Satellite Times

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Volume 4
Number 9
July 1998

Solar Activity Heats Up

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Satellite Times

Cover Story

Cover Photo: Pictured is one of the first images taken from the new TRACE (Transition Region and Coronal Explorer) spacecraft. The high resolution of the TRACE ultraviolet light telescope reveals the fine structure in loops of plasma (hot, electrically charged gas) contained by strong magnetic fields. The false colors represent different temperatures; blue is approximately 360,000 degrees Fahrenheit, green is roughly 900,000 degrees Fahrenheit and red is about 2,700,000 degrees Fahrenheit. White is seen where all three colors combine. (Dr. Alan Title/Stanford Lockheed Institute for Space Research and NASA)

Solar Cycle 23: What a Blast!

By Philip Chien, ST Staff

The new solar sunspot cycle has just started and an armada of scientific spacecraft will be watching old Sol to learn more about the mechanics of the process. As the sunspot count goes up, radio hobbyists worldwide will be able to enjoy the benefits of improved reception conditions. You can do your own research and keep tabs on the latest solar conditions from a variety of sources. Author Chien shows you how, starting on page 10.

Vol. 4, No. 9

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July 1998

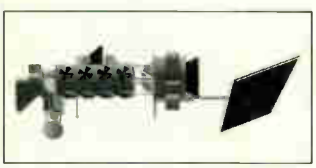
The Next Generation of Weather Satellites

By Philip Chien, ST Staff

Everybody talks about the weather, but nobody ever does anything about it. Weather forecasting has become more reliable, though, since forecasters started using weather satellites. In the future more powerful and capable polar orbiting satellites will be launched. These new satellites will require some changes to be made by radio hobbyists that monitor weather satellite imagery before they can receive transmissions from the new spacecraft. Turn to page 16 for the latest details on the new NOAA spacecraft.

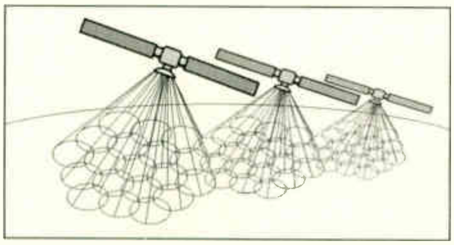
The Weather from Above

By Troy Thrash, Analytic Graphics Inc.



As satellites in orbit continue to proliferate to meet the changing needs of society, weather satellites do, too. With each passing day, more remote areas of the globe are becoming populated, requiring the extension of telecommunications, video and weather networks to provide for the needs of those people. Vast amounts of weather data are collected and transmitted to virtually any location on the Earth via two distinct meteorological systems. This story takes an indepth look at the various weather satellite constellations starting on page 20.

DEPARTMENTS



Monitoring Times magazine readers will recognize *ST*'s newest columnist, Dan Veeneman. Dan will be covering the Personal Communications Services beat and his introductory column will give the reader an overview of all the new exciting PCS systems coming on line soon. Turn to page 60 for the complete story.

ST

SATELLITE TIMES (ISSN: 1077-2278; CPC IPM Sales Agreement #1253484) is published monthly by Grove Enterprises, Inc., Brasstown, North Carolina, USA.

Address: P.O. Box 98, 7540 Highway 64 West, Brasstown, NC 28902-0098
Telephone: (828) 837-9200
Fax: (828) 837-2216 (24 hours)
Web site: http://www.grove-ent.com/grove/hmpgst.html
Internet Address: steditor@grove.net

Subscription Rates: $23.95 in US and $36.50 in Canada per year. Call for air mail rates for other countries. For more information, please see page 78.

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

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DOWNLINK

By Larry Van Horn
Managing Editor
steditor@grove.net

You Ain't Seen Nothing Yet!

Unless you have been living in a shell the last few weeks, you know that we have suffered a major satellite loss with the demise of Galaxy IV. If you think the loss of that satellite caused problems, think about the upcoming Leonids meteor shower in November with the potential of viewing between 100,000 and 150,000 meteors per hour raining down on the earth and our various satellite constellations. The results could be catrosphic. *Satellite Times* magazine was the first national publication to inform its readers of the impending danger.

You can read more about this astronomical event in our exclusive cover story, *Leonid Meteors–Bracing for the Leonid Firestorm* in the March/April 1997 issue of *ST*. You can view that story online at **http://www.grove-ent.com/grove/leonids.html**. You can also get a reprint of this article by sending $3 and a self addressed stamped envelope to: Leonids Firestorm, P.O. Box 98, Brasstown, NC 28902.

Does it Really Weigh That Much?

I purchased my first *Satellite Times* this weekend and I will be faxing you my subscription request. I am really writing you email now about the cutline for the cover photo of the May 1998 issue says that Arecibo antenna weighs 600 tons. That is over a million pounds. Is that a typo?

–Richard Parry, email: ***rparry@qualcomm.com***

*Actually Richard, according to the Arecibo website (**http://www.naic.edu/**) the platform that Jodie Foster is standing in front of is heavier than the 600 tons mentioned in the May issue. From the Arecibo website: "Those who see the Arecibo radio telescope for the first time are astounded by the enormity of the reflecting surface, or radio mirror. The huge 'dish' is 305-meters (1000 feet) in diameter, 167 feet deep, and covers an area of about twenty acres. The surface is made of almost 40,000 perforated aluminum panels, each measuring about 3 feet by 6 feet, supported by a network of steel cables strung across the underlying karst sinkhole. It is a spherical (not parabolic) reflector.*

"Suspended 450 feet above the reflector is the 900 ton platform. Similar in design to a bridge, it hangs in midair on eighteen cables, which are strung from three reinforced concrete towers. One is 365 feet high, and the other two are 265 feet high. All three tops are at the same elevation. The combined volume of reinforced concrete in all three towers is 9,100 cubic yards. Each tower is back-guyed to ground anchors with seven 3.25 inch diameter steel bridge cables. Another system of three pairs of cables runs from each corner of the platform to large concrete blocks under the reflector. They are attached to giant jacks which allow adjustment of the height of each corner with millimeter precision. A total of 26 electric motors control the platform."

Satellite Access to the Internet

I don't know if you can help, but I am looking for a satellite TVRO receiver that will decode Internet downlink streams provided by the Hughes Aerospace (Joint Venture) Internet Satellite Service. The uplink access method is via traditional modem access to your local Internet Service Provider.

The receiver is actually contained a single PCB (Printed Ciruit Board) which slots into the back of any standard PC computer (using the PCI bus I think).

I need this equipment to service clients in the geographic areas of Toronto-CANADA (satellite unknown to me), and Manchester, ENGLAND (via EutelSat Hotbird-3). This service has been up and running in Germany on EutelSat for a year now. Can you help?

–Ray Dipple email: ***ray@northbay.com***

Reader Dipple is referring to the DirecPC service from Hughes Network Services that was sent via the Galaxy IV satellite (see Domestic TVRO column in this issue).

DirecPC beams satellite technology directly to your home or office machine using a 21-inch dish. You'll need a Pentium PC and an Internet service provider, an unobstructed line of site to the South from your home or office, Microsoft Windows '95, 16 MB of RAM (minimum) and 20 MB of hard disk space, and a Modem (9,600 or better)

Currently, DirecPC does not support the following operating systems: Macintosh, Windows 3.1 or lower, DOS, or UNIX.

You can get more information on DirecPC by contacting the Digital Satellite Source toll free at 1-888-377-4327/1-972-889-3474 (voice)/1-972-889-8095 (FAX) or via mail at 12092 Forestgate Drive, Dallas, TX 75243.

By Wayne Mishler, KG5BI

Black hole devours neighbor galaxy

As you read this, a neighbor galaxy not so different from our own just ten million light years from Earth's doorstep is being gobbled up by a monstrous black hole.

Astronomers are watching helplessly through the Hubble telescope as the galactic cannibal chews a swath through a cloud of stars, leaving blackness in its wake.

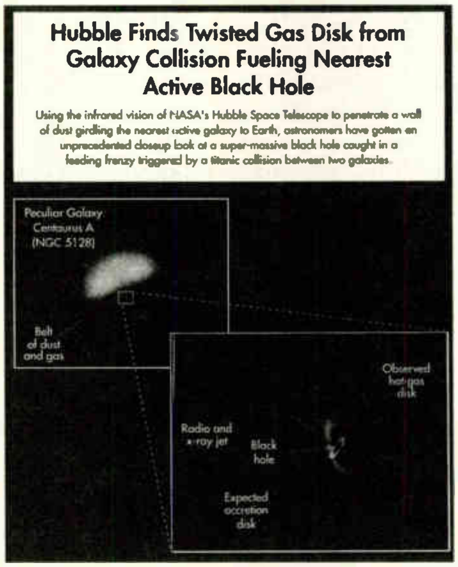
But the news is not all bad. A galaxy being devoured so near the Earth, rather than hundreds of millions or billions of light years away, gives astronomers a ringside seat and a unique laboratory for studying the elusive feeding habits of black holes.

This laboratory is doubly revealing because, like in an afternoon soap opera, there are sub-plots at play. The galaxy being eaten is actually two galaxies colliding with each other, providing the black hole with a lucrative killing field and galactic feast.

"This black hole is doing its own thing. Aside from receiving fresh fuel from a devoured galaxy, it may be oblivious to the rest of the galaxy and the collision," says Ethan Schreier, of the Space Telescope Science Institute at Baltimore, Maryland.

Although the cause-and-effect relationships are not yet clear, the views from Hubble's instruments are revealing new insights into the powerful forces being exerted in this complex maelstrom.

Hubble's wide-field camera is showing a visible image of the galaxy, known as NGC 5128. Looming in this image in sharp clarity is a dramatic dark lane of



dust girdling the galaxy. Infrared vision penetrates this wall of dust, revealing a twisted disk of hot gas being swept into the black hole's gravitational whirlpool. At the bottom of that whirlpool are the remains of perhaps a billion stars scrunched into a galactic stomach about the size of our Solar System.

Studies continue as Hubble pumps out additional data. Ground base observers are measuring the velocity of entrapped material around the black hole in an effort to calculate the hole's mass. Results were to be published in the June 1 issue of *Astrophysical Journal* Letters.

Color images of NGC5128 can be found in this issue of *Satellite Times* on pages 70/71 in the *Space Watch* column.

Big bang replay leaves astronomers clueless

Now the story can be told. Almost.

A couple of weeks before Christmas, while we were all nestled in our beds with visions of sugar plums more or less dancing in our heads, scientists were staring agape into space at the greatest explosion ever witnessed by man.

They had no idea–and still don't–of exactly what they saw. So they told no one, and quietly documented their findings in a report. The world was oblivious to their discovery until the report was published in the May 7 edition of *Nature*, the international weekly journal of science.

Reporters picked up the story from the journal and the news flashed around the world. "Astronomers say they cannot explain (the blast)," Reuters news service reported.

But there are theories.

Scientists believe the explosion they witnessed was a gamma-ray burst more powerful than any previously detected by man–possibly a replay of the alleged "big bang" that may have given birth to our universe 14 billion years ago.

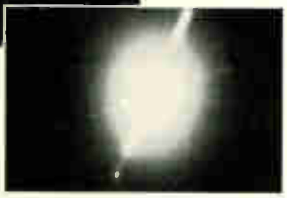
"This confirms that (gamma-ray) bursts are by far the most powerful bombs in nature's arsenal, only explicable by invoking the most copious known energy source–the direct collapse into a black hole of a massive stellar core or of merg-

DECEMBER 15TH

DECEMBER 16TH

MDM Observatory image of GRB 971214: These images of the area of the sky where the gamma ray burst was observed were taken on 15 December 1997 (left) and 16 December 1997 (right), respectively 1 and 2 days after the burst. The star at the center of the image has faded significantly in only one night, indicating that it is the rapidly dimming afterglow of the gamma ray burst. These images were taken by a team of astronomers from Columbia University, New York, N.Y., and Dartmouth College, Hanover, N.H., at the MDM Observatory near Tucson, Arizona. The MDM Observatory is named after its founding institutions; the University of Michigan, Ann Arbor, Mich., Dartmouth College, and the Massachusetts Institute of Technology, Cambridge, Mass. Photo Credit: Columbia University.

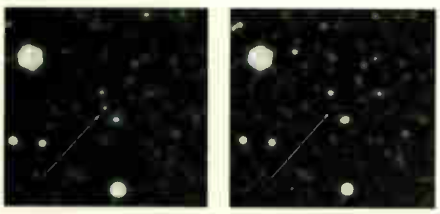
SATELLITE MONITOR



ing neutron stars," *Nature* reported.

Caltech professor George Djorgovski, one of the two principal investigators from the California Institute of Technology, Pasadena, Calif., told reporters "for about one or two seconds this burst was as luminous as all the rest of the entire universe."

He and colleagues from the University estimated the distance from Earth to the source to be about 12 billion light years, implying an enormous energy release.



KECK IMAGE OF GRB 971214: Images of the gamma ray burst (GRB) 971214 field, obtained with the W.M. Keck 10-meter telescope on Mauna Kea, Hawaii. This GRB was detected on December 14, 1997, and is the most powerful one to date. The image on the left shows the visible-light afterglow of the burst (marked with an arrow), obtained about two days after the burst, while it was still relatively bright. The image on the right shows the same field as seen about two months later, after the burst afterglow has faded away, revealing a faint galaxy at its position (also marked with an arrow). The measurement of its distance shows it to be some 12 billion light years away (assuming the current best guess of the age of the universe of about 14 billion years). Image credit: S.G. Djorgovski and S.R. Kulkarni/W.M. Keck Observatory

The burst was detected on Dec. 14, 1997, by the Italian/Dutch BeppoSAX satellite and NASA's Compton Gamma Ray Observatory satellite. The Compton observatory measured the brightness of the burst. BeppoSAX pinpointed its location. Follow-up observations were made with ground-based telescopes and NASA's Hubble Space Telescope.

"The energy released by this burst in its first few seconds staggers the imagination," said Caltech professor Shrinivas Kulkarni.

The burst appears to have released several hundred times more energy than a supernova, until now the most energetic phenomenon known in the universe.

"In a region about a hundred miles across, the burst created conditions like those in the early universe, about one millisecond (1/1,000 of a second) after the Big Bang," said Djorgovski.

This surprised astronomers. "Most of the theoretical models proposed to explain these bursts cannot explain this much energy," said Kulkarni. "However, there are recent models, involving rotating black holes, which can work. On the other hand, this is such an extreme phenomenon that it is possible we are dealing with something completely unanticipated and even more exotic."

HUBBLE IMAGE OF GRB 971214: Image of the gamma ray burst (GRB) 971214 field, obtained with the Hubble Space Telescope about four months after the burst, well after the afterglow has faded away. This GRB was detected on December 14, 1997, and is the most powerful one to date. The extremely faint and distant galaxy (marked with an arrow) is the host galaxy of the gamma-ray burst. It was discovered earlier using the Keck 10-meter telescope, but it is shown here as seen with a superior sharpness of the HST. Image credit: S.R. Kulkarni and S.G. Djorgovski/STScI/NASA/AURA, Inc.

Gamma-ray bursts are mysterious flashes of high-energy radiation that appear from random directions in space and typically last a few seconds. They were first discovered by U.S. Air Force Vela satellites in the 1960s. Since then, numerous theories of their origin have been proposed, but the causes of gamma-ray bursts remain unknown.

NASA is planning two missions to investigate gamma-ray bursts. High Energy Transient Experiment II is scheduled to launch in the fall of 1999. Gamma Ray Large Area Space Telescope (GLAST), scheduled to launch in 2005.

Astronomers discover giant tornadoes on the Sun

Recent data from the solar spacecraft SOHO reveal that our Sun has tall, gyrating storms far larger and faster than tornadoes on Earth. British scientists have detected a dozen such events. They occur most frequently near the north and south poles of the Sun and are almost as wide as the Earth.

Steady wind speeds of 15 kilometers per second and gusts ten times faster (500,000 kilometers per hour) occur in solar tornadoes. Tornadoes on the Earth blow at 400-500 kilometers per hour. The solar measurements are made by the Doppler effect–the same principle used by police radar to detect speeding motorists.

One of SOHO's main tasks is to trace the sources of Solar wind. Gusts and shocks from the Sun buffet the Earth's environment, causing auroras and magnetic storms, and endangering satellites and power supplies.

Now we are seeing that giant tornadoes on the Sun may contribute to the solar wind, especially to a fast wind stream that emanates from relatively cooler parts of the solar atmosphere called coronal holes.

"We see the hot gas in the tornadoes spiraling away from the Sun and gathering speed," says David Pike of the Rutherford Appleton Laboratory, UK, who is co-discoverer of the solar tornadoes with Helen Mason of Cambridge University. "These spectacular events in the Sun's atmosphere must have widespread effects. Our next step will be to try to relate the solar tornadoes to observations of the fast solar wind farther out in space, as seen by other instruments in SOHO."

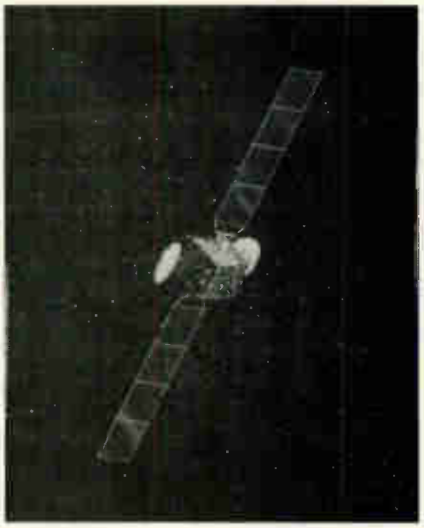
Solar storms are expected to increase in ferocity and frequency over the next couple of years, and SOHO is the world's solar watchdog. From a special vantage point 1.5 million kilometers out in space, where the Sun never sets, the spacecraft observes solar activity for 24 hours a day. Its images go to the regional warning centers of the International Space Environment Service, which alert engineers responsible for power systems, spacecraft and other technological systems to impending effects on the Earth's environment.

Satellite rescued in first commercial lunar mission

In a Star-Trek like "sling-shot" maneuver, Hughes engineers have retrieved a lost communications satellite and are swinging it around the moon en route to a geostationary Earth orbit from which the satellite can fulfill its intended mission for terrestrial customers.

The unprecedented salvage mission was devised by orbital analysts at Hughes Space and Communications Company, which built the HS 601HP model spacecraft.

Analytical Graphics, Inc., producer of Satellite Tool Kit software for the aerospace industry, is supporting Hughes with the mission. Their software enabled engineers to determine the fuel burns necessary to boost the satellite's apogee and use the moon's gravity to fling it into geostationary orbit.



The maneuver will use most of the 3700 pounds of propellant onboard the satellite. "We're going for the best obtainable orbit," says Ronald V. Swanson, HGS president.

This is the first known commercial use of the moon and the first lunar mission attempted by a non-governmental entity.

The lost spacecraft, originally called AsiaSat 3, became stranded in an unplanned orbit after a failed launch on Christmas Day of last year.

The spacecraft was originally intended for geostationary orbit (36,000 kilometers/23,000 miles) over Asia, but the fourth stage of its Russian Proton booster rocket shut down prematurely, stranding the satellite in an inclined elliptical orbit.

After the launch failure, the original owner of the spacecraft, Asia Satellite Telecommunications Co. Ltd. of Hong Kong, filed an insurance claim declaring the spacecraft a total loss.

Hughes Global Services, Inc., (HGS) worked out a deal with the insurers, got title to the spacecraft, and plunged into the high-risk salvage mission. Hughes controllers fired the satellite's onboard rocket motor several times to raise the craft out of its elliptical orbit of 350 kilometers by 36,000 kilometers (217 miles by 22,300 miles).

The last firing, on May 7, sent the satellite on a 9-day round-trip to the moon. The untried maneuver is sending the spacecraft into a three-dimensional figure-8 orbit around the moon, using lunar gravity to fling it back into a usable Earth orbit.

"While NASA has used gravity assists to send spacecraft off on interplanetary missions, no one has ever tried it to bring a communications satellite back into Earth orbit," Swanson says, although a similar maneuver was used during the early Apollo missions.

"It's a very powerful, capable satellite," Swanson adds, "and the potential applications are great if we can get it into a usable orbit. Keep in mind, however, that nothing like this has ever been done and it is still an experiment."

