 degrees east longitude. But 85 degrees east longitude could also be measured as 275 degrees west longitude.

LOSS OF SIGNAL (LoS): The time at which a particular ground station loses radio signals from a satellite.

MEAN ANOMALY (MA): This number represents the angular distance from the perigee point (closest point) to the satellite's mean position. This is measured in degrees along the orbital plane in the direction of motion. This number is entered like the argument of perigee, as a value between 0.0 and 360.0.

MEAN MOTION (MM): This is the number of complete revolutions the satellite makes in one day. This number may be entered as a value greater than 0.0 and less than 20.0. (See DECAY)

NASA: U.S. National Aeronautics and Space Administration.

ORBITAL ELEMENTS: Also called Classical Elements, Satellite Elements, Element Set, etc. Includes the catalog Number; epoch year, day, and fraction of day; period decay rate; argument of perigee, inclination, eccentricity; right ascension of ascending node; mean anomaly; mean motion; revolution number at epoch; and element set number. This data is contained in the TWO LINE ORBITAL ELEMENTS provided by NASA.

DSCAR: Orbiting Satellite Carrying Amateur Radio.

PERIOD DECAY RATE: Also known as Decay. This is the tendency of a satellite to lose orbital velocity due to the influence of atmospheric drag and gravitational forces. A decaying object eventually impacts with the surface of the Earth or burns up in the atmosphere. This parameter directly affects the satellite's MEAN MOTION. This is measured in various ways. The NASA Two Line Orbital Elements use revolutions per day.

PERIGEE: The point in the satellite's orbit where it is closest to the surface of the earth.

POSIGRADE ORBIT: Satellite motion which is in the same direction as the rotation of the Earth.

RETROGRADE ORBIT: Satellite motion which is opposite in direction to the rotation of the Earth.

REVOLUTION NUMBER: This represents the number of revolutions the satellite has completed at the epoch time and date. This number is entered as an integer value between 1 and 99999.

REVOLUTION NUMBER AT EPOCH: The number of revolutions or ascending node passages that a satellite has completed at the time (epoch) of the element set since it was launched. The orbit number from launch to the first ascending node is designated zero, thereafter the number increases by one at each ascending node.

RIGHT ASCENSION OF THE ASCENDING NODE (RAAN): The angular distance from the vernal equinox measured eastward in the equatorial plane to the point of intersection of the orbit plane where the satellite crosses the equatorial plane from south to north (asecending node). It is given and entered as a real number of degrees from 0.0 to 360.0 degrees.

SATELLITE SITUATION REPORT: A report published by NASA Goddard Space Flight Center listing all known man-made Earth orbiting objects. This report lists the Catalog Number, International Designator, Name, Country of origin, launch date, orbital period, inclination, beacon frequency, and status (orbiting or decayed).

TLM: Short for telemetry.

TRANSPONDER: A device aboard a spacecraft that receives radio signals in one segment of the radio spectrum, amplifies them, translates (shifts) their freuency to another segment and retransmits them.

TELEVISION RECEIVE ONLY (TVRO): A TVRO terminal is a ground station set up to receive downlink signals from 4-GHZ or 12-GHZ commerical satellites carrying TV programming.

TWO LINE ORBITAL ELEMENTS (TLE): See ORBITAL ELEMENTS.

UPLINK: A radio link originating at a ground station and directed to a spacecraft.

VERNAL EQUINOX: Also known as the first point of Aries, being the point where the Sun crosses the Earth's equator going from south to north in the spring. This point in space is essentially fixed and represents the reference axis of a coordinate system used extensively in Astronomy and Astrodynamics.