The satellite is fully functional and capable of covering more than a quarter of the Earth. It had been kept in a stowed and dormant state until its fate was decided. With 44 high-power active transponders–28 in C-band and 16 in Ku-band–it was built to provide television distribution and telecommunications services throughout Asia, India, the Middle East, Australasia, and the Commonwealth of Independent States.

The wide coverage area, plus fixed and steerable spot beams, would make it a valuable and flexible asset, Swanson says.

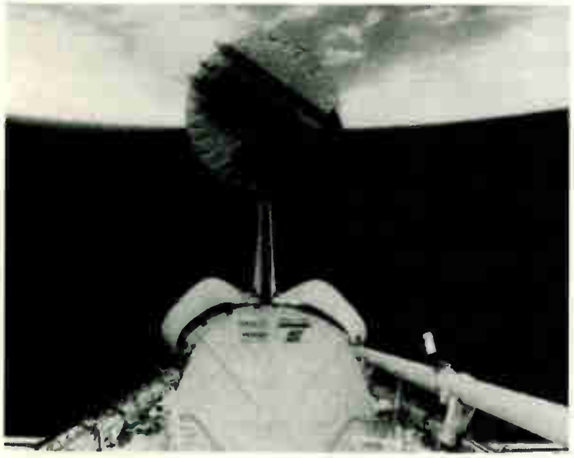
The U.S. and Air Force Space Commands, NASA's Goddard Space Flight Center, and EMBRATEL of Brazil are also assisting in the rescue mission.

Australian military will use U.S. satellite

Through an unusual arrangement between Hughes Global Services, PanAmSat Corporation, and the Australian Defense Force, a Hughes-built communications satellite formerly used by the U.S. Navy is now providing communications services for the Australian military. The craft will provide that nation with ultra high frequency satellite communications services for the next five years, if all options of the arrangement are exercised.

To perform its new mission, Leasat 5, owned and operated by PanAmSat, had

SATELLITE MONITOR



to be moved from its original position over the Indian Ocean to a new location at 156 degrees East longitude.

PanAmSat will monitor and control the spacecraft's attitude and orbital position via tracking, telemetry, and control, and will monitor and control its communications payload.

"This satellite was literally within days of being propelled into useless orbit, since its service to the U.S. Department of Defense had been completed," said Ronald V. Swanson, president of Hughes Global Services.

"We were able to expedite the U.S. government approval for the relocation and operation of Leasat 5 on behalf of our customer, the Royal Australian Navy. It's a win-win situation," Swanson said.

Leasat 5 began limited service to the Australian Defense Force on Oct. 17, 1997. On March 4, the relocation began with the successful execution of the first of a series of on-board thruster burns. Full service began on May 7.

The PanAmSat Operations Center in Long Beach, Calif., provides tracking, telemetry, and control capability via its Guam ground station, and also plans and executes all orbital maneuvers.

When built, the 14-foot-diameter spin-stabilized satellite was one of a new line of wide-body spacecraft designed exclusively for launch from the Space Shuttle. The last of a five-satellite constellation, it was launched in January 1990 and leased to the U.S Navy for five years.

Leasat satellites were used for mobile air, surface, subsurface, and fixed Earth stations of the Navy, Marine Corps, Air Force and Army.

The communications payload of Leasat 5 consists of two large helical UHF antennas, providing receive and transmit capability in the UHF band (240 to 400 MHz). Telemetry, command and Fleet Broadcast uplink and beacon are in the "exclusive" portions of the SHF band (7250 to 7500 MHz, and 7975 to 8025 MHz). Twelve UHF repeaters provide the main communications capability.

Mountain climbers may help space station astronauts

As four climbers ascended Mt. Everest in mid-May, NASA and Yale University were monitoring their health for use in studies to improve space science technology.

It seems the medical challenges of high altitude adaptation and physiological stress of mountain climbing are similar to those faced by astronauts in space.

"In a few months we will begin assembly of the International Space Station with an eye toward further exploration of our solar system," says NASA Administrator Daniel S. Goldin. "To ensure a safe trip for our astronauts, we need the best computational, communication, engineering, and medical technology. At NASA, we are working on virtual environments for surgery, decision support systems and the most advanced medical monitoring techniques. Just think what this could mean for health care here on Earth. The NASA-Yale project is helping us achieve these goals. I wish our Mt. Everest pioneers great success as they help NASA climb the final frontier."

A team of Department of Defense and MIT personnel were to be stationed at base camp at 17,500-feet. Sensors were to monitor and transmit back to camp the climbers' vital signs and location. Video of their progress was also to be transmitted.

Scientists hope the tests will lead to improvements in automated medical monitoring and care systems for astronauts who will be in space for months at a time.

And finally...

Speaking of vital signs, just when I was learning to like coffee, researchers came out with a warning that "coffee causes health problems."

Soon afterward they told everyone "eggs cause high cholesterol." My wife limited me to two eggs a week.

And my favorite: "salt causes high blood pressure." Have you ever really *tasted* those salt substitutes? Yuk.

"Research," I often muse to my obese friends, "causes worry."

Ah, but this morning I rolled out of bed, navigated on instinct to the coffee pot, drank four cups black and bitter, ate three eggs (with extra salt), and chased them with a slab of bacon. In repentance I exercised all the way to my recliner to do some serious research for this column (grueling work but someone has to do it.)

"Damn the researchers," I told my wife, "make another pot of coffee." One of these days they'll make a mistake and I'll be ready, I mumbled. At that very moment I opened the morning newspaper and dropped my jaw at a blooper headline: "Research causes cancer in rats."

It may have been a blooper but, hey, truth is where you find it. Here was the proof I'd been waiting for: research is bad for us.

"Ha!" I said. With soaring spirits, I gazed in ecstasy out the east window at the golden sunrise and discretely expressed my glee to a bluebird smiling at me through the rainbow in the glass. I was a kid again, squirming in my chair and singing "Na na naw ne na naw. Research causes cancer."

"What on Earth are you chanting about?" my wife yelled from the kitchen.

"Justice, dear" I replied. "Poetic justice." ST

Sources: European Space Agency, Hughes Global Services, Inc., NASA, Space Telescope Science Institute

Reach out to the Future of Portable, Global Communications

Get Global E-mail in a Handheld Package: The Magellan GSC-100 is Shipping Soon!

Customers have clamored for the **GSC-100** from the time we first introduced it in *Satellite Times* more than a year ago. Now, 12 of the planned 36 ORBCOMM satellites are in low earth orbit, and the system is scheduled to be switched on by September 1998. **The era of handheld global communications has begun!**

Magellan says users who activate their GSC 100 units with ORBCOMM by Sept. 30, 1998, will receive special pricing for the first six months of service, featuring **no monthly access fee and no limit on the size of the first 10 messages. (See the April '98 ST for more information.)**

The GSC 100 gives you the ability to **send and receive e-mail messages to and from anywhere on Earth**. It lets you stay in touch wherever life takes you. And, with its **integrated GPS receiver**, the GSC 100 not only lets you know where you are, it guides you anywhere you want to go. You can also relay that position to anyone, anywhere—no matter how remote you may be—with a GSC 100 e-mail message.

The GSC 100 utilizes the **ORBCOMM network**—the world's first wireless, two-way satellite personal communications system, providing true global coverage. Because the GSC 100 uses standard e-mail protocols, sending and receiving messages is easy. Communicate to any e-mail (Internet) address or another GSC 100. **Additional services will allow you to send your message via fax or voice.**

The GSC 100 communicates with the satellites on a standard narrow-band VHF frequency. Your e-mail message goes up to an ORBCOMM satellite and then down to a gateway station and is routed to its final destination via traditional methods. Retrieving your incoming e-mail is just as easy.

Unlike traditional land-line, cellular, and paging systems, the space-based ORBCOMM network offers global coverage, eliminating dead zones and providing seamless worldwide communications. The GSC 100 is a **convenient, reliable, and affordable solution for your global communication and navigation needs.**

*The first hand-held global satellite communicator with integrated **e-mail** and **GPS** is available from Magellan and Grove Enterprises. Winner of the 1997 Consumer Electronics Manufacturers Association's Innovations '97 Award at the Winter CES Show in Las Vegas.*

Twelve of the planned 36 ORBCOMM satellites (shown below) are now in place. Read Satellite Times *for updates on future launches.*

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Solar Cycle 23: What a Blast!

By Philip Chien, Earth News

This is an image of a solar flare as seen in H-Alpha. (Courtesy National Solar Observatory/Sacramento Peak)

Even animals realize that weather exists–when it storms animals seek shelter. Early civilizations realized that weather came in seasons with long-term predictability. And early astronomers realized that Aurora were brighter in some years than others. But it wasn't until recently that there was an awareness of another type of weather beyond the Earth's atmosphere and how it affects day-to-day life on Earth.

Space weather is as complicated and hard to predict as weather in the atmosphere. Like conventional weather, space weather has long term climates as well as day-to-day events. And as with Earth weather, space weather comes primarily from the sun. Our sun is a magnetically variable class G0 star, and the only star close enough to study in detail. It generates 4×10^{23} kilowatts of energy every second, enough to supply the U.S. with all of its energy needs at the current rate of usage for the next nine million years. The sun is a population II star, and has enough hydrogen to produce energy for another hundred billion years or so. But don't make any really long-range plans; within 10 to 20 billion years the sun will turn in to a red giant, engulfing the inner solar system–including the Earth.

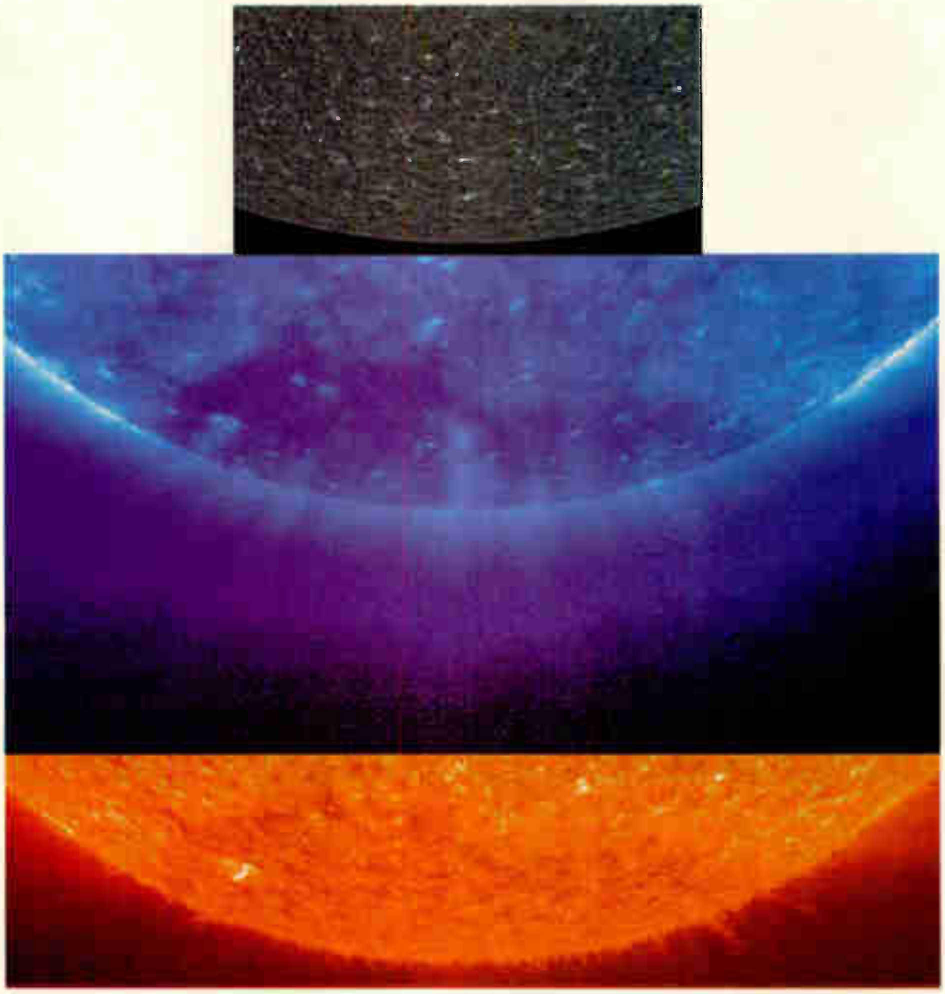
The sun goes through an eleven year solar cycle which has been tracked for hundreds of years. The most notable feature on the sun is sunspots–areas which appear dark in comparison with the rest of the sun's surface. When the sun's at the peak of its cycle the Earth's ionosphere expands, interfering with long-range shortwave signals. The last solar maximum was in 1989 and we are now just coming out of a solar minimum.

The biggest transients on the sun are solar flares–up to the power generated by 40 billion Hiroshima-class atomic bombs. Flares can be observed in optical wavelengths by ground-based telescopes, and in bursts of radio noise. Solar flares radiate throughout the electromagnetic spectrum–from the highest energy gamma rays through the lowest frequency radio signals.

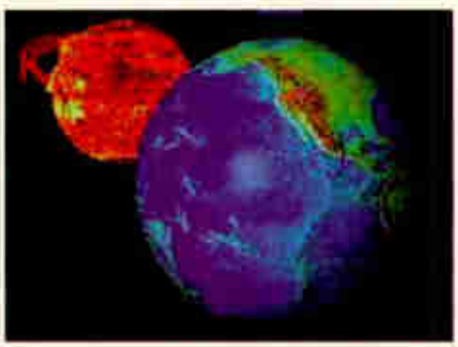
The Earth's magnetic field normally protects it from most solar outbursts. The magnetopause is normally at a distance of 10 Earth radii; however, during intense storms the magnetopause shrinks to just 6.6 Earth radii–about the altitude of geostationary satellites. Intense solar storms have resulted in critical electronics failures on a handful of geostationary satellites.

The most obvious effect of solar storms is the aurora, at least at high altitudes. Shortwave communications, which rely on signals bounced off charged layers of the ionosphere, are also affected. While GPS satellites transmit microwave signals which are not bounced off of the ionosphere, the accuracy of GPS positions are dependent on the density of the ionosphere. A rapid variation can cause GPS signals to lose accuracy. At periods of solar max, large satellites at low altitudes require more propellant to remain in orbit due to the increased atmospheric drag effects.

On the other hand, this is also an advantage since the increased atmosphere tends to remove space debris from low altitude orbits. During the most intense solar storms a space shuttle flight may have to be called home early to prevent excess radiation hazards. If a lunar base had existed during a particularly intense storm in October 1989, an astronaut on the moon's surface wearing only a spacesuit and caught unaware would probably have died. Lunar bases will require radiation shelters just in case, and NASA is examining potential radiation shelters for the space station's Habitat module.



Sources of the Solar Wind? "Plumes" of outward flowing, hot gas in the Sun's atmosphere may be one source of the solar "wind" of charged particles. These images, taken March 7, 1996, by the Solar and Heliospheric Observatory (SOHO), show (top) magnetic fields on the sun's surface near the south solar pole; (middle) an ultraviolet image of the 1 million degree plumes from the same region; and (bottom) an ultraviolet image of the "quiet" solar atmosphere closer to the surface. (Courtesy ESA/NASA)



This composite image showing the Earth in the foreground and the Sun in the background is courtesy of the National Geophysical Data Center (NGDC).

The operational NOAA satellites are primarily intended to observe the Earth's weather. Imaging and sounding instruments are aimed down towards the atmosphere. But these spacecraft also include Space Environment Monitor (SEM) instruments. The geosynchronous GOES satellites include a magnetometer, energetic particle sensors (EPS), and a solar X-ray monitor. Future GOES satellites will include a solar X-ray telescope returning full-disk images of the sun. X-rays pass through conventional mirrors, so X-ray telescopes need to use grazing mirrors, similar to skipping a rock off a pond's surface. The Soft X-ray Imager (SXI) will make continuous coronal x-ray images through several broadband filters in the soft-xray wavelengths of 6 to 60 Å. These images will be used to monitor solar activity for its effect on the Earth's upper atmosphere and near space environment.

The lower altitude NOAA polar satellites, well within the Earth's protective magnetic field, feature the Total Energy Detector which

monitors energy fluxes between 300 and 20,000 electron Volts (eV) and the Medium Energy Proton and Electron Detector (MEPED)–four solid-state detector telescopes which measure the intensity of electrons between 30 and 1000 keV.

NOAA flies operational satellites which are used as day-to-day tools by meteorologists as well as by theoretical scientists. Other spacecraft are flown for pure science, intended to examine why the sun-earth environment operates the way it does. Experimental scientific satellites carry one-of-a-kind scientific instruments and it's rare for satellites to be funded or flown in a series. In experimental satellites it isn't as important for the data to be returned in real-time. In addition the data may require more refinement before it's in an understandable format. Still, various complementary scientific satellites are useful for measuring space weather.

NASA, the European Space Agency, the Japanese space agency NASDA, and other space faring nations have been participating in the multinational International Solar-Terrestrial Program (ISTP). The primary spacecraft in this series are Geotail–a joint U.S./Japanese effort; Polar and Wind–U.S. spacecraft; SOHO–a joint U.S/European effort; and Cluster–a European effort. Other parties also participate in each of these spacecraft.

The Cluster series was lost in the Ariane 501 accident, but the other spacecraft are all in operation. In addition over twenty other spacecraft, designed for other projects, have contributed useful data. Many different space physics spacecraft have been launched before the ISTP project was established. The first U.S. satellite, Explorer 1, detected the Earth's magnetic fields. An Explorer-class satellite launched in the 1970s, IMP-8 remains in operation returning valuable data.

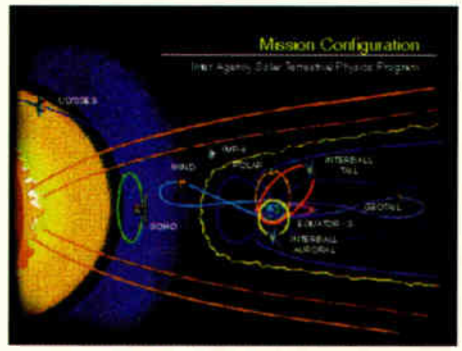


Diagram of the orbits of the various ISTP spacecraft observing the sun.

The ISTP web site at **http://www-istp.gsfc.nasa.gov/** includes online documentation, source code, programs, and access to the actual data from the various spacecraft. Real-time data is available for many of the instruments, including pho-

TABLE ONE: USEFUL SOLAR WEATHER WEBSITES

10 cm solar radio noise	**http://www.drao.nrc.ca/icarus/www/sol_home.shtml**
ACE satellite data quick look way to browse data	**http://www.srl.caltech.edu/ACE/ASC/view_browse_data.html**
ACE satellite home page	**http://www.gsfc.nasa.gov/ace.html**
Auroral Activity from NOAA/TIROS	**http://www.sel.noaa.gov/pmap/**
Excellent primer on the sun and space environment	**http://sec.noaa.gov/primer/primer.html**
GOES X-ray imager information	**http://wwwssl.msfc.nasa.gov/ssl/pad/solar/sxi.htm**
How far is it? (Useful for figuring station-receiver distances)	**http://www.indo.com/cgi-bin/suid/~bali/dist**
Information on different spacecraft involved in the sun-Earth environment	**http://nssdc.gsfc.nasa.gov/space/helios/cospar.html**
ISTP Events	**http://www-istp.gsfc.nasa.gov/istp/events/**
LASCO CME List	**http://lasco-www.nrl.navy.mil/cmelist.html**
Latest Yohkoh Satellite Solar X-ray Image	**http://www.lmsal.com/SXT/html2/Last_SXT_Image.html**
Los Alamos National Lab space weather page	**http://leadbelly.lanl.gov/lanl_ep_data/campaigns_projects/space_weather.html**
Near-Real-Time MUF Map	**http://solar.uleth.ca/solar/www/realtime.html**
NOAA SEC Radio Users' Page	**http://www.sel.noaa.gov/radio/radio.html**
NOAA's space weather web page	**http://www.sec.noaa.gov/**
Propagation Info Gopher	**gopher://proton.sel.noaa.gov/**
Propagation Support For HF Radio in North America	**http://www.ips.gov.au/asfc/usa_hf/**
Real time solar wind data	**http://www.sel.noaa.gov/wind/rtwind.html**
Shortwave Catalog: MUF/LUF Propagation Form	**http://itre.uncecs.edu/radio/mufluf.html**
SOHO Synoptic Database	**http://sohowww.nascom.nasa.gov/synoptic/**
SOHO: The Solar and Heliospheric Observatory	**http://sohowww.nascom.nasa.gov/**
Solar images at SDAC	**http://umbra.nascom.nasa.gov/images/latest.html**
Solar Propagation Information–The Latest	**gopher://solar.sec.noaa.gov:70/11/latest**
Solar Weather Bulletins/Forecasts	**gopher://gopher.sel.noaa.gov/**
Solar wind corotating interaction regions: The third dimension	**http://earth.agu.org/revgeophys/goslin01/goslin01.html**
Space Environment Center Home	**http://www.sel.noaa.gov/index.html**
Space Environment Center Prop Gopher Reports	**http://sec.noaa.gov**
Sun Imagery From a Variety of Sources	**http://www.lmsal.com/SXT/html2/First_Light.html**
The Repository	**http://www.millenngroup.com/repository.html**
Today's space weather	**http://www.sel.noaa.gov/today.html**
VHF Propagation Live	**http://raven.cybercomm.net/cgi-bin/cgiwrap/slapshot/vhfprop.sh**
Web page describing how amateur radio operators helped set up an IMP-8 ground station in Antarctica	**http://webhost.gsfc.nasa.gov/nasamike/essays/imp/imp.htm**

tographs, graphs, and numeric data.