UPLINK

By Bob Grove, Publisher
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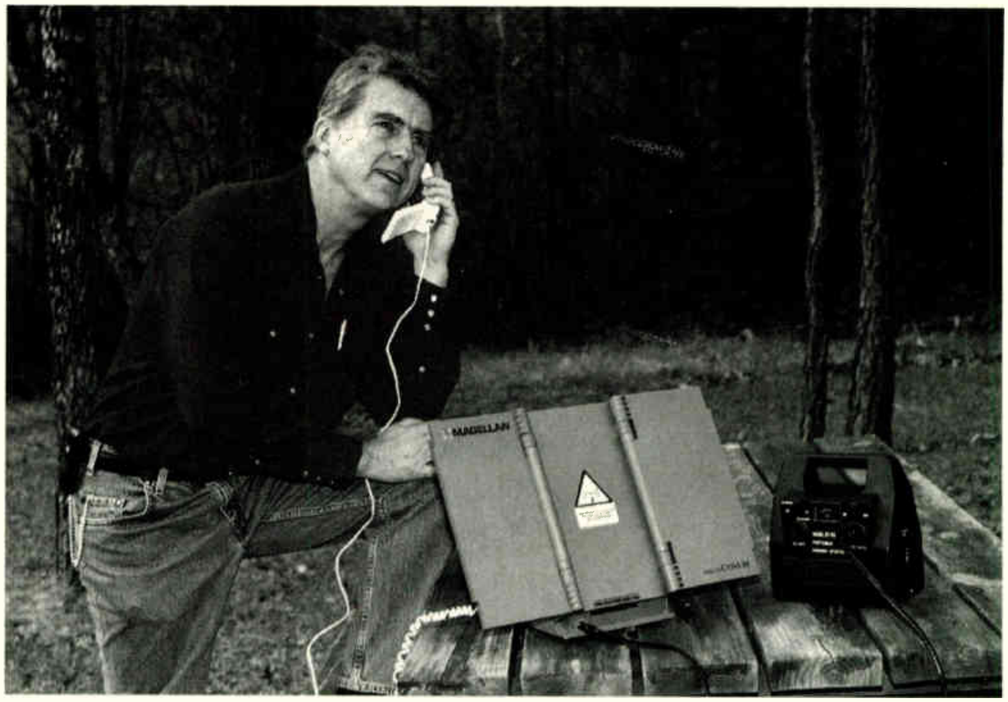
Gates' Way (by) 2000?



A few days ago I had the interesting experience of visiting the future. In our parking lot, I unfurled the flat-panel array of a tiny, portable Inmarsat terminal, lifted the telephone handset from its cradle, and called my office—fifty feet away. In seconds, the link was established and I talked to our sales receptionist.

The 50,000 mile trip to talk to someone fifty feet away (I waved to her through the window) cost $4.25 per minute, and the Magellan terminal sells for about $7000 (Want one? Call Grove Enterprises!): the experience was certainly unique. It opened a window on the future of communications. Unlike cellular telephones, this little package works anywhere in the world, from the sands of the Sahara to the ice packs of the Antarctic, and voices are clear as a bell.

Things are looking up—*way* up! Future wideband Internet activities will be relayed by satellite. Real-time video, stereo audio, as well as voice phone and data will be conducted from home and office terminals which uplink to various constellations of LEO satellites. And Bill Gates will be there.

Earlier this year, Gates scored a coup when the International Telecommunications Union (ITU) awarded Teledisc, a major Gates investment, exclusive spectrum for Personal Communications Services (PCS) use. Gates, whose sole commercial focus is computer systems, would stand to reap incredible dividends by offering Internet satellite services with unrestricted bandwidth—the major obstacle to high-resolution graphic imaging via the Net, which is now confined to narrow-bandwidth telephone lines.

Typical phone line data transmission is at a rate of only 28,800 bytes per second (28.8 kb/s), whereas orbiting birds can deliver bandwidths in the hundreds of megabytes (Mb/s), more than adequate for high definition services. But there has to be hardware as well.

Gateway 2000 has just annnounced that, with every qualifying purchase of one of their computer packages, they will include a coupon for a free EchoStar DISH Network when accompanied by a paid subscription to the Ka-band satellite TV service (see this month's *What's New* column). Nice first step.

It takes little imagination to envision the next step: tying the Gateway computer system into the Internet from space. Watch for it—coming soon to a dealer near you! ST

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–Michael Wyrick, N4USI
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