The closer an observation platform is to its source the faster information can be gathered. And if the information can be relayed quickly, it can be put to use when it can do the most good. The SOHO and ACE spacecraft are located at the L1 point where the Earth and sun's gravity cancel each other out. If the sun and the Earth were the same mass the L1 point would be the point on a line halfway between their center of masses. But since the sun is much more massive than the Earth, the L1 point is located 1.5 million km. (930,000 miles) from the Earth.

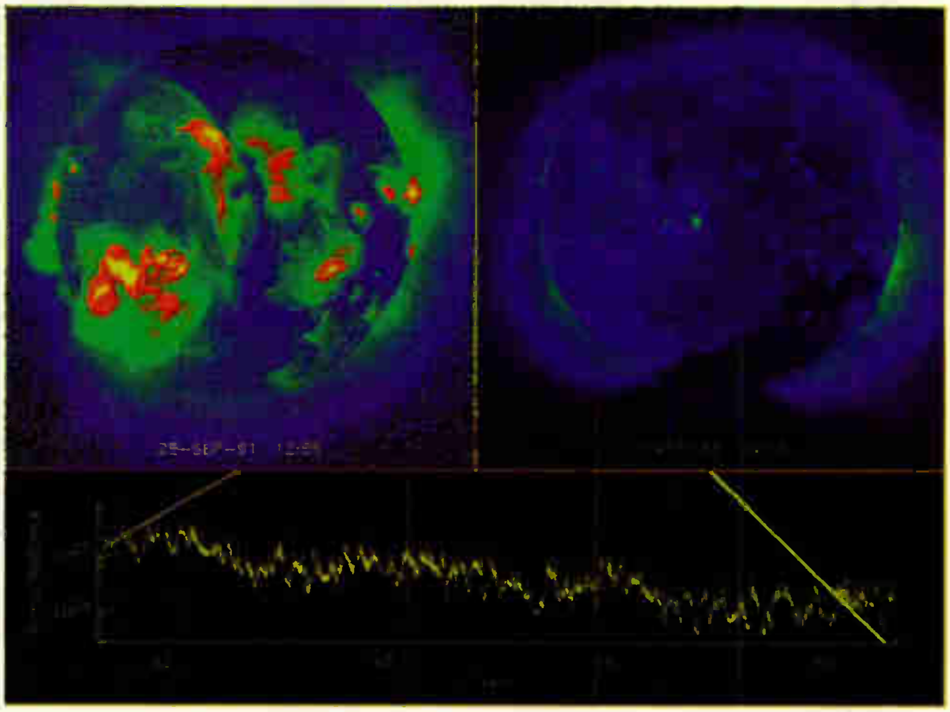
A solar storm passing through the L1 point is still five light seconds away from Earth. But, since solar storms are much slower than the speed of light, a satellite at L1 can give several minutes warning, enough time for electrical grid operators to reconfigure their systems and satellite operators to shut off critical electronics or engage protective systems.

The L1 location has several advantages, including no eclipses, a continuous view of the sun, and a direct line-of-sight to the Earth. The key disadvantage of the L1 location is distance. Since it's much further from the Earth than most satellites, a fairly powerful launch vehicle is required. The distance also requires more powerful radio transmitters on the satellite (or more sensitive receivers on the ground).

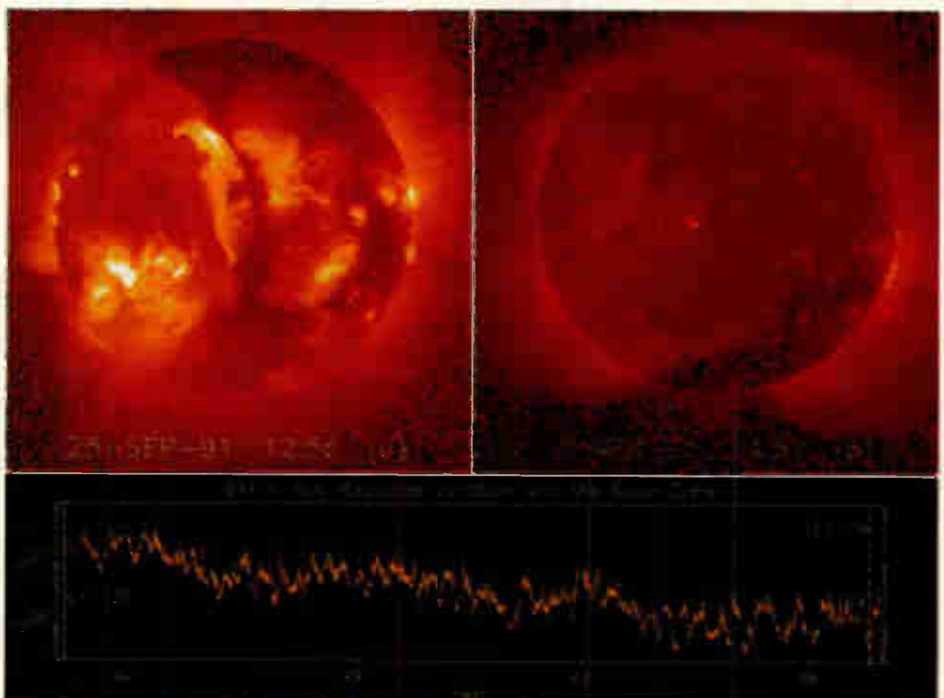
In practice the L1 location isn't the best place for a satellite. Any Earth-based antennas would have to aim directly towards the sun, since the L1 point is on the same line as the sun. This has the dual disadvantage of solar noise interfering with the signals from the satellite and increased heating for the antenna since it's pointed towards the sun. The alternative is a "halo orbit," an elliptical orbit which circles the L1 point. While the L1 point is where the sun and Earth's gravity cancel out it is not gravitationally stable. It's similar to balancing on top of a ball: While it can be done, the slightest upset causes you to fall off. So satellites at L1 have lifetimes limited by their onboard propellant supplies.

SOHO observes the sun continuously while ACE's instruments actually "sniff" the solar wind to measure the sun's particles chemically. While ACE was funded as a pure science experimental satellite, it also has operational functions. A subset of

The solar x-ray images above are from the Yohkoh mission of ISAS, Japan. The x-ray telescope was prepared by the Lockheed Palo Alto Research Laboratory, the National Astronomical Observatory of Japan, and the University of Tokyo with the support of NASA and ISAS.



The violently hot solar corona is visible in X-radiation. These images from the Yohkoh satellite show how the corona varies with the 11-year solar activity cycle. The bright corona at the left shows high activity, which may be associated with magnetic storms on the Earth and other injurious effects. The dark corona on the right shows the present situation (ca. 1995) of low magnetic activity. The plot at the bottom shows the time variation. Solar activity indicating the start of cycle 23 has already begun.



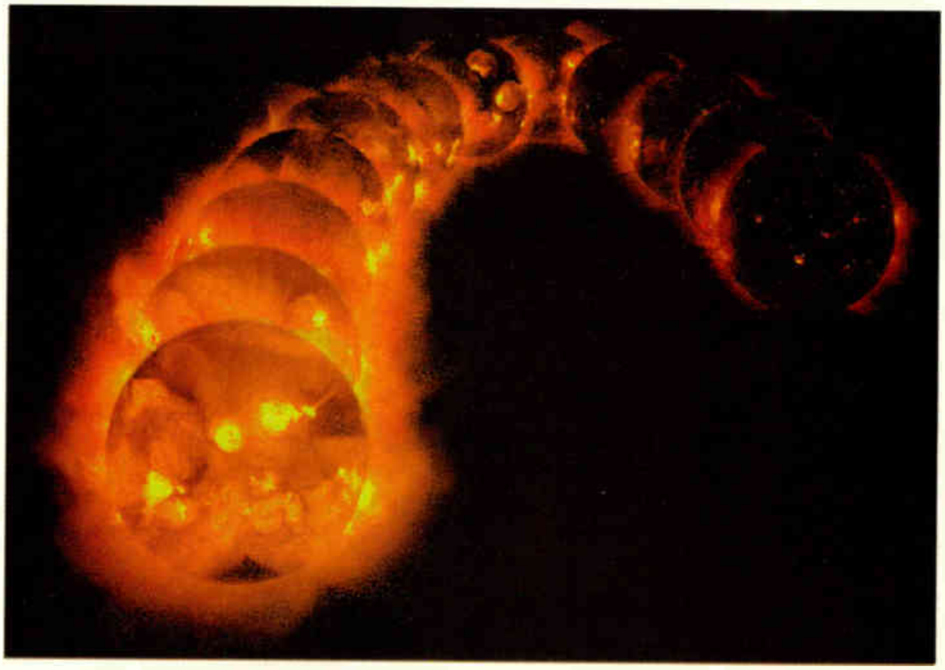
the data from some of the instruments is continuously transmitted to a worldwide network of receiving stations and forwarded to the Space Environment Center in Colorado. The data is available in near-real-time on the WWW at **http://www.srl.caltech.edu/ACE/ASC/view_browse_data.html.**

There are several excellent WWW sites with information about Space Weather, the satellites which are used to collect data, and the actual real-time data. Table one list some of the more popular and useful sites for the radio hobbyists and students of solar weather.

The Space Environment Center operates an automated listserver which transmits official bulletins. All you need is an email account to receive information directly from the source. The reports in table two are available through the SEC e-mail listserver.

Over the last few years, especially because of the internet and new solar satellites/sensors, the amount of information available to the radio hobbyists on solar weather conditions has exploded. It is now possible to listen at the receiver and directly correlate propagation conditions with the current solar weather.

While the accuracy of propagation forecasting isn't as good as terrestrial weather forecasts, with the armada of satellites looking at old Sol, the future of radio propagation forecasting looks very bright.



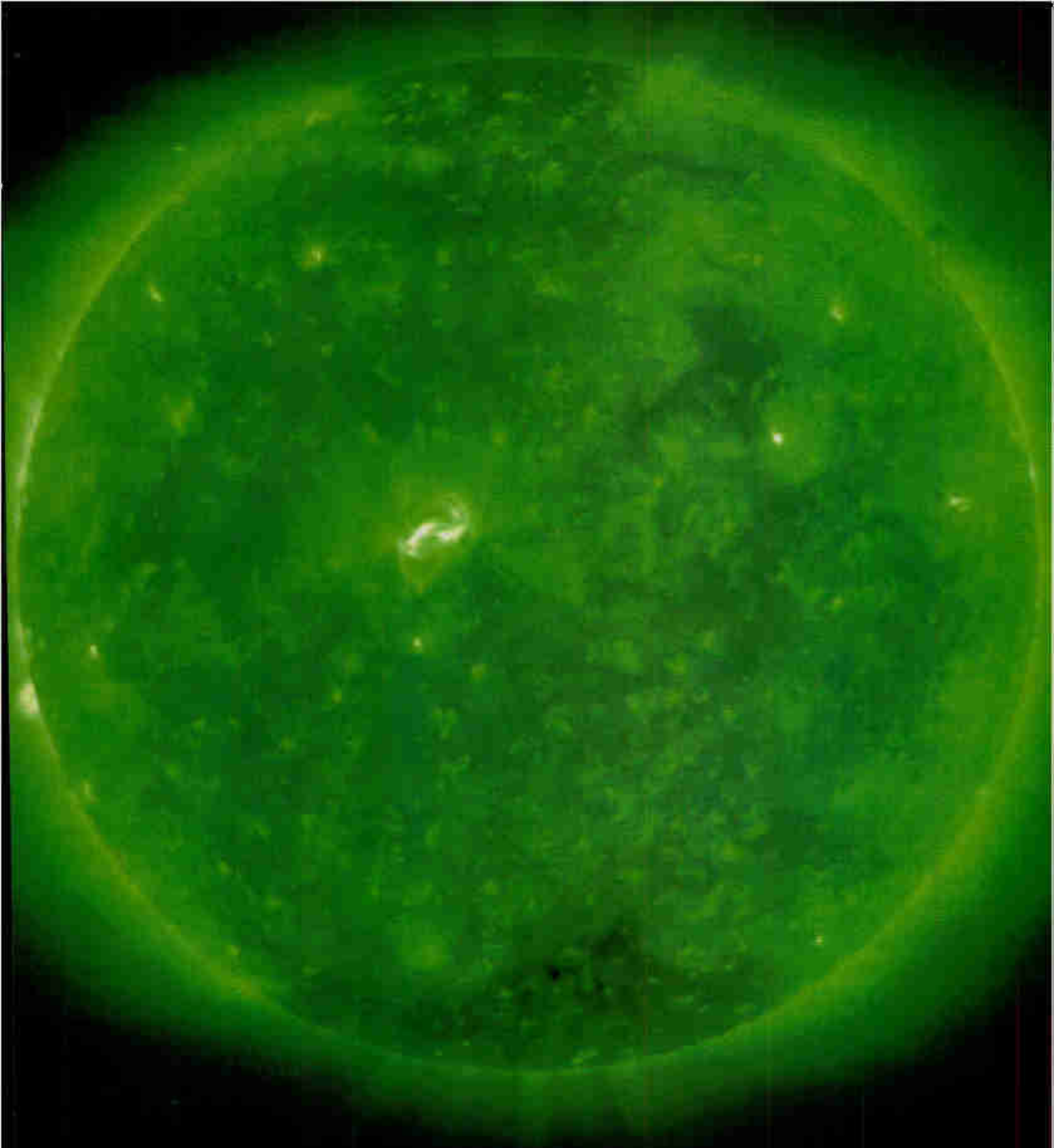
The 12 x-ray images of the Sun's atmosphere, obtained between 1991 and 1995 at 120 day increments, provide a dramatic view of how the corona changes during the waning part of the solar cycle. The x-ray Sun appears completely different from the Sun we see in the sky. Only very hot gases can emit x rays; the Sun's atmosphere, at millions of degrees, is hot enough to emit x rays, while the much cooler surface of the sun, at 6000 degrees C., is not. As a result, an x-ray image reveals a bright glow for the corona and a black disk for the surface of the Sun. In the corona, the shape and character of the hot gases are controlled by the magnetic fields, just as beads move with string upon which they are threaded. As the solar activity cycle progresses from maximum to minimum, the Sun's magnetic field changes from a complex structure to a simpler configuration with fewer fields. Since the Sun's hot gases are controlled by these fields, the x-ray images reflect this gloabl change, with an overall decrease in brightness by 100 times. (Courtesy of G.L. Slater and G.A. Linford)

TABLE TWO: SEC MESSAGES AVAILABLE VIA THE INTERNET

List Name	Message Name and Description
alerts-list	Space Weather Alert and Watch Messages–These messages are issued as conditions warrent.
forecast	Report of Solar and Geophysical Activity–A daily summary and analysis of solar and geomagnetic activity during the previous 24 hours as well as the most recent solar indices; it also includes a forecast of activity and indices for the next 3 days.
srs	Solar Region Summary–A daily report describing the active solar regions observed during the preceding day.
sgas	Solar and Geophysical Activity Summary–A daily report containing energetic solar event reports, plus solar and geomagntic daily indices for the previous day.
scdr	Solar Coronal Disturbance Report—A daily report describing coronal holes inferred from an image of the sun (in the Helium 1083 nm wavelength) and interplanetary solar wind observations.
geoa	GEOALERT–A coded message containing a summary of sunspot characteristics, energetic solar-geophysical activity, and selected solar-geophysical indices for the previous day, plus a brief forecast of solar-geophysical activity.
hfprop-list	USAF High-Frequency Radio Propagation Report–A forecast and description of HF Radio Propagation conditions, updated issed four times a day.
wwv-list	Geophysical Alert Message–The text of the SEC WWV and WWVH messages. The messages contains recent solar indices, a summary of present solar-terrestrial conditions, and a brief 24 hour forecast. It is updated every three hours.
wwire-list	SEC Weather Wire Messages–All messages send to the NOAA Weather Wire are also emailed to this list.

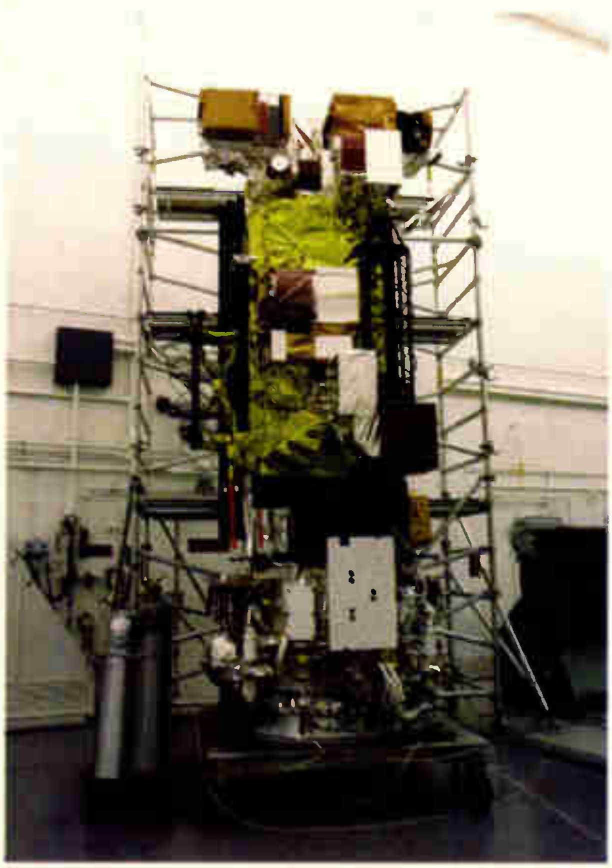
To subscribe to these list send email to **majordomo@sel.noaa.gov**with no subject line. In the body of the text type: subscribe wwv-list **you@your email.site**. Substitute the list name you want to receive for "wwv-list" in the example. Substitute your email address for "**you@your.email.site**" in the example.

To get information about a list send email to: **majordomo@sel.noaa.gov**and in the body of the message type: info wwv-list.



A New Look at the Sun. This image of 1,500,000 C gas in the Sun's thin, outer atmosphere (corona) was taken March 13, 1996 by the Extreme Ultraviolet Imaging Telescope onboard the Solar and Heliospheric Observatory (SOHO) spacecraft. Every feature in the image traces magnetic field structures. Because of this high quality instrument, more of the subtle and detail magnetic features can be seen than ever before. (Courtesy ESA/NASA)

The Next Generation of Weather Satellites



NOAA-K SPACECRAFT READY FOR LAUNCH - This photo shot on April 8, 1998 shows the National Oceanic and Atmospheric Administration (NOAA)-K Polar-Orbiting Operational Environmental Satellite being prepared for launch. Photo credit: NASA.

by Philip Chien

Everybody talks about the weather, but nobody ever does anything about it. To be fair, engineering is still far from powerful enough to influence or control weather, but weather forecasting has become much more reliable since the existence of weather satellites. The latest NOAA polar orbiting weather satellite adds new capabilities, providing more detailed information on the Earth's atmosphere, enabling meteorologists to generate more accurate models of the situation, and more accurate forecasts for the future.

NOAA-K was launched on May 13, from Vandenberg Air Force Base in California. NASA's Goddard Spaceflight Center is responsible for the procurement and launch of civilian weather satellites. Once the satellite is checked out on orbit it's given a numeric designation (NOAA-15 in this case) and turned over to the National Oceanic and Atmospheric Administration (NOAA).

NASA obtains launch services from the US Air Force. Surplus Atlas ICBMs, converted into launch vehicles by the addition of range safety destruct systems and improved electronics were used for the previous NOAA weather satellites. The inventory of flyable Atlas ICBMs was depleted and the Air Force decided to convert Titan II ICBMs into launch vehicles.

Titan IIs had been previously used by NASA in the Gemini program. Converted Titan II ICBMs were used to launch three military satellites, Landsat 6, the Clementine mission, and a military weather satellite.

The NOAA polar satellites are manufactured by Lockheed Martin (formerly General Electric) in Valley Forge, Pennsylvania. NOAA-15 will replace NOAA-12 as the morning satellite. NOAA-12 was launched in 1991 with a nominal lifetime of three years. Satellites usually last much longer than their planned lifetimes, which makes up for the few satellites which have activation or early failures like NOAA-13 which was launched in 1993. The exact length of time a satellite remains in operation is a vague number since instruments degrade gradually over time. Occasionally an older satellite can be nursed along with manual commands to override failed components.

From the outside NOAA-K looks similar to the recent NOAA polar orbiting weather satellites. But under the skin it has had many improvements. (See the article *NOAA-K: A Brief Overview of Changes* which describes the various improvements).

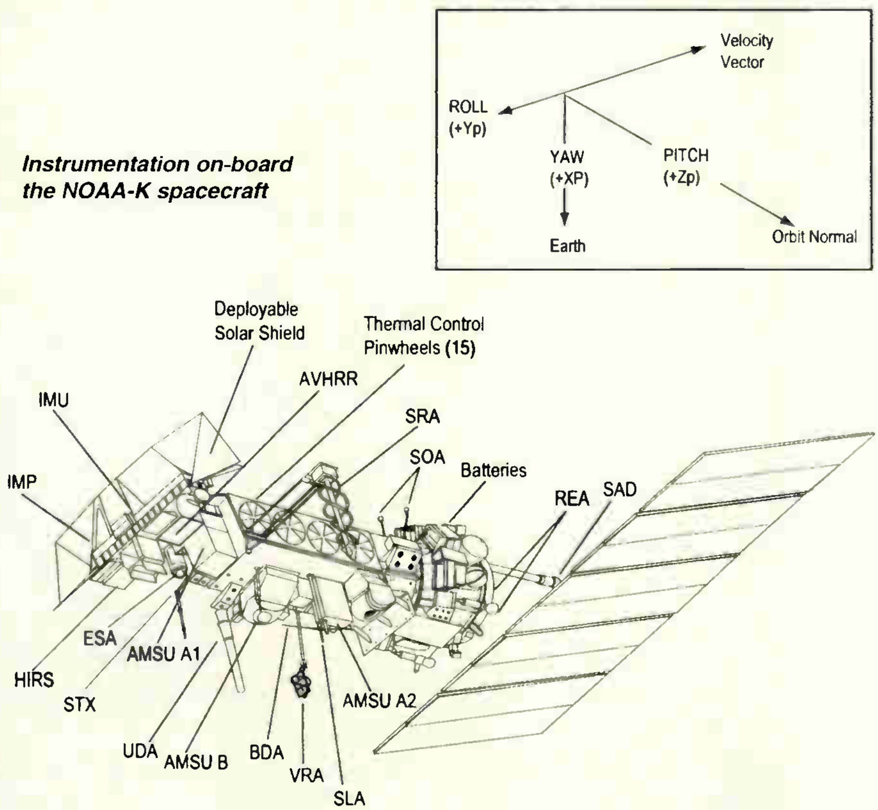
More significant changes are in store for future polar orbiting weather satellites. For many years it's been questioned why there is a requirement for separate military and civilian weather satellites with complementary purposes. In addition the NOAA satellites serve the entire world, even though they're funded by the U.S. taxpayer.

The first European polar satellite, METOP-1 is scheduled for launch in 2002. It will be the first satellite to feature Low Resolution Picture Transmission (LRPT) instead of APT (Automatic Picture Transmission). LRPT is a digital system which will permit more data to be transferred than APT.

LRPT increases the number of channels from two to three and spatial resolution increases from 4 km to 1 km. In addition while APT only transmits data from the imaging instruments LRPT will permit the addition of the sounding instruments which measure the temperature and moisture in the atmosphere. LRPT is expected to operate at 72,000 bps.

NOAA plans to continue the use of analog APT through NOAA-N Prime which is expected to operate through

Instrumentation on-board the NOAA-K spacecraft



LEGEND

AMSU	Advanced Microwave Sounding Unit	SAD	Solar Array Drive
AVHRR	Advanced Very High Resolution Radiometer	*SAR	Search and Rescue
BDA	Beacon Transmitting Antenna	SEM	Space Environment Monitor
*DCS	Data Collection System	SRA	Search-and-Rescue Receiving Antenna
ESA	Earth Sensor Assembly	STX	S-Band Transmitting Antenna (1 of 4 shown)
HIRS	High Resolution Infrared Radiation Sounder	SLA	Search and Rescue Transmitting Antenna (L-Band)
IMP	Instrument Mounting Platform	SOA	S-Band Omni Antenna (2 of 6 shown)
IMU	Inertial Measurement Unit	*TED	Total Energy Detector
*MEPED	Medium Energy Proton/Electron Detector	UDA	Ultra High Frequency Data Collection System Antenna
REA	Reaction Engine Assembly	VRA	Very High Frequency Real-time Antenna

* Not shown in this view

NOAA/NESDIS Office of Research and Applications

The AMSU-A and AMSU-B instruments will provide valuable information for deriving a number of non-sounding related products

✦Over the Ocean

–precipitable water

–cloud liquid water

–sea ice concentration

–instantaneous rain rate

–cloud ice content*

–sea surface wind*

✦Over Land

–snow cover

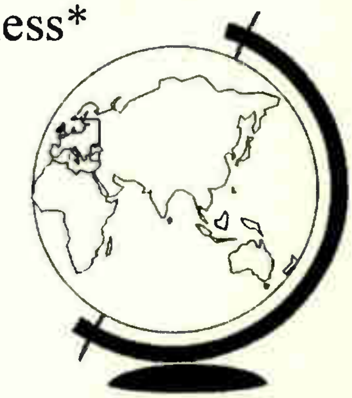
–instantaneous rain rate

–surface emissivity

–snow depth*

–surface temperature*

–surface wetness*



products with an * are particularly difficult and are not expected to be ready for transition to operations as soon as the others

the year 2010. NOAA-L and NOAA-M, the next two satellites, will continue to use the existing APT frequencies. NOAA-N and NOAA-N Prime will transition to the new APT frequencies 137.1 and 137.9125 MHz.

The National Polar Orbiting Satellite System (NPOESS) combines the NOAA and DMSP programs. Its first satellite will be launched

around 2005, introducing LRPT for U.S. satellites. It will use the same transmission frequencies as NOAA-N and NOAA-N Prime.

Besides the low altitude polar satellites the geosynchronous GOES satellites will transition from WEFAX to Low Rate Image Transmission (LRIT) on GOES N starting in 2002. Europe is planning a Meteosat second generation (MSG) system which will begin in 2000. LRIT is expected to be a digital packet system transmitting at 128k bps with a bandwidth of .66 MHz and 8 bits resolution.

There will be a transition period during which existing satellites will use APT and WEFAX as new satellites are introduced with LRPT and LRIT capabilities. It's difficult to predict how much improvement will happen over the next decade in radio receivers and microcomputer technology, but there's no doubt that hobbyist LRPT and LRIT receiving stations will be ready to go by the time the next generation of satellites are launched.

Sources for additional information: Information on the polar satellites is available on the World Wide Web at:

http://poes2.gsfc.nasa.gov and at http://www2.ncdc.noaa.gov/docs/intro.htm

An excellent guide on how to build an APT system is available from NOAA for free. Call Wayne Winston at 301-457-5681 and ask for a copy of the *User's Guide for Building and Operating Environmental Satellite Receiving Stations,* July 1997 edition.

Grove Enterprises (the publisher of *Satellite Times* magazine) sells the *Weather Satellite Handbook* (Bok 56) for $19.95 plus $5.50 shipping and handling. Call 800-438-8155 in the U.S. or Canada, 828-837-9200 elsewhere. Fax your order to 828-837-2216 or send your order via the internet to **order@grove.net**. You can get more information by visiting the company website at **http://www.grove-ent.com.**

NOAA-K CHARACTERISTICS

Main body:	4.2m (13.75 ft.) long, 1.88m (6.2 ft.) diameter
Solar array:	2.73 by 6.14m (8.96 by 20.16 ft.): 16.76m² (180.63 ft.²)
Weight:	At liftoff 2231.7 kg (4920 lbs.) Weight includes 756.7 kg of expendable fuel.
Lifetime:	Greater than 2 years
Load Power Requirements:	833 Watts fopr 0° sun angle, 750 Watts for 80° sun angle

NOAA-K: A BRIEF OVERVIEW OF CHANGES

The NOAA-K, L, and M are the successors to the current NOAA polar orbiting satellites. These new satellites carry a series of instruments which have been modified and improved from the instruments on the existing operational satellites.

The Advanced Very High Resolution Radiometer (AVHRR/2) has been modified. The new instrument, AVHRR/3, adds a sixth channel in the near-IR, at 1.6 micrometers. This will be referred to as channel 3A and will operate during the daylight part of the orbit. Channel 3B corresponds to the previous channel 3 on the AVHRR/2 instrument, and will operate during the night portion of the orbit. The operational scheduling of the channel 3A/3B switching has not been precisely determined yet. A flag (Word 7, Bit 10) of the telemetry will indicate which of the two channels is operating. Splitting channel 3 in this way maintains the HRPT data format which was designed to handle five AVHRR channels. Channels 3A and 3B are output at the same telemetry locations.

Automatic Picture Transmission (APT) users will receive the AVHRR/3 channel 3A the same as channel 3B, with an ID wedge equivalent to grey scale wedge 3.

The AVHRR/3 visible channels (1, 2, and 3A) all have "split gains" or "dual slopes" that require the use of two calibration equations per channel, where previously one would suffice. The split gains, in effect, increase the sensitivity at low light/energy levels. The prime reason for these changes are to improve ice, snow and aerosol products produced from the visible channel data. The visible channel ramp voltage calibrations will also have dual slopes.

The Microwave Sounding Unit (MSU) and Stratospheric Sounding Unit (SSU) instruments have been deleted. NOAA-K will fly with Advanced Microwave Sounding units AMSU-A1, AMSU-A2 and AMSU-B. The AMSU-A is a 15-channel microwave radiometer in two separate units. For AMSU-A1,-A2, the word 0001H will be used as fill data most of the time in the telemetry stream. The new AMSU data is expected to provide improved temperature and humidity soundings. Additionally, window channels 1, 2 and 15 will provide information on precipitation, sea ice and snow cover. The AMSU-B is a five-channel microwave radiometer; three of the channels are centered on the 183.31 GHz water vapor line. The other two channels are at 89 GHz and 150 GHz.

The afternoon NOAA satellites include the Solar Backscatter Ultraviolet Radiometer (SBUV). While it was assumed that NOAA-K would be used as a morning satellite there was always the possibility that it could have been required as an afternoon satellite if there was an on-orbit problem with NOAA-14. So NOAA-K was built with the SBUV instrument just in case. NOAA-K carried the SBUV/2, which has only minor changes from similar instruments carried on previous spacecraft.

The new High Resolution Infrared Radiation Sounder (HIRS/3) will have the calibration sequence changed. On HIRS/2, the calibration mode required the use of three calibration targets (space view, cold target, and warm target). On HIRS/3, the cold target will not be routinely used in the calibration sequence, resulting in one additional scan line of Earth data (38 Earth scans per 256 second cycle).

The Argos Data Collection System (DCS) aboard the NOAA polar orbiting satellites will be improved for NOAA-K. The DCS/2 will have an increased data transmission rate (from 1200 to 2560 bits per second) and the onboard data recovery units (DRUs) will be increased from four to eight.

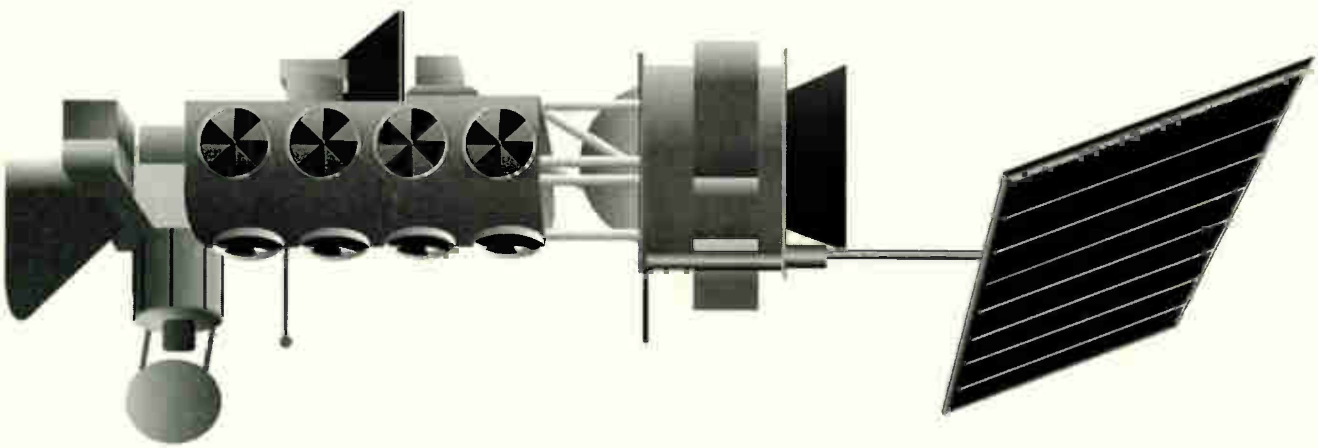
An improved Space Environment Monitor (SEM-2) has added in-flight calibration capabilities and improved particle detection. The Total Energy Detector (TED) will measure to a lower energy (0.05 keV versus 0.3 keV on NOAA-J). The Medium Energy Proton/Electron Detector (MEPED) has a fourth, omnidirectional, proton sensor for greater than 140 Mev. More data will will be included in the telemetry stream.

The Search and Rescue Processor (SARP) has added capabilities for the handling of distress messages. The number of Data Recovery Units has been increased from two to three.

With the new instruments, data formats will be changed slightly. Within the HRPT Minor Frame format, the first Minor Frame will be TIP data, the second Minor Frame will be spare, and the third Minor Frame will be the AMSU-A1, -A2, and B data.

Within the TIP Minor Frame (orbital mode format), the deletion of the MSU and SSU instruments will make available several words. DCS/2 data will now be contained in additional words 18, 19, 24, 25, 32, 33, 40, 41, 44, 45, 61, 68, 69, 76, 77, 86 and 87. HIRS data will move from words 14/15 to 16/17. Word 102 will be a spare.

As noted above, the third Minor Frame will contain only AMSU data. The AMSU information processor (AIP) inputs data from the three AMSU instruments and the TIP. This Minor Frame will contain 208 words. In summary, words 8 through 33 will contain AMSU-A1 data, words 34 through 47 will contain AMSU-A2 data, and words 48 through 97 will contain the AMSU-B data.



The Weather From Above

By Troy Thrash, Analytic Graphics

Since the days of Benjamin Franklin's local weather observations only two centuries ago, the study of meteorology has undergone several major technological revolutions. In the 1800's, data from ships at sea enabled weather watchers to attain a more global perspective of cloud and precipitation patterns. The 20th century saw the advent of the aircraft, weather balloon, radar, and rocket, all of which gave meteorologists a complete 3-D view of the entire atmosphere. In 1961, the first satellite devoted to the study of weather from space, Tiros-1, was launched, marking the advent of a new age of unprecedented volume and accuracy of weather data.

As satellites in orbit continue to proliferate to meet the changing needs of society, weather satellites do, too. With each passing day, more remote areas of the globe are becoming populated, requiring the extension of telecommunications, video and weather networks to provide for the needs of those people.

Today, vast amounts of weather data are collected and transmitted to virtually any location on the Earth via two distinct meteorological systems: a group of satellites in a low-Earth orbit designed to collect high-resolution data from even the most remote areas of the world daily, and a geostationary, Earth orbiting system which collects low- and high-resolution weather data continuously over large regions of the globe. Each system serves a specific function and, together with improved ground and airborne data-collection systems, allows for the most extensive and accurately-detailed weather data ever collected.

Into Each Life a Little Rain Must Fall...

From public to private activities on the ground, at sea, or airborne, everyone is affected by the phenomenon of weather. The couple going to take their dog for a walk needs to know if they should take an umbrella. Their son may not have his first baseball game today if the rain begins soon. Farmers rely on temperature and precipitation patterns to maximize crop growth. Construction crews need information on long-term weather patterns to determine the type of structures to build at a specific location and short-term forecasts to determine their building schedule. The military needs weather data for nearly every function they perform. Artillery and ground troops rely on accurate weather prediction for more efficient and effective operation. Long-range aircraft cannot be refueled in cloudy or turbulent skies. Even hi-tech lasers become ineffective over areas of excess humidity.

Although satellites orbit well above the Earth's atmosphere, they, too, are significantly influenced by weather. Satellites transmit and receive signals to/from other satellites and ground locations for communications, navigation, broadcasting, and data relay. As these signals travel through the Earth's atmosphere, they are partially scattered and absorbed by atmospheric particles such as rain, snow and ice particles, and the water vapor particles which form clouds. Satellites designed to image the surface of the Earth also are affected by the existence of these particles, as visibility decreases as the number of particles increases.

Data gathered by weather satellites allow people to better control the effects of weather on their daily lives. These data help weather forecasters provide advance warnings of floods, hurricanes, storms, and other severe weather and provide early detection of forest fires, fog, and volcanic activity mitigating the loss of lives, property, money, and time, and benefiting aviation, terrestrial, and marine activities around the world.

For these benefits to be realized it is important for weather data to become increasingly accurate as meteorological satellite systems evolve along with the demands of the people.

The Views from Our Eyes in the Sky

Weather satellites have been giving us views of the atmosphere from above for almost 40 years. The earliest satellites were placed into low-Earth orbits (LEO), in which the satellite orbits the Earth once every 100 minutes at a typical altitude of 850 km above the surface of the Earth. These satellites are in sun-synchronous, near-polar orbits, meaning they cross the equator at the same local time for each orbit and are inclined to pass close to the north and south poles of the Earth. With this inclination and the aspherical shape of the Earth, the orbital plane of the satellite rotates at the same rate that the Earth rotates around the Sun. Therefore, a sun-synchronous satellite passes over a specific location on the Earth at the same time each day.

These polar satellites orbit the Earth approximately 14 times per day. They make weather observations using sensors which have a rectangular beam pattern with a ground-swath width of approximately 3000 km. A sensor footprint of this size allows a polar satellite to collect a complete high-resolution data set of the entire atmosphere twice each day.

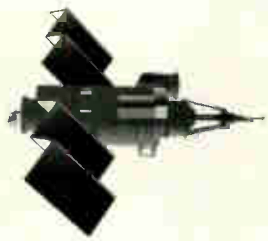
Since their sensors cover a particular location on the Earth for a very short period of time each day, polar satellites are best suited for long-term observations of the atmosphere. These observations include surface temperature, vertical atmospheric temperature and water vapor profiles, and global cloud cover over periods of days to years. For the same reason, polar satellites cannot monitor short-term meteorological events such as hurricanes and tornadoes.

In 1966, a satellite was launched with the purpose of allowing meteorologists to continuously monitor only a specific region of the globe. The satellite, called ATS-1, was launched into a geostationary orbit (GEO) and added a new dimension for weather observation and prediction.

GEO weather satellites collect low-resolution data from a circular orbit approximately 35,800 km above the equator, an orbit in which the period matches the rotational period of the Earth (24 hours). This orbit allows the satellite to remain above the same location of the Earth, appearing stationary from the point of view of the rotating Earth. Thus, a GEO satellite always views the same portion of the globe.

Sensors on GEO weather satellites are roughly circular and cover the full disk of the Earth visible from a geostationary orbit, approximately 42 percent of the Earth's surface. Thus, GEO satellites are ideal for monitoring rapid, short-term changes in weather systems and events as they make repeated observations over a fixed area on the Earth, providing constant watch for warning signs of tornadoes, hurricanes, and floods.

GEO satellites have two distinct disadvantages: they are too far away from the Earth to make accurate, high-resolution observations and they cannot image the polar regions beyond about 81 degrees latitude. These shortcomings are compensated for by the polar satellites. Together, the polar and GEO weather satellites comprise the global network of meteorological satellites, in place for weather data collection since the early 1970s.



What Your Sensors See is What You Get

The global network of meteorological satellites provides meteorologists with more data than just the satellite images we see on the evening weather forecast. Sensors on board the satellites collect atmospheric data ranging from the visible band through the thermal infrared band of the electromagnetic spectrum. This collection of sensors allows for a global data set of all climatological parameters which affect peoples' daily lives for any time of the day or night.

Both visible and infrared data are collected by a satellite's multi-channel imager. Visual channels are primarily used to take "pictures" of the Earth and the visible features of the atmosphere: clouds, precipitation, and fog. Over time, these images can show local and global weather patterns, including the onset and dissipation of storms, frontal movements, and wind patterns. Thermal infrared channels primarily collect surface and atmospheric temperature data. These data are displayed as a digital image of black, white, and shades of gray, each shade corresponding to a specific temperature at that location.

Another instrument used for collecting weather data is the atmospheric sounder. The sounder detects the temperatures of various atmospheric gases, from which temperature, moisture content, pressure, and ozone content can be deduced.

GEO and polar satellites also may contain one or more space weather sensors, which measure the degree of solar activity and the interaction between solar particles and the Earth's ionosphere. GEO weather satellites are also equipped to relay distress signals from land or sea to ground stations of the Search And Rescue Satellite Aided Tracking System.

From Satellite to User: The Weather Data Path

Following collection by the various satellite sensors, weather data are transmitted from the satellite to specific ground stations and processed in preparation for retransmission to the user community. After processing, the data are sent back to the GEO satellites, which retransmit the data to data-collection platforms across the globe. These platforms, found in both highly-populated and remote areas of the Earth, collect unencrypted, high-resolution weather data from the entire network of satellites. Most data, including data from civil weather satellites operated by the United States, the Russian Federation, China, Japan, and a European Consortium, are sent unencrypted to allow anyone with the proper receiver to obtain and manipulate the data. (Recently, however, the European Consortium began the practice of encrypting data from their GEO satellite in an attempt to sell commercial licenses to access the imagery data above and around Europe.)

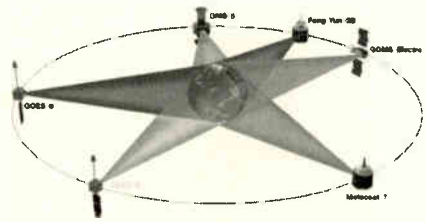
Weather data is transmitted to data

collection platforms in two different formats, depending on the needs of the user. Digital (high-resolution) data are commonly used by private industry and are sent via satellite to any location on the globe. The advantage of this type of data transmission is the elimination of the slower, less reliable web of telephonic cables. Analog image data, a low-resolution derivative of the digital data, are available for the commercial market. These data can be received by any individual or group owning a simple, shortwave receiver attached to a decoder.

All weather data are also collected by various weather organizations for analysis, prediction, archiving, and dissemination. At the top of the weather-data business is the World Meteorological Organization (WMO), which plays a major role in the coordination of the global network of meteorological satellites. Technical and operational control of the satellite network is provided by the Coordination Group for Meteorological Satellites (CGMS). Data archiving is the responsibility of organizations such as the National Climatic Data Center (NCDC), which maintains both national and global data sets. Other organizations, such as the Climate Prediction Center, perform the tasks which are deemed most important by almost everyone: they predict regional and global climate variations, analyses eventually seen on the broadcast of the evening news.

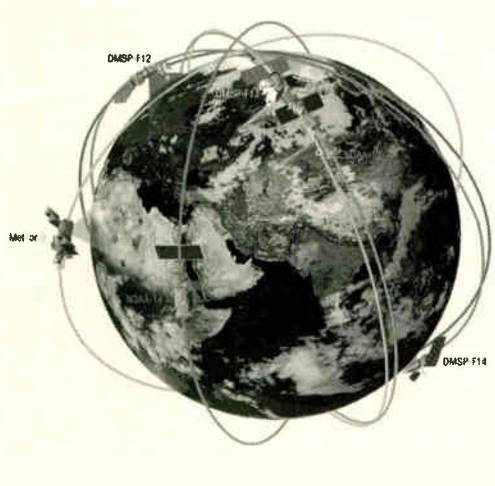
Present Status of the GEO and Polar Weather Satellites

As mentioned above, the global network of meteorological satellites currently



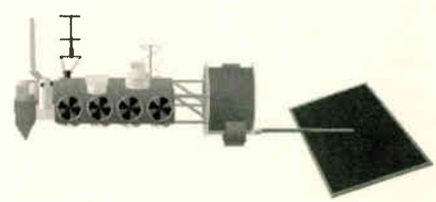
consists of two vital components: GEO and polar systems. The GEO component consists of six satellites from five countries. The United States operates two Geostationary Operational Environmental Satellites (GOES) under the direction of the National Oceanic and Atmospheric Association (NOAA). GOES-8 monitors North and South America and the western Atlantic Ocean while GOES-9 monitors North America and the Pacific Basin. Features of the current generation of GOES satellites include more efficient imaging and sounding capabilities and a more effective data processing and dissemination system. As result, GOES imagery is available to over 10,000 data collection centers in over 120 countries.

West of the orbital position of GOES-9 is the current Japanese weather satellite, Geostationary Meteorological Satellite (GMS)-5, which provides coverage of the western Pacific Basin. Feng Yun 2B is China's first geostationary weather satellite, filling in the data gap in the Indian Ocean-Southeast Asia region. Providing coverage for Asia, Africa, and the Indian Ocean is the Geostationary Orbit Meteorological Satellite (GOMS)-Electro, the Russian Federation's first meteorological satellite. Rounding out the GEO component of the satellite network is Meteosat-7, operated by Eumetsat, the consortium of 16 European countries dedicated to creating and operating a European weather satellite system. Meteosat-7 collects weather data for all of Europe.



Unlike GEO satellites, polar satellites are not defined by permanent positions. In fact, all polar satellites, including those of the current military and civil systems, cover the entire globe at least once daily. The United States launched the first polar-orbiting weather satellite in 1960 under the direction of NOAA. Today, NOAA has two active, polar satellites: NOAA-12 and NOAA-14. Each NOAA satellite orbits the Earth approximately 14.1 times a day, resulting in a complete, global set of atmospheric data daily. The Russian Federation operates up to five Meteor satellites in several orbital planes to provide global atmospheric infrared data.

The Defense Meteorological Satellite Program (DMSP) military weather satellites are of the same basic design, function, and orbital geometry as the civil polar satellites. However, because they are used to support U.S. Department of Defense operations, DMSP satellites have a higher overall sensor resolution and have instruments to view the atmosphere through a larger portion of the electromagnetic spectrum, including microwave imagers and sounders.



The Future of Weather Satellites

In the future, weather satellites will continue to be more accurate, effective, and efficient. Several GEO satellites with improved designs and new and enhanced sensors will replace their predecessors. NOAA is planning to launch at least six new GOES satellites by 2010 to provide more accurate weather and space environment data, along with a more reliable search and rescue system. Eumetsat is planning to deliver three Meteosat Second Generation (MSG) satellites to geostationary orbit by 2006. The Russian Federation, Japan, and China also plan to replace their existing satellites with improved versions within the next several years.

The polar component will also undergo expansion and improvement over the next two decades. The United States is planning for several new and improved polar satellites in the NOAA/TIROS series. These satellites will be used in conjunction with Eumetsat's three planned MetOp satellites to provide the most accurate and extensive weather data sets ever collected. The Russian Federation is also planning improved satellites in its Meteor series. Ultimately, by 2010, the United States plans to replace its civil and military polar weather satellite systems with the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program, which will comprise satellites with remote sensing, meteorological, and search and rescue capabilities.

Troy Thrash is a senior aerospace engineer at Analytical Graphics, Inc. All images were provided by Analytical Graphics, Inc.

GEO PROGRAMS

Program Name: Geostationary Operational Environmental Satellites (GOES)
Active Satellites: GOES-8, GOES-9
Country: USA
Operator: NOAA
Launch Date: 4/13/94, 5/23/95
Orbital Longitude: 74.6 degrees West, 135.3 degrees West
Planned Replacements: 7 GOES satellites planned for 1998-2003

Program Name: Geostationary Meteorological Satellite (GMS)
Active Satellites: GMS-5
Country: Japan
Operator: Japan
Launch Date: 3/18/95
Orbital Longitude: 140.0 degrees East
Planned Replacements: MTSAT-1 planned for 1999

Program Name: Meteosat
Active Satellites: Meteosat-7
Country: European Consortium
Operator: Eumetsat
Launch Date: 9/2/97
Orbital Longitude: 10.3 degrees West
Planned Replacements: 3 Meteosat Second Generation (MSG) satellites planned

Program Name: Feng Yun
Active Satellites: Feng Yun 2B
Country: China
Operator: Japan
Launch Date: 6/10/97
Orbital Longitude: 103.7 degrees East
Planned Replacements: Feng Yun 2C planned

Program Name: Geostationary Orbit Meteorological Satellite (GOMS)-Electro
Active Satellites: GOMS-Electro
Country: Russian Federation
Operator: RPA-Planeta
Launch Date: 11/31/94
Orbital Longitude: 76.5 degrees East
Planned Replacements: GOMS-N2 satellite planned

LEO PROGRAMS:

Program Name: Meteor
Active Satellites: Meteor 3
Country: Russian Federation
Operator: RPA Planeta
Launch Date: 8/15/91
Orbital Period: 109.3 minutes
Orbital Inclination: 82.5 degrees
Orbital Altitude: 1200 km
Planned Replacements: Meteor 3-M series slated for 2000

Program Name: National Oceanic and Atmospheric Administration (NOAA)
Active Satellites: NOAA-12, NOAA-14
Country: USA
Operator: NOAA
Launch Date: 5/15/91, 12/30/94
Orbital Period: 101.2 minutes, 102.0 minutes
Orbital Inclination: 98.6 degrees, 98.9 degrees
Orbital Altitude: 826x806 km, 861x846 km
Planned Replacements: 7 replacements planned

Program Name: Defense Meteorological Satellite Program (DMSP)
Active Satellites: DMSP-F12, DMSP-F13, DMSP-F14
Country: USA
Operator: United States Air Force
Launch Date: 8/29/94, 3/24/95, 4/4/97
Orbital Period: 101.9 minutes (for all)
Orbital Inclination: ~98.8 degrees (for all)
Orbital Altitude: ~856x842 km (for all)

Planned Replacements: 7 replacements planned

THE VIEW FROM ABOVE

By Lawrence Harris
lawrenceh@peverell.demon.co.uk
http://www.peverell.demon.co.uk

NOAA-K (15) Launched

Within a few hours of its successful launch on May 13, the first transmissions from NOAA-15's automatic picture transmission (APT) transponder were heard. Dale Ireland (who lives near the west coast of the United Kingdom) logged his first image at 0140 UTC on May 14, and I logged mine at 0840 UTC.

My initial impression of the NOAA 15 APT signal is that it is much weaker than the other NOAA birds with deep fades. At presstime, NOAA-12 remained operational, so we currently have four weather satellites transmitting in the VHF band–the other two being NOAA-14 and Meteor 3-5. Meanwhile, the image quality from Meteor 3-5 has improved significantly during the month of April. We no longer see the image jitter.

Over in Europe the switch from METEOSAT-6 to the new METEOSAT-7 is scheduled for June 3, necessitating a short maneuver for each satellite. Meanwhile METEOSAT-5 is fully operational and has been drifted to longitude 63 degrees east. Starting in July it will take part in the project to support the Indian Ocean experiment (INDOEX). This is an international project concerning pollution. For more details, you can visit the web site: **http://www.eumetsat.de/en/**

FIGURE 1: ***NOAA-15 0840 UTC on May 15 showing sun glint around the French coastline.***

Fengyun-2 suffers problems

The Australian Bureau of Meteorology (BOM) has been informed that FY-2 (the Chinese geostationary weather satellite) suffered a failure of the S-band antenna pointing mechanism on April 8. Vertical sounding and ranging was restored for about 12 hours on April 10, but no S-band services have been detected from FY-2 since. Information courtesy Mike Kenny of the Australian BOM.

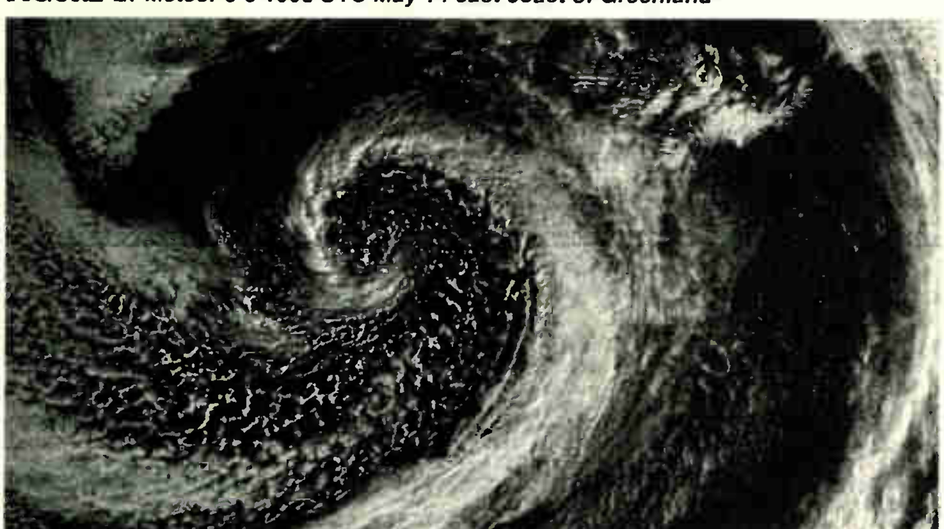
Global warming?

Pictures from a NOAA weather satellite have provided evidence that an area of ice about 40-km by 5-km on the Larsen B Ice Shelf (Antarctica) recently broke off, according to Ted Scambos, a research associate at the Co-operative Institute for Research in Environmental Sciences, a joint institute of CU-Boulder and the National Oceanic and Atmospheric Administration. Pictures from February 15 and March 23 confirmed the disintegrated area of ice. "The March 23 image made it crystal clear that a significant portion of the ice shelf had broken off." Earlier studies by the British Antarctic Survey predicted the 12,000 square kilometer ice shelf was nearing its stability limit.

UK Weather Satellite Conference

When the subject of the table talk at the evening meal is Meteor edge code–you know you are at the right place! So it was during the weekend residential conference on weather satellites organized by the United Kingdom's Remote Imaging Group (RIG). Conference ran from Friday evening May 1 through Sunday afternoon May 3, and I was pleased to have the opportunity to address the audience in my capacity as a columnist for *Satellite Times*.

FIGURE 2: ***Meteor 3-5 1008 UTC May 14 east coast of Greenland***



Remote Imaging Group - UK residential conference

RIG is a unique organization in Britain, catering to weather satellite enthusiasts of all ages and abilities. Membership is currently something over 2,000–including many overseas. For the second time in five years they held a residential conference–this time in Newport, South Wales. Conference organizer Dave Cawley (also the manager of Timestep Weather Satellite Systems–UK) introduced the speakers to the near-100 people attending.

Conference speakers

Frank Bell, current chairman of RIG, was the first speaker and has a long history of satellite monitoring. As head of science

"Although the cause of El Nino was not known, its existence was now quickly identified by satellite observations, and it is believed to self-destruct by its very nature."

Picture of Meteosat courtesy Eumetsat.

at a Guildford school, their station made the first contact with British astronaut Helen Sharman during her time on *Mir*. Frank introduced satellite-based activities to his pupils within the framework of the curriculum; during the STS-56 SAREX mission, Frank's group transmitted a picture of the students to the shuttle via slow scan television (SSTV).

Les Hamilton maintains the organization's collection of general remote imaging software for members. Between conference sessions, Les did impromptu demonstrations of software, enabling several members to discuss computer problems. Les's presentations within the exhibition center were well received and we spent a large amount of time discussing the various aspects of image processing and reception.

The RIG booth included various items of hardware and microwave components made by Sam Elsdon. Also on display were books and several copies of *Weather Satellite Report*.

El Nino

The latest research into this phenomenon was described by Carl Davies, an environmental scientist now in the second year of his Ph.D project on oceanographic studies at University College London. Carl said that although the cause of El Nino was not known, its existence was now quickly identified by satellite observations, and it is believed to self-destruct by its very nature. To study the phenomenon, a United States-funded, extensive global monitoring system had been set up, and this is making measurements of the oceans via buoys; data is relayed via satellite.

The orbit of the TOPEX/POSEIDON satellite–vital for this research–provides a 10-day repeat cycle. It monitors sea-surface roughness, and provides temperature and color measurements. Carl emphasized the need for continued satellite monitoring, which shows how the oceans respond to El Nino.

Fengyun-2 image from 0801 UTC April 10

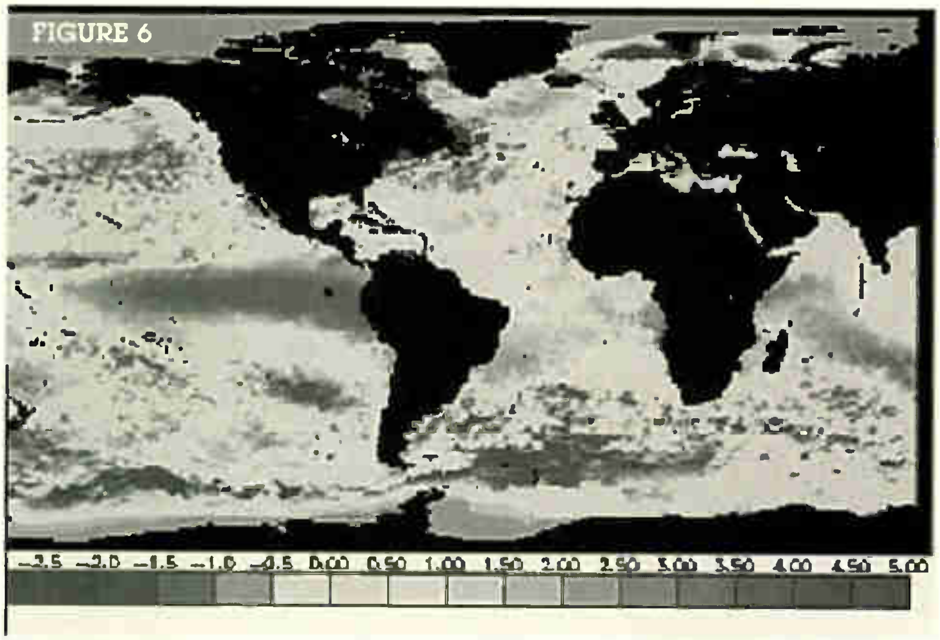
In my own presentation, I summarized the years which followed my leaving professional satellite operations with the early UK-series of scientific satellites into satellite monitoring as an amateur. I reported on the results of my contacts with UK suppliers of weather satellite equipment, which revealed that two UK companies had ceased trading and two others failed to respond to repeated requests for information. My enquiries of American companies were far more productive!

Another speaker, Steve Padar from the

FIGURE 5A: ***February 15 Larsen B Ice Shelf***

FIGURE 5B: ***March 23 Larsen B Ice Shelf***

Geoffrey Perry passed along a tip for ST readers to be on the lookout for OBZOR, a satellite likely to have the following orbital parameters and characteristics: inclination 83 degrees, 650 km circular orbit, period 97.8 mins.



Sea Surface Temperature anomalies from AVHRR channels in December 1997 (courtesy NOAA).

United States, currently monitors APT, WEFAX, EMWIN, HRPT, GVAR and SEASTAR from his home which overlooks the Gulf of Mexico. Steve had come to the conference to explain about two of the main data transmissions from GOES-8–GVAR and EMWIN. He pointed out that the data is freely available on the web, in addition to information on tornadoes. He confirmed that the telemetry was non-encrypted, and that there was even free software to decode images, but it was obviously necessary to assemble suitable hardware to receive the signals.

His explanation of NOAA's non-encryption philosophy produced a very appreciative audience reaction. This comment is significant for European audiences because high resolution image transmissions from the Meteosat satellites (Europe's equivalent of GOES) are almost all encrypted, requiring the purchase of a very expensive decoding box and therefore effectively preventing amateurs from seeing them. Only a few images are non-encrypted.

I had the pleasure of meeting with Geoffrey Perry prior to his talk, and mentioned that I had long admired his skill in signal analysis and his original work on the Russian satellite scene.

His interest in "space" apparently began in 1944 when a V2 fell a few miles from his home. He was a teacher at Kettering Grammar School when, in 1957, the first satellites were launched. He observed and photographed them and, in 1960, he and fellow teacher Derek Slater (G3FOZ) succeeded in tuning in to the newly launched Sputnik-4.

He continued to monitor Cosmos satellites during the next 35 years and his "Kettering Group" published a number of articles on aspects of the Soviet space program–revealing information not otherwise available from publicly released data.

Geoffrey passed along a tip for *ST* readers to be on the lookout for OBZOR, a satellite likely to have the following orbital parameters and characteristics: inclination 83 degrees, 650 km circular orbit, period 97.8 mins, 43 meter resolution from a sensor of 512 lines (4 by 128 matrix) in near-infrared, 6-channels, a 150 km visual swath width and transmitting telemetry in the 137 MHz band.

Timestep Weather Satellite Systems was the only UK commercial company of its type present–represented by conference organizer Dave Cawley. He had expanded his company's work in weather satellites in 1984, specializing in hardware for the amateur market. A DOS-based HRPT system had been produced by John du Bois around 1988 and Dave obtained an agreement to use John's designs. Timestep subsequently produced the UK's first commercial amateur HRPT system. The hardware currently includes a 90-cm dish which, when used in prime focus mode, could be driven by computer to accurately track satellites.

Sam Elsdon's interest in electronics led him to the RAF and then to a satellite

FIGURE 7: ***Dutch booth at RIG conference.***

Arne's fellow members would like to see all the weather amateurs around the world united to try to acquire the right to decrypt scrambled satellite imagery for non-commercial purposes!

NOAA-14 May 4 from Dale Ireland

ground station. Discovering and joining RIG in 1985, he has been working on 1.7 GHz band components. He explained how the early production of PCBs was developed and the various means to produce microwave components, of which he had several on display.

Dutch remote imaging

Arne van Belle addressed the conference on behalf of the Dutch activity group "Kunstmanen"–founded by Ruud Jansen and Bram Dorreman in 1973. The name "Kunstmanen" means "artificial (manmade) moons." Their group consists of over 400 members, many of whom are amateur astronomers who visually observe the polar satellites. Some build and operate home-made frame-stores for monitoring. A Dutch APT decoding program called *DIGISAT* is widely used, though many members now have SoundBlaster PC cards and use *WXSAT*.

Arne has built an experimental HRPT and PDUS receiver, and an antenna. He said that Holland does not experience pager interference in the 137 MHz band, but suffers from interference by the state owned video-link on 1708 MHz. In many areas, reception of NOAA-14 HRPT on 1707 MHz is almost impossible.

Member Chris van den Berg regularly reports on the life of the cosmonauts aboard the *Mir*, and on other Russian missions. He receives all the communications. Arne's fellow members would like to see all the weather amateurs around the world united to try to acquire the right to decrypt scrambled satellite imagery for non-commercial purposes! The Dutch stand was very well presented–see figure 7.

Weather Satellite Monitoring for Global Balloon Racing

Martin Harris is a director of Oxford Scientific Services Ltd. which provides environmental consultancy services to a number of clients–including the Virgin Global Challenger team. His interest in weather satellites began when they were invented while he was a student at Oxford University. His talk was titled "Ballooning around the world–use of weather satellite images in global forecasting."

During our RIG conference Martin spoke and summarized the needs of every balloon crew including the requirement to remain safely airborne for 10-20 days, an ability to maneuver vertically to optimize speed and direction, and to overfly countries only after obtaining full air traffic control clearance. Sadly, at least, one group had not sought ATC approval and had been shot down, causing fatalities.

The meteorological hazards of balloon flight were considerable–just 1-mm of ice on the balloon or cabin could add 8-tons of mass. Severe air turbulence, lightning strikes, and regions of stagnant air were real hazards.

During and prior to each mission, extensive use was made of WEFAX images, including animations. The European D2 (infra-red), C02 (visible-light) and ETOT (near-infra-red) formats, together with relays from GOES-8 and GMS were essential for the project. Monitoring of GOES-8 and GMS provided global coverage of major weather systems. Launch and landing operations were greatly aided by high resolution images from NOAAs-12 and 14. The Russian GOMS weather satellite provided images that helped identify important circulation systems, and the animation of GMS images enabled the tracking of fronts and identification of cirrus clouds. GOES-9 helped the monitoring of frontal lows, and GOES-8 provided full coverage of the airflow over the United States.

The final speaker of the weekend was Gordon Bridge, head of user services–Eumetsat, who described the last twenty years of Meteosat operations.

The next UK RIG conference is expected to be held in five years' time.

Contrails in APT images

Figure 8 is a NOAA-14 visible-light image from Dale Ireland showing contrails near Seattle in early May.

Next month

Some very interesting images from the DMSP satellites are included in the next edition of *View from Above*.

Frequencies

NOAA-12 and -15 transmit APT on 137.500 MHz
NOAA-14 transmits APT on 137.620 MHz
NOAAs transmit beacon data on 137.770 or 136.770 MHz
METEOR 3-5 transmits APT on 137.850 MHz when in sunlight
OKEAN-4 and SICH-1 sometimes transmit briefly on 137.400 MHz
GOES-8 and GOES-9 use 1691.0 MHz for WEFAX

By John Magliacane, KD2BD
magliaco@email.njin.net

Commercial Threats To Amateur Radio Spectrum Continue

The *Amateur Radio Satellites* column of the April 1998 issue of *Satellite Times* magazine began as follows:

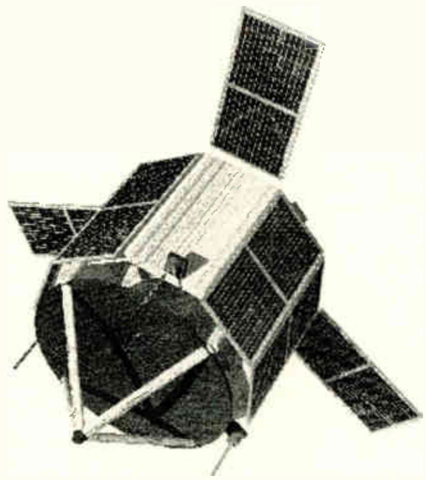
"In late January, the Telecommunications Authority in the country of Guatemala auctioned off four frequencies between 430 MHz and 435 MHz for commercial use, despite their use by amateur radio operators in that part of the world. Amateurs in the region have been trying to convince authorities not to auction spectrum that is shared by amateurs to commercial users for over a year, but as is often the case, the money that could be gained through such a frequency auction spoke much louder than reasonable arguments by hams against the selling of spectrum rights to the highest bidder. Mexico also recently lost UHF amateur band spectrum to commercial interests, and this appears to be a disturbing trend.

"Although the 430 MHz to 435 MHz spectrum loss in Guatemala does not directly affect OSCAR satellite communications, a precedent has now been set, and just as arguments against such an auction by amateur radio operators largely fell on deaf ears, there is no guarantee that frequencies within the 435 MHz to 438 MHz UHF amateur satellite sub-band will not be auctioned off to the highest bidder in the future."

Well, as luck would have it, a precedent has been set, and it has now been made known that the Guatemalan Telecommunications Authority was recently petitioned for the use of 436.500 MHz by commercial interests. 436.500 MHz just happens to be the downlink frequency for the KITSAT-OSCAR-25 amateur communication satellite.

Troubles with the LMCC

In May, the Federal Communications Commission placed a petition filed by the Land Mobile Communications Council (LMCC) on notice for public comment that sought, among other things, "immediate....reallocation of 420-430 MHz, paired with 440-450 MHz, from Federal use to PMRS [Private Mobile Radio Service]." The Land Mobile Communications Council is a loose affiliation of organizations with interests in mostly private land mobile communications.



UoSAT and SSTL are combining forces to launch an interplanetary research spacecraft to the moon in the year 2000. The spacecraft is a direct result of the experience gained through building amateur as well as some commercial microsatellites.

The petition, identified as RM 9267, noted that land mobile services already have access to the 420-430 MHz band segment in three U.S. cities along the Canadian border that was the result of a move by Canada at the time of the 1979 World Administrative Radio Conference (WARC-79) to reallocate that part of the band from amateur radio to land mobile. The petition made brief reference to expected "reduction in military use of this band" and to Wind Profiler use of 449 MHz, which according to the Land Mobile Communications Council, "should be discouraged or at least minimized, in favor of higher frequency operation (i.e. 915 MHz), if reallocation to PMRS is considered."

The petition noted that "The band is generally popular with radio amateurs, currently on a secondary basis, with repeater use in 440-450 MHz and satellite links and amateur television in 430-440 MHz," and said, "Amateur applications in the 420-430/440-450 MHz should remain secondary to PMRS."

In addition to this, the Land Mobile Communications Council is also seeking new spectrum allocations between 1390 and 1400 MHz, 1427 and 1432 MHz, and the region between 1670 and 1675 MHz. The LMCC is also demanding the frequency range between 960 and 1215 MHz, and would like all its petitioned spectrum turned over to the Private Mobile Radio Service no later than the year 2010.

The LMCC, however, is not willing to wait until the year 2010 to take over the 70-cm band, despite it being the second most popular band of the Amateur Radio Service's VHF and UHF frequency allocations. While the Land Mobile Communications Council petition indicated that it is willing to permit Amateur Radio communications on the 70-cm band, such use by amateurs would have to be on a secondary basis, and cause no interference to the Private Mobile Radio Service.

FCC Frequency Sharing Requirements

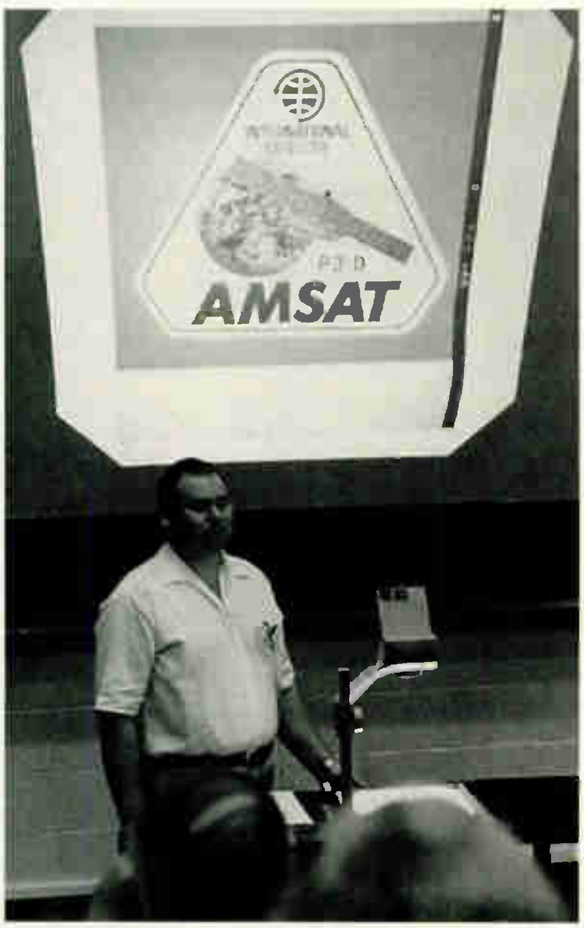
Why is the Land Mobile Communications Council so interested in using a segment of RF spectrum so popular with amateur radio communications? Well, it all has to do with frequency sharing and the fact

According to present Federal Communications Comission (FCC) rules and regulations, the 420-430 MHz segment of the 70-cm band is currently allocated to the amateur radio service on a secondary basis. It is also allocated in the fixed and mobile services in the international table of allocations on a primary basis.

that the 70-cm, as well as many other bands above 148 MHz, do not belong exclusively to amateur radio communications.

According to present Federal Communications Comission (FCC) rules and regulations, the 420-430 MHz segment of the 70-cm band is currently allocated to the amateur radio service on a secondary basis. It is also allocated in the fixed and mobile services in the international table of allocations on a primary basis. Because of this, both services may share their common spectrum provided no amateur station transmitting in this band causes harmful interference to stations authorized by other nations in the fixed and mobile services. Amateurs, being secondary users, are offered no protection from interference caused by the operation of the primary users of the band.

The annual AMSAT-UK Space Colloquium and AMSAT-NA annual meeting are excellent opportunities to learn more about amateur communication satellites from the designers themselves.



The 430-440 MHz segment of the 70-cm band is allocated to the amateur service on a secondary basis in International Telecommunications Union (ITU) Regions 2 and 3. No amateur station transmitting in these regions is permitted to cause harmful interference to stations authorized by other nations operating in the radiolocation service, nor are they protected from interference from stations operating as primary users of the band.

In ITU Region 1, the 430-440 MHz segment is allocated to the amateur service on a co-primary basis with the radiolocation service, provided services sharing the common spectrum do not cause themselves harmful interference.

What the Land Mobile Communications Council proposes to do is displace the current primary users of the 70-cm band with their own communication services, leaving amateur radio operators perhaps in a worse situation than they are in now in coping with interference from primary users of the 70-cm band. Interestingly enough, parties wishing to comment on the Land Mobile Communications Council petition were given less than one month's time to respond, placing amateur radio operators at a serious disadvantage in responding appropriately to the petition.

Combating the problem

There are at least three possible methods of successfully combating outside threats to amateur spectrum of which amateur radio operators should be aware. The first, and possibly the most difficult, is to encourage the effective use of RF spectrum that uses each band to its fullest potential. It makes little sense to justify our 70-cm band allocation by filling it with FM voice repeaters since FM voice repeaters are permitted and/or already exist on other bands in high numbers. However, wide bandwidth modes such as amateur television, high-speed packet switching, and spread spectrum communications should be strongly encouraged on the 70-cm band since these modes are not permitted on lower frequencies due to bandwidth restrictions and FCC regulations.

Secondly, Amateurs must respond in high numbers when petitions such as RM 9267 are brought to the attention of the Federal Communications Commission. The old adage that "silence is acceptance" is very true. Failure to respond pro-actively to such petitions is clear grounds for suffering spectrum loss in favor of commercial interests. Remember, the effort in writing an occasional letter to the FCC in response to a petition made by a commercial radio service is a small price to pay for the free use of RF spectrum that is worth millions of dollars in the commercial telecommunications world.

And lastly, communication techniques such as spread spectrum need to be encouraged on amateur bands such as 70-cm to allow amateur communications to peacefully co-exist with other modes of communications within the same frequency spectrum with a minimum of mutual interference. In this way, if spectrum ever needs to be shared with commercial services, the amount of negative impact to amateur communications will be minimal. This tactic is affectionately known in the business world as "C.Y.A."

GPS Threat to 1.2 GHz Band

The 70-cm band isn't the only amateur band that is currently under the greedy eye of commercial radio services. The *ARRL Letter*, dated April 4, 1998 stated that the second civilian frequency for the Global Positioning System (GPS) could wind up within amateur radio's secondary allocation at 1.2 GHz (23-cm band). A decision on whether the new, second frequency will be 1205 or 1250 MHz is expected to be made in August. An allocation at 1250 MHz could mean the end of amateur radio communi-

Surrey Satellite Technology Limited (SSTL), based at the Surrey Space Center in Guildford, England, recently won the prestigious Queen's Award for Technological Achievement in recognition of their national standing as a center of excellence in the research, development, and application of small satellites.

cations in the band between 1240 and 1260 MHz. The amateur 23-cm band runs from 1240 to 1300 MHz.

In February 1997, the Departments of Transportation (DOT) and Defense (DOD) announced an agreement assuring civilian GPS users of a second frequency, referred to as L5, and considered essential for critical civilian GPS uses. According to a DOD news release, the White House Commission on Aviation Safety and Security, chaired by Vice President Al Gore, "called for the establishment of a second civil frequency as part of a broader program to maintain U.S. leadership in aviation and satellite technology."

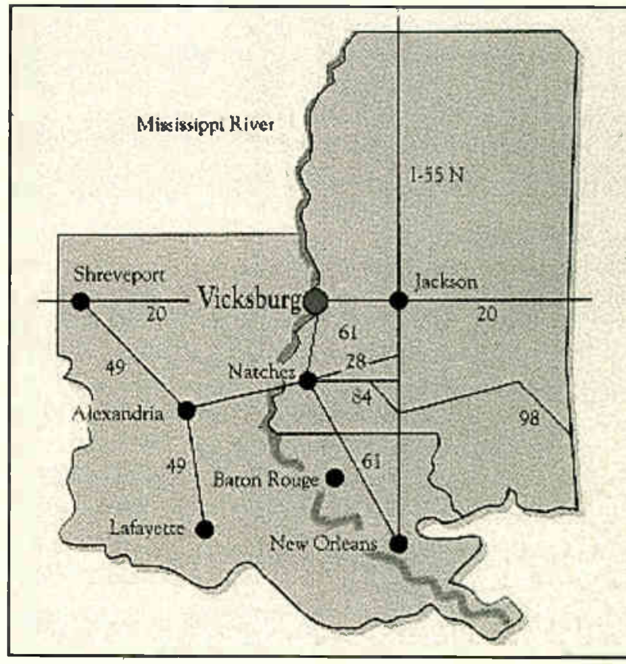
SSTL Wins Prestigious Award

Luckily, there actually is some good news to report in the world amateur radio satellites this month. Surrey Satellite Technology Limited (SSTL), based at the Surrey Space Center in Guildford, England, recently won the prestigious Queen's Award for Technological Achievement in recognition of their national standing as a center of excellence in the research, development, and application of small satellites. Surrey Satellite Technology was one of only 14 recipients of the award out of a total of 200 submissions. SSTL previously won The Queen's Anniversary Prize for Higher and Further Education in 1996.

Surrey Satellite Technology Limited is the University of Surrey's small satellite technology transfer company, and is a wholly owned company of the University of Surrey. SSTL is the commercial arm of UoSAT, providing technical training and technology transfer for industry. UoSAT is the University of Surrey's Spacecraft Engineering Research Group. UoSAT and the University of Surrey have been responsible for developing amateur radio communication satellites such as UoSAT-OSCAR 9, 11, 14, 15, and 22, and collaborated with other AMSAT organizations around the globe in the development of even more OSCAR satellites. The University of Surrey is also the site for AMSAT-UK's 13th Annual Space Colloquium, which will be held this year between July 31 and August 2, 1998.

Surrey Satellite Technology Limited is the product of the University of Surrey and success in designing and building mini and microsatellites, including many OSCAR satellites.

SSTL was formed in 1985 to make the cost-effective small satellite techniques developed by the University of Surrey's researchers available in the commercial marketplace. Although independent from the University, SSTL retains close links with the advanced research and educational facilities on the University campus, while providing postgraduate MSc and PhD degree courses combined with practical satellite projects within the Surrey Space Center.



The AMSAT-NA Annual Meeting will be held in Vicksburg, Mississippi this year.

To date, Surrey Satellite Technology Limited has designed, built, and launched a total of 12 microsatellites including ten since 1990. These satellites were designed and built for commercial customers requiring communications services, remote sensing, technology verification and space science missions with civil and military applications.

UoSAT Lunar Mission

SSTL, in cooperation with UoSAT, is currently developing a low-cost mini-satellite capable of entering lunar orbit, mapping the lunar surface, and carrying out scientific research. Current plans are to launch a demonstration mission in the year 2000, with follow-ups in later years. The possibility of including a small impact lander with the spacecraft is also being studied.

1998 AMSAT-NA Annual Meeting

AMSAT-North America will be holding its 16th annual space symposium and meeting at the Park Inn International in Vicksburg, Mississippi, between October 16 and 19, 1998. The symposium will be hosted by the Vicksburg Amateur Radio Club, and will feature papers covering all aspects of amateur satellite communications.

Vicksburg is located on the banks of the Mississippi River midway between Memphis and New Orleans on Interstate Highway 20. Vicksburg is served by Jackson International Airport, and shuttle bus service between Jackson International and the conference will be available for those attending the symposium. Additional information on the symposium is available at: **http://pages.prodigy.com/DXHF93A/.**

See you on the birds!

ST

Satellite Listening Post

By Keith Stein
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PoSAT News

For those of you who are interested not only in the reception, but also in decoding of digital satellite transmissions, here is some information regarding PoSAT-1.

PoSAT-1 is based on a Surrey Satellite Technology Ltd. (SSTL) microsat bus system and was built at the University of Surrey in the United Kingdom. The first weeks after launch this satellite was active on ham frequencies, but then it was switched to frequencies outside the ham bands.

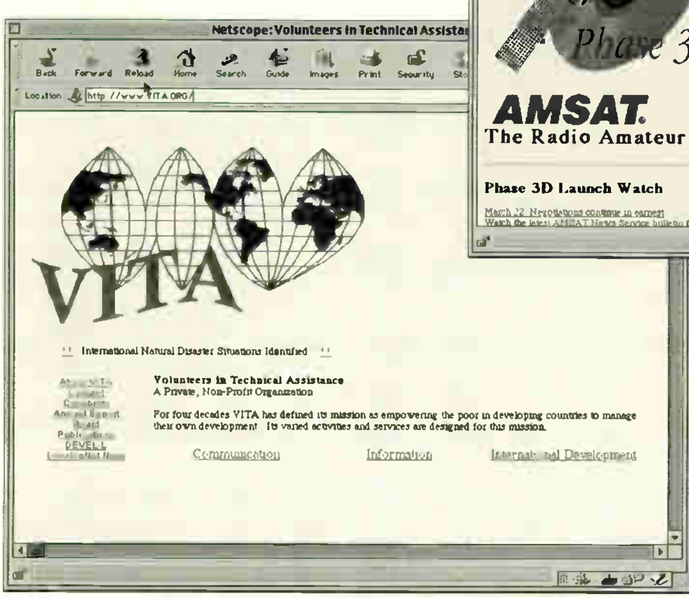
The actual downlink frequency is now 429.950 MHz. The mode of transmission is normal 9600 baud frequency shift keying (FSK) packet radio (AX.25 protocol) with the PACSAT sub-protocol, as it is used also by the amateur PACSAT satellites.

The advantage of the broadcast protocol is that you do not really need to have a uplink to the satellite in order to grab a lot of data during one satellite pass. But the uplink is necessary to request missing parts of a file, directory entries or file requests.

There are various types of software available at **ftp.amsat.org** for decoding of the PACSAT broadcast protocol. Furthermore, you will need a 9600 baud FSK type of packet radio terminal node controller (TNC). You can also use the new Baycom 9600 baud FSK modems for decoding only the AX.25 packets, but with this setup you will not be able to use the various PACSAT programs (all the available PACSAT programs need a real TNC as a decoder).

Another important consideration for decoding these satellites is the relatively high amount of Doppler shift on the UHF band (about +/- 9 kHz), compared to VHF.

It is quite difficult to discriminate the satellite signal, because with 9600 baud FSK the only thing you will hear is noise, but with a sensitive receiver and/or small directional antenna you should notice an increase in signal strength on an s-meter. You should also be able to detect the Doppler effect by tracking the maximum signal peak. A 1 kHz frequency step in narrowband FM is the optimum for tracking the satellite, although 5 kHz steps might also work quite well.



PoSAT-1 is used by different organizations for digital store and forward communications and there are also some interesting experiments on board. The Volunteers in Technical Assistance organization (VITA) at URL **www.vita.org** is using PoSAT for forwarding messages to and from the internet to gateway stations in Africa. Also the Portuguese Army and Navy are using it for e-mail purposes. United Nations troops in Bosnia and Angola have also used the satellite for email.

The most interesting experiment on board is the earth imaging system (EIS) which is quite similar to the systems used on the Korean ham PACSATs KO-23 and KO-25. The only "interesting" difference is that the "narrow angle" image is 200 meters in ground resolution, higher than NOAA weather satellite pictures.

The pictures are not sent continuously. They are taken during an orbit with a pre-programmed "request" by the control station and are then stored as a file in the satellite mailbox. When flying over Europe the control stations can download the image file from the satellite. Image files are normally requested either by the Portuguese control station or the control station at the University of Surrey in Guildford, UK.

The ham PACSATs UO-22, KO-23 and KO-25 will give you good practice in reception of the PACSATs before trying to start with PoSAT-1.

A listener from Japan recently reported that he could not monitor any directory or message traffic overhead Japan from the PoSAT amateur radio satellite. Only the normal telemetry and status messages could be observed. The problem in some parts of the world is that there are no PoSAT ground stations operational, so you will not be able to monitor any interesting traffic. You will be successful in Europe (ground stations in Madeira, Portugal, England and Bosnia), Africa (Angola, Volunteers in Technical Assistance;VITA internet gateway in Tanzania), North America (VITA headquarters satellite gateway), South America (Brazilian ground station) and Antarctica (Brazilian base).

VITA will get their own satellite launched soon, so it is obvious that they will shift their traffic from PoSAT-1.

Another set of Surrey University built store and forward microsats are called HealthSat-1/2.

When Healthsat-1 was first launched it was possible to decode its telemetry. However, since the onboard computer crashed, the satellite has only transmitted telemetry in an unknown mode (sounds slower speed than 9600 baud FSK). Healthsat-1 transmits on 429.980 MHz and is listed as UO-14 in the NORAD element sets.

Healthsat-2 is listed as Healthsat in NORAD Keplerian element sets. The Healthsat-2 downlink is reported to be somewhere in the 400 MHz satellite downlink band. Thanks to Oscar Diez for providing the Healthsat information via the Hearsat-L internet distribution list.

NOAA 15 in Orbit

On Wednesday, May 13, 1998, the U.S. Air Force placed America's newest polar orbiting weather satellite into orbit. At 1552 UTC a Titan 2 rocket lifted off the SLC4 launch pad at Vandenberg AFB carrying NOAA 15 into orbit.

Launch Sequence of Events

Event	HH:MM:SS
Liftoff	00:00:00
Stage 1 shutdown	00:02:30
Stage 1/2 separation	00:02:33
Space Vehicle Separation	00:06:34
Apogee Kick Motor Ignition	00:14:39
Apogee Kick Motor Burnout	00:15:55

The Titan second stage separated from the NOAA-K payload at approximately 391 seconds (00:06:31 mission elapsed time), and the satellite performed a reaction control system (RCS) separation burn immediately. The Titan stage re-entered over the southern Pacific, and the NOAA-K payload achieved orbit during an apogee kick motor (AKM) burn, which ended at approximately 931 seconds. The NOAA-K payload performed an RCS trim burn at approximately 961 seconds, at which time the NOAA-K achieved final orbit injection.

NASA's Tracking and Data Relay Satellites locked onto the NOAA-K carrier with no problem and recorded downlink telemetry. The National Science Foundation (NSF) assisted the launch with a ground station located in McMurdo, Antarctica, using a six foot S-band tracking antenna. McMurdo is the first land-fall for most launches in polar orbits from Vandenberg AFB.

The spacecraft body is 4.2-meters in length and 1.88-meters in diameter. The solar panels are 2.73 by 6.14-meters. The spacecraft has a mass of 2,231.7-kg, of which 756.7-kg is fuel.

The two stage Titan 2's overall height is 34.75-meters and diameter is 3.05-meters. The first and second stages use liquid propellant engines.

NOAA-K is a meteorological satellite which will provide environmental information of the earth's atmosphere, surface and cloud cover. The final orbit will be 833 km altitude with an inclination of 98.7 degrees (retrograde motion).

The following frequencies are used by the Titan 2 launch vehicle and NOAA 15 spacecraft:

Titan 2	2287.500 MHz	12.5 watts S-band tracking beacon
NOAA 15 (K)	137.500 MHz	Automatic Picture Transmission downlink
NOAA 15 (K)	137.620 MHz	VHF spacecraft tracking beacon
NOAA 15 (K)	1698.000 MHz	High Resolution Picture Transmission downlink

LES-9 Active

The Lincoln Experimental Satellite-9 (LES-9), an experimental military communications satellite launched in 1976 and developed by the MIT Lincoln Laboratory, is still very active today according to *Satellite Access Request* obtained over the Internet.

LES-9 supports voice and data communications for Operation

Deep Freeze (ODF) in Antarctica and the U.S. Air Force Advanced Range Instrumentation Aircraft (ARIA). ODF uses LES-9 for information transfer via voice between McMurdo, South Pole Station, and Palmer Station in Antarctica; and Christ Church in New Zealand; and Malabar Station in Palm Bay, Florida.

The spacecraft is located at 105.2 degrees West longitude, but inclined 13 degrees to the earth's equator. With this type of orbit, LES-9 makes a figure eight on a flat tracking map moving between earth's northern and southern hemisphere along the equator (US Space Command catalog number 08747/International Designator 1976-023B).

Here is the complete bandplan for the LES-9 satellite. All channels use narrowband FM (NFM) mode.

Channel	Uplink (MHz)	Downlink (MHz)
1	303.150	249.350
2	303.175	249.375
3	303.200	249.400
4	303.225	249.425
5	303.250	249.450
6	303.275	249.475
7	303.300	249.500
8	303.325	249.525
9	303.350	249.550
10	303.375	249.575
12	303.425	249.625
13	303.450	249.650
14	303.475	249.675
15	303.500	249.700
16	303.525	249.725
17	303.550	249.750
18	303.575	249.775
19	303.600	249.800
20	303.625	249.825
21	303.650	249.850

LES-9 Satellite Antennas

Three crossed dipoles on a ground plane, 35-deg beamwidth, approximately 8-dB gain (edge of earth).

Satellite Listening Post Intercepts (All times in UTC)

AFS	Air Force Skid
APT	Automatic Picture Transmission
ETR	Eastern Test Range
FBI	Federal Bureau of Investigation
Fltsatcom	Fleet Satellite Communications
K	kHz
M	MHz
NFM	Narrowband FM
NOAA	National Oceanographic and Atmospheric Administration
STS	Space Transportation System
UFO	UHF Follow-On satellites
USAF	United States Air Force
USB	Upper Side Band
USSS	United States Secret Service
WBFM	Wideband FM

K10780 — Cape Radio–USAF ETR, Cape Canaveral AFS, at 1120 in USB mode, calling *USS Philippine Sea* during 2nd launch attempt of space shuttle mission STS-90. (Rick Baker-NE Ohio)

M137.500 — Received a weak APT image from NOAA-K at 0140 in NFM mode. (Dale Ireland)

M143.625 — Russian voice heard at 1207 from the *Mir* space station in NFM mode. I could also hear the uplinked signal from Moscow coming out of the speaker onboard *Mir* being picked up by the microphone being used by the cosmonaut. Then Andy Thomas came on the air speaking English. I guess Moscow was trying to talk the crew through some maintenance activity because I heard Andy say "you can't do that, the wire's in the way." (John David Corby-Caledon, Toronto, Canada)

M145.985 — Received U.S. astronaut Andy Thomas loud and clear from Toronto at 1110 onboard the Russian space station *Mir* in NFM mode. The signal was unusually strong–it came booming in like a local terrestrial signal and didn't fade into the noise until *Mir* dipped below the horizon. I heard the downlink side of the conversation only, of course. Andy asked how things were on the ground and said that he had heard that the daughter of the ham on the ground had been ill recently. He then remarked that on the next pass the crew had to check in with Moscow through Wallops. That gave me the clue to check 143.625 MHz on the next pass. Sure enough, at 1245 I heard Russian language voice on 143.625 MHz. I have heard *Mir* many times before, but this time was remarkable because of the strength and clarity of the signal on 145.985 MHz. (Corby-Canada)

M150.000 — Russian navigation satellite Nadezhda 3 transmitting in NFM mode. (Corby-Canada)

M249.650 — Several voice transmissions heard over LES-9 channel 13 in NFM mode at 1527. May be from "Operation Deep Freeze" in Antarctica. (Keith Stein-Woodbridge, VA)

M250.400 — I was able to hear the main transponder from one of the UFO satellites. (Markus-South Germany)

M259.700 — Just caught about five minutes of communications from space shuttle *Columbia* (mission STS-90) as it passed over the Houston area in the final orbit, AM mode. Caught four communications from about 1418 to 1421. First thing I heard was that they were looking out the front window and saw somebody's home town and how beautiful it was. Signal was surprisingly loud and clear here. (Chris Parris-Conroe, TX)

M265.400 — Picked up a strong carrier on this frequency. After a while I heard what sounded a lot like the encryption that the FBI and Secret Service use (It was actually 2 beeps and what sounded like NFM static), but on WBFM. Then I heard clear comms, but were very weak and I was on a handi talkie and couldn't make them out. The encrypted comms came on 2300 and it began fading about an hour later. I have this listed as a Fltsatcom channel. (Alex Sanks-San Jose, CA)

M380.200 — NASA-843 (tail number N843NA) in AM mode, landing in Colorado Springs. (Sandy-Denver, CO)

Keith Stein is the Associate Technical Editor for Launchspace Publications, Inc. (http://www.launchspace.com) and ISI Consulting (www.isi-consulting.com)

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. **Satellite Transponder Guide** — This guide lists 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.

4. **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.

5. **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.

6. **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.

7. **Amateur Satellite Frequency Guide** — This guide lists 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.

8. **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–Fine Arts	G5, 7	6.30/6.48 (DS)
WQXR-FM (96.3) New York, NY	S4, 14	6.20/6.80 (DS)

Satellite Computer Services

Superguide	G5, 7	5.48

Contemporary Music

Radio Desjardins 1	T5, 14	6.80
Radio Desjardins 2	T5, 14	6.20
SuperAudio–*Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
WPHZ-FM (96.9) Bremen, IN (South Bend market)	G6, 15	6.48, 7.30 (DS)

Country Music

SuperAudio–*American Country Favorites*	G5, 21	5.04/7.74 (DS)
WSM-AM (650) Nashville, TN	C4, 24	7.38, 7.56

Easy Listening Music

IAM Radio-easy listening music	G6, 6	7.69
SuperAudio–*Soft Sounds*	G5, 21	5.58/5.76 (DS)
FCC mandated safe-harbor program audio-easy listening music	G3R, 9	6.80
	G5, 2	6.80
United Video–easy listening music	C4, 8	5.895 (N)

Foreign Language Programming

Antenna Radio (Greek)	S4, 14	7.80
Apna Sangeet Radio India	GE1, 16	7.38
Arab Network of America radio network	GE2, 22	5.80
La Cadena CNN Radio Noticias (CNN Radio News in Sp.)	G5, 17	7.56
KAZN-AM (1300) Pasadena, CA–Radio Chinese (Chinese)	GE1, 22 (Ku-band)	5.80
Radio Maryja–religious programming (Poland)	G7, 10	5.80
Radio Maria	G7, 10	8.03
SRC AM Network	E2, 1	7.38
SRC FM Network	E2, 1	5.41/5.58 (DS)
Unidentified station-foreign language	GE-1, 22 (Ku-band)	7.78
WCRP-FM (88.1) Guyama, PR–religious (Spanish)	G6, 6	6.53
XEWA-AM (540) San Luis Potosi, Mexico (Spanish)	M2, 8	7.38
XEW-AM (900) Mexico City, DF Mexico (Spanish), ID-*La Voz de la America Latina*–contemp. music	M2, 14	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

Broadcast News	E2, 1	5.78
Business News Network	C4, 10	8.06 (N)
Cable Radio Network	G5, 2	7.24 (N)
	C1, 21	7.30
CNN Headline News	G5, 22	7.58
CNN Radio News	GE3, 9	5.62
	G5, 5	7.58
	G5, 22	6.30
USA Radio Network–news, talk and information	GE3, 13	5.01 (ch 1), 5.20 (ch 2)
Virginia News Service	G5,11	5.90
WCBS-AM (880) New York, NY–news	G7, 19	7.38
WCCO-AM (830) Minneapolis, MN	GE3, 6	6.20

Religious Programming

Ambassasor Inspirational Radio	GE3, 15	5.96, 6.48
Brother Staire Radio	G5, 6	6.48
KHCB-FM (105.7) Houston, TX	C1, 10	7.28
Salem Radio Network	GE3, 17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
WHME-FM (103.1) South Bend, IN, ID-*Harvest FM*	G6, 15	5.58/5.78
WROL-AM (950) Boston, MA (occasional Spanish)	GE3, 3	6.20
Z-music–Christian rock	G1R, 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)
WOKI-FM (100.3) Oak Ridge-Knoxville, TN., (oldie rock) ID-*The Eagle*	E2,57	6.20

Shortwave Broadcasters via Satellite

C-SPAN Audio 1: Various shortwave broadcasters	C3, 7	5.20
C-SPAN Audio 2: British Broadcasting Corporation (BBC)	C3, 7	5.41
Deutsche Welle	GE1, 22	7.38, 7.56, 7.74, 7.92
Radio Dubai United Arab Emirates (Arabic)	G7, 10	7.48
RAI Satelradio Italy (Italian)	G7, 14	7.38
WEWN–Worldwide Catholic Radio, Vandiver, AL	G1R, 11	5.40 (English), 5.58 (Spanish)
WHRA Africa/Middle East–World Harvest Radio, South Bend, IN	G6, 15	7.82
WHRI Americas–World Harvest Radio, South Bend, IN	G6, 15	7.46
WHRI Europe –World Harvest Radio, South Bend, IN	G6, 15	7.55
KWHR Asia–World Harvest Radio, South Bend, IN	G6, 15	7.64
KWHR South Pacific–World Harvest Radio, South Bend, IN	G6, 15	7.73
World Radio Network: WRN1 North America	G5, 6	6.80
World Radio Network: WRN2 North America	G5, 6	6.20 (Multi-lingual)

Sports

New York Yankees Spanish Language S.A.P. (occ)	C4, 6	6.20

Speciality Formats

Aries In Touch Reading Service	C4,10	7.87
Colorado Talking Book Network	C1,3	5.60
Ozarkana Radio Network	G6, 6	7.96
SuperAudio–Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
Weather Channel–background music	C3, 13	7.78
Wisdom Radio Network	GE1, 12	7.10
Yesterday USA–nostalgia radio	G5, 7	6.80
	G1R, 24	7.38

Talk Programming

American Freedom radio network	GE1, 7	5.80
Amerinet Broadcasting	G1R, 17	5.58
For the People radio network	C1, 6	7.50
Friday Night Live (Friday 9 p.m.ET)	SBS6, 15 (Ku-band)	6.20
Omega Radio Network	GE1, 6	7.56
Orbit 7 Radio Network	C1, 14	7.48
Radio America Network	C1, 2	5.58
Republic Radio International	G7, 14	7.70
Talk America Radio Network #1–talk programs	GE3, 9	6.80
Talk America Radio Network #2–talk programs	GE3, 9	5.41
Truth Radio	GE1, 7	7.56
TVRO.NET (featuring Keith Lamonica)	S4, 16	5.80
United Broadcasting Network	C1, 2	7.50
WOKIE Network–tech talk	SBS6, 15 (Ku-band)	6.20 (network active when Megabingo on Monday-Friday 21-22 ET)
WWTN-FM (99.7) Manchester, TN–news and talk	G5, 18	7.38, 7.56

Variety Programming

CBM-AM (940) Montreal, PQ Canada–variety/fine arts	E2, 1	6.12
KBVA-FM (106.5) Bella Vista, AR., ID-*Variety 106.5*	G6, 6	5.58/5.76 (DS)
KSL-AM (1160) Salt Lake City, UT–news/talk/country (*Road Gang*-overnight)/BYU Sports	C1, 6	5.58
WCBS-FM (101.1) New York, NY	S4, 16	5.80 (when TVRO.NET is not on the air)
West Virginia Public Radio	GE1, 12	7.74
WHVN-AM (1240) Charlotte, NC–religious/WIST-AM (550) Statesville, NC–country (The two stations above are on at varous times)	G1R, 17	7.92
WUSF-FM (89.7) Tampa-St. Petersburg, FL (Public Radio), ID-*Concert 90*	C4, 10	8.26 (N)
WWRL-AM 1600, New York, NY–American Urban Radio Network	GE3, 9	6.30, 6.48 (DS)

Satellite Radio Guide/SCPC Services Guide

FM SQUARED (FM^2) AUDIO SERVICES

Another type of satellite audio carrier is known as FM Squared. FM Squared signalsdo not require a video carrier to exist. These signals are similar to audio subcarriers as we know it except that they are normally located below the 5.00 MHz audio subcarrier frequency that a normal satellite receivers can tune to. The new Universal SC-50 can tune these frequencies and was used to update this section.

GE-3 Transponder 13 (C-band)

Ambassador Inspirational Radio	1.410, 4.470 and 4.650 MHz
Blank audio carriers	1.050 and 3.570 MHz
Focus on the Family	1.230 MHz
Information Radio Network	3.390 MHz
International Broadcasting Network (IBN)	4.830 MHz
USA Radio Network	5.010 (ch 1) and 5.200 MHz (ch 2)
Various Religious Programs no common ministry)	.330 and 3.750 MHz
VCY/America (channel 1)	.510 MHz
VCY/America (channel 2)	.780 MHz

GE-3 Transponder 17 (C-band)

Blank audio carriers	1.770 and 3.570 MHz
Data Transmission	.800 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
SRN News	.330 MHz
KDMM-AM (1150) Highland Park, TX–Indian, Vietnamese and Chinese multi-ethnic format	1.280 MHz

Galaxy 3R Transponder 3 (Ku-band)

Blank Audio Carriers	1.000, 1.050, 2.060, 3.250, 3.620, 4.200, 4.340 and 4.450 MHz
Data transmissions	2.950, 3.070 and 3.190 MHz
AP Network News	3.530 MHz
In-Store audio network ads various companies)	.710, .810, .910, 1.150, 1.260, 3.440, 3.700, 3.800, 3.880 and 3.970 MHz
Muzak Services	.150, .270, .390, .510, 1.360, 1.480, 1.600, 1.720, 1.840, 1.960, 2.190, 2.310, 2.440, 2.560, 2.680, 2.800, 3.340 and 4.080 MHz

SBS 6 Transponder 13 (Ku-band)

Blank Audio Carriers	.960 and 1.350 MHz
Data Transmissions	.060, .180, .255, .300, .350, .470, .575, .650, .710, .740, .765, .845, .890, .930, 1.120, 1.225 and 2.080 MHz

Galaxy 3R Transponder 16 (Ku-band)

Blank audio carriers	2.280 MHz
Data transmissions	.645, 2.140, 2.400, 2.730, 3.205, 3.245, 3.265, 3.475, 3.735 and 3.970 MHz
In-Store audio networks	.150, .270, .390, .755, .870, .990, 1.110, 1.230, 1.350, 1.470, 1.590, 1.710, 1.835 and 2.070 MHz

Anik E1 Transponder 6 (Ku-band)

Nova Network FM Squared Services

FM CUBED (FM^3) 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 SBS6. WEFAX transmissions and Accu-Weather (for subscribing stations) are transmitted on this transponder.

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.

GE-2 Transponder-Horizontal 12 (C-band)

1204.90 (75.1)	*Radio Marti*–U.S. Information Agency Spanish language radio service to Cuba

GE-2 Transponder-Vertical 13 (C-band)

1178.70 (81.3)	NASA space shuttle audio

GE-3 Transponder-Horizontal 13 (C-band)

1207.90 (52.1)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming
1204.45 (55.55)	KJAV-FM (104.9) Alamo, Tex–Spanish language religious programming/ *Nuevo Radio Christiana Network*
1204.25 (55.75)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming
1204.00 (56.0)	SRN (Salem Radio Network) News
1201.50 (58.5)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming
1201.30 (58.7)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming

Galaxy 6 Transponder 1-Horizontal (C-band)

1443.80 (56.2)	Voice of Free China (International Shortwave Broacaster) Taipei, Taiwan
1443.60 (56.4)	KBLA-AM (1580) Santa Monica, CA–*Radio Korea*
1443.40 (56.6)	Voice of Free China (International Shortwave Broadcaster) 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–network news feeds

Galaxy 6 Transponder 3-Horizontal (C-band)

1405.00 (55.0)	Illinois News Network–network news feeds
1404.80 (55.2)	KOA-AM (850)/KTLK-AM (760) Denver, Colo–news and talk radio/Colorado Rockies MLB radio network
1404.60 (55.4)	WGN-AM (720) Chicago, IL–news and talk radio/Chicago Cubs MLB radio network
1404.40 (55.6)	Illinois News Network–network news feeds/WMVP-AM (1000) Chicago, IL–talk/ Chicago White Sox MLB radio network
1404.20 (55.8)	Tribune Radio Networks/Wisconsin Radio Network
1402.70 (57.3)	WLAC-AM (1510) Nashville, TN–news and talk/*Road Gang* trucker program (overnight)
1402.20 (57.8)	Occasional audio
1402.00 (58.0)	Occasional audio
1401.80 (58.2)	Michigan News Network–network news feeds
1401.50 (58.5)	Occasional audio/Agrinet–Agriculture news/USA Radio Network–network feeds
1399.60 (60.4)	Talk America Radio Network 1–talk radio
1399.20 (60.8)	Talk America Radio Network 2–talk radio
1399.00 (61.0)	Sports Byline USA/Sports Byline Weekend/ *On Computers* radio show

(Continued on Page 38)

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

(Continued from Page 37)

1398.80 (61.2)	United Broadcasting radio network–talk radio
1398.50 (61.5)	Occasional audio
1398.30 (61.7)	WJZK-FM (104.1) La Grange, GA– smooth jazz format/WSB-AM (750) Atlanta, GA–news/talk/Atlanta Braves MLB radio network
1398.00 (62.0)	Occasional audio
1397.80 (62.2)	Occasional audio
1397.50 (62.5)	Minnesota Talking Book Radio Network–reading service for the blind
1397.30 (62.7)	Occasional audio
1397.10 (62.9)	WTMJ-AM (620) Milwaukee, WI–talk radio/Wisconsin Radio Network/Milwaukee Brewers MLB radio network
1396.90 (63.1)	KRLD-AM (1080) Dallas, TX–news/talk/Texas Rangers MLB radio network
1396.70 (63.3)	Radio America/American Entertainment Network
1396.40 (63.4)	Georgia Network News (GNN)–network news feeds
1396.20 (63.8)	WCNN-AM (680) Atlanta, GA–all sports talk radio
1396.00 (64.0)	WHO-AM (1040) Des Moines, IA–talk radio/Iowa News Network–network news feeds
1395.80 (64.2)	WTMJ-AM (620) Milwaukee, WI–talk radio/Wisconsin Radio Network–network news feeds/Milwaukee Brewers MLB radio network
1395.60 (64.4)	WGST-AM/FM (640/105.7) Atlanta, GA IO *Planet Radio*–news and talk radio
1395.40 (64.6)	Michigan News Network–network news feeds
1395.00 (65.0)	Occasional audio
1394.70 (65.3)	WJR-AM (760) Oetroit, MI–news and talk radio/Michigan News Network/Detroit Tigers MLB radio network
1394.50 (65.5)	XEPRS-AM (1090) Tijuana, Mexico–Spanish language programming/California Angels MLB Network (Spanish)
1394.30 (65.7)	Michigan News Network
1384.40 (75.6)	KOA-AM (850)/KTLK-AM (760) Denver, CO–news and talk radio/Colorado Rockies MLB radio network
1384.20 (75.8)	WSB-AM (750) Atlanta, GA–news and talk radio/Atlanta Braves MLB radio network/ WJZK-FM (104.1) La Grange, GA–smooth jazz format
1383.70 (76.3)	Motor Racing Network (occasional audio) NASCAR racing
1383.40 (76.6)	Occasional audio
1383.10 (76.9)	KIRO-AM (710) Seattle, WA–news and talk radio/Seattle Mariners MLB radio network
1382.90 (77.1)	Michigan News Network–network news feeds
1382.60 (77.4)	Soldiers Radio Satellite (SRS) network–U.S. Army information and entertainment radio
1382.00 (78.0)	Tennessee Radio Network–network news feeds
1381.80 (78.2)	WHO-AM (1040) Oes Moines, IA–news and talk radio/Iowa News Network–network news feeds
1381.60 (78.4)	KEX-AM (1190) Portland, OR–news and talk radio
1381.40 (78.6)	Occasional audio
1381.20 (78.8)	KJR-AM (950) Seattle, WA– sports talk radio
1377.10 (82.9)	In-Touch–reading service for the blind
1376.00 (84.0)	Kansas Audio Reader Network–reading service for the blind
1375.40 (84.6)	USA Radio Network/Agrinet Agriculture news service

Galaxy 6 Transponder 4-Vertical (C-band)

1376.00 (64.0)	Oata Transmissions

Galaxy 6 Transponder 6-Vertical (C-band)

1347.00 (53.0)	WCRP-FM (88.1) Guayama, PR–Spanish language religious programming

Anik E2 Transponder 1-Horizontal (C-band)

1446.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (Quebec) service

Anik E2 Transponder 7-Horizontal (C-band)

1326.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (Eastern Arctic) service

Anik E2 Transponder 13-Horizontal (C-band)

1206.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (MacKenzie) service
1205.00 (54.5)	Canadian Broadcasting Corporation (CBS) Radio–Occasional feeds/events

Anik E2 Transponder 17-Horizontal (C-band)

1126.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (Western Arctic) service
1125.50 (54.5)	Canadian Broadcasting Corporation (CBC) Radio–North (Newfoundland and Labrador) service

Anik E2 Transponder 23-Horizontal (C-band)

1006.00 (54.0)	Societe Radio-Canada (SRC) Radio–AM Network
1005.50 (54.5)	Canadian Broadcasting Corporation (CBC) Radio-North (Yukon) service

Anik E1 Transponder 21-Horizontal (C-band)

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)

1013.60 (80.4)	Wal-Mart in-store network (English)
1013.20 (80.8)	Wal-Mart in-store network (English)
1012.80 (81.2)	Sam's Wholesale Club in-store network (English)
1004.00 (90.0)	Wal-Mart in-store network (English)
1003.60 (90.4)	Wal-Mart in-store network (English and Spanish ads)
1003.20 (90.8)	Sam's Wholesale Club in-store network (English)
1002.80 (91.2)	Wal-Mart In-Store Network (English)

SBS5 Transponder 12-Vertical (Ku-band)

1095.00 (91.0)	Russian-American Radio Network

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2)	RFD Radio Service
1404.60 (55.4)	Wyoming News Network–network news feeds/Colorado Rockies MLB radio network
1400.60 (59.4)	Learfield Communications
1400.40 (59.6)	Learfield Communications/Missouri Net
1400.20 (59.8)	Occasional audio/Data transmissions
1400.00 (60.0)	Learfield Communications
1396.60 (63.4)	Kansas Information Network/Kansas Agnet–network news feeds
1396.20 (63.8)	Missouri Network/St. Louis Cardinals MLB radio network
1396.075 (63.93)	Occasional audio
1395.90 (64.1)	Occasional audio/Red River Farm Network
1395.70 (64.3)	Missouri Net/WIBW-AM (580) Topeka, KS–country music/Kansas City Royals MLB radio network
1386.40 (73.6)	Learfield Communications
1386.20 (73.8)	Radio Iowa
1386.00 (74.0)	United broadcasting Network–talk radio
1384.60 (75.4)	Capitol Radio Network
1384.00 (76.0)	Occasional audio/ABC Direction Network–network news feeds
1383.80 (76.2)	Occasional audio
1383.40 (76.6)	Capitol Radio Network
1382.90 (77.1)	Missourinet
1382.50 (77.5)	Virginia News Network–network news feeds
1382.10 (77.9)	Learfield Communications/Missourinet

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

EchoStar 3 61.5°West

This direct-to-home satellite operates in the 12.2-12.7 GHz BSS band and delivers local television channels and international channels.

SBS 6 (SBS6) 74° West

1	11717-H	Data transmissions/FamilyNet [digicipher]
2	11749.5-V	Occ video
3	11774-H	MSNBC feeds/Occ video
4	11798.5-V	Occ video
5	11823-H	Occ video
6	11847.5-V	Data transmissions
7	11872-H	Occ video
8	11896.5-V	Occ video/Unknown user [digital video] (occ)
9	11921-H	Occ video
10	11945.5-V	Occ video/CONUS Communications (occ-lower half)/DigitalXpress [digital] (upper half)
11	11963-H	Data transmissions
12	11994.5-V	CONUS Communications (half-transponders)
13	12019-H	FM2/3 Transmissions
14	12043.5-V	Data transmissions
15	12075-H	Occ video
16	12092.5-V	Occ video
17	12110-H	Data transmissions
18	12141.5-V	Occ video/CNN Newsbeam (occ)
19	12174-H	CNN Newsbeam (occ)

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

Transponders 2-10 on this satellite are used for NBC feeds.

1	11725-H	Data transmissions

Satcom K2 (K2) 81° West

15	12142-H	Satcom K2 ID Slate

Spacenet 3R (S3R) 83° West

19	11740-H	Unknown user [digital video]
22	11980-H	NY Network (occ)/SUNY (occ)
23	12060-H	Oregon Educational Network (occ)

GE-2 (GE2) 85° West

Primestar direct-to-home programming uses trasponders 1-24 (11.7-12.2 GHz FSS band). These transmissions are encrypted and compressed using the Digicipher system.

GE-3 (GE3) 87° West

1	11720-H	New Mexico State University Instructional TV [MPEG-CLI]
2	11740-V	Data transmissions
3	11760-H	Occ video
4	11780-V	Occ video
5	11800-H	Unknown user [digital video]/ Data transmissions
6	11820-V	Unknown user [digital video]/ Data transmissions
7	11840-H	Occ video
8	11860-V	Occ video/CNN Newsource (secondary feeds) (occ)
9	11880-H	CNN Newsource [LEITCH]
10	11900-V	National Technology University (NTU) [Spectrumsaver]
11	11920-H	Data transmissions
12	11940-V	Occ video
13	11960-H	Occ video
14	11980-V	Occ video
15	12000-H	Occ video
16	12020-V	Occ video
17	12040-H	Occ video
18	12060-V	PBS leased digital services (High Definition TV testing)
19	12080-H	PBS leased analog services (occ) /PBS *The Business Channel (occ)*
20	12100-V	PBS adult learning service (ALS)
21	12120-H	PBS leased analog services (occ)
22	12140-V	PBS leased digital services/ Indiana Higher Education [Spectrumsaver]
23	12160-H	PBS stations/regionals 1, 2 and 3 [Digicipher 2 SCPC]
24	12180-H	PBS six-channel affiliate feeds [Digicipher 2] [4DTV]

Telstar 4 (T4) 89°West

1	11730-V	Loral Skynet services [digital]
2	11743-H	Loral Skynet services [digital]
3	11790-V	Loral Skynet services [digital]
4	11803-H	Loral Skynet services [digital]
5	11850-V	Loral Skynet services [digital]
6	11863-H	Georgia Public TV [4DTV]
7	11910-V	Data transmissions/Unknown user [digital video]
8	11923-H	Data transmissions
9	11971-V	Occ video (half-transponders common)
10	11984-H	Occ video (half-transponders common)
11	12033-V	South Carolina Educational TV [4DTV]
12	12046-H	Occ video (half-transponders common)
13	12095-V	Occ video (half-transponders common)
14	12108-H	Louisiana Public TV [Digicipher]/LeHigh University [Spetrumsaver]
15	12157-V	DMX for Business [digital data]/Muslim TV Ahmadiyya (Powervu)
16	12170-H	Occ video

Galaxy 7 (K7) 91° West

TCI Headend in the Sky [digicipher] uses transponders 1, 3, 4, 6-7, 9-10, 12-13, 15, 19, and 21-22. Using a 4DTV receiver, an unidentified digital audio service (40 channels: 820-859) has been observed on this satellite.

2	11750-H	Data transmissions/Unknown user [digital video]
3	11750-V	Data transmissions
5	11810-H	Data transmissions
8	11870-H	Data transmissions
11	11930-H	Westcott Communications? [Spectrumsaver]
14	11990-H	Occ video (half transponders common)
16	12020-V	Occ video
17	12050-H	Westcott Communications [Spectrumsaver] (lower half transponder)
17	12050-H	National Weather Networks (upper half transponder occasional)/Occ video
18	12050-V	Westcott Communications [Spectrumsaver]
20	12110-H	Data transmissions
23	12170-H	Data transmissions/Unknown user [digital video]
24	12170-V	Data transmissions

Galaxy 3R (G3R) 95° West

Additional DirecTV United States capacity to be used for international programming and other services that are to be announced. At presstime this satellite and SBS 6 carry the bulk of the Ku-band traffic rerouted from the failed Galaxy 4 satellite.

2	11750-V	Data transmissions
3	11750-H	FM² services/Muzak/Data transmissions
4	11780-H	Data transmissions
5	11810-H	Data transmissions
8	11870-V	Data transmissions
9	11870-H	Data transmissions
10	11900-H	CNN Airport Network [Powervu]/Data transmissions
11	11930-V	Occ video (half-transponders common)
13	11960-H	CCTV-4 (China)
14	11990-V	Data transmissions
15	11990-H	DirecTV services
16	12020-H	FM² services
19	12080-H	DirectPC [digital]
20	12110-V	Data transmissions
21	12110-H	Conus Communications
22	12140-H	Data Transmissions
24	12170-H	Conus Communications

Telstar 5 (T5) 97° West

1	11728.5-V	Data transmissions
2	11735.0-H	Data transmissions
3	11789.5-V	Occ video (half transponders common)
4	11796.0-H	Data transmissions
5	11836.0-V	Unknown user [digital video]
8	11873.5-H	Unknown user [digital video]
9	11898.0-V	Occ video
10	11904.5-H	Unknown user [digital video]
11	11929.0-V	Occ video
12	11935.5-H	Occ video
13	11960.0-V	Occ video
15	11991.0-V	Thai TV 5 Global Network [MPEG-2]
17	12022.0-V	Occ video
18	12028.5-H	Occ video
19	12053.0-V	Occ video
20	12059.5-H	Occ video
21	12084.0-V	Unknown user [digital video]
23	12115.0-V	Unknown user [digital video]
24	12121.5-V	Occ video
25	12148.0-V	Occ video
26	12152.5-H	T.C.I. [Digicipher]
27	12177.0-V	Asian TV Network/Rehab TV Network/Healthsouth/ReMax Satellite TV [MPEG2/DVB]

Spacenet 4 (S4) 101° West

Transponders 19 (11740-H), 21 (11900-H), and 23 (12060-H) have failed on this satellite.

20	11820-H	Data transmissions
22	11980-H	Data transmissions
24	12140-H	E.M.G. courses [Digital video] (upper half)

DBS-1 101.2° West/DBS-2 & DBS-3 100.8° West

These satellites provide direct-to-home entertainment and operate in the 12.2-12.7 GHz BSS range.

GE-1 (GE1) 103° West

1	11720-H	Qualcomm data [digital]
2	11740-V	Data transmissions
3	11760-H	NBC Eastern/Central Time Zone programming
4	11780-V	Data transmissions
6	11820-V	Empire Sports [Wegener digital]/Kentucky Educational TV (KET) [Digicipher]
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]
12	11940-V	Microspace Velocity [digital]/ Serbian TV/TV Polonia/WRAL-TV Raleigh [MPEG-2]
13	11960-H	NSN data transmissions [digital]
14	11980-V	Qualcomm data [digital]
15	12000-H	NBC Contract Channel
16	12020-V	DirectPC [digital]
17	12040-H	NBC Contract Channel
18	12060-V	Starnet [Digicipher]
19	12080-H	NBC Newschannel [Wegener digital]
20	12100-V	Vyvx TV Commmercials distribution [Digicipher]/Occ video
21	12120-H	NBC NewsChannel SNG feeds [Wegner digital]
22	12140-V	Chinese Communications Channel (CCC) [Oak]
23	12160-H	NBC Newschannel SNG/NBC Contract Channel –mixture of Wegener digital SNG and analog feeds
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 Newsbeam (occ)/Occ video
4	11913-H	Data transmissions
5	11974-H	Occ video/Court TV Backhauls (occ video)
6	12035-H	CBS NewsNet SNG feeds
7	12096-H	CNN Newsbeam/Occ video
8	12157-H	CNN Newsbeam (occ vdieo)/ CNN Newsource International
9	11744-V	Data transmissions
10	11805-V	Data transmissions
11	11866-V	ABSAT (ABC) SNG feeds
12	11927-V	Data transmissions
13	11988-V	Occ video
14	12049-V	Data transmissions
15	12110-V	Occ video
16	12171-V	Data transmissions/Unknown users [digital video]

Anik E2 (A1) 107.3° West

Expressvu DBS service uses transponders 1, 2, 11, 13-14, 22-26, and 31-32. Star Choice DBS service uses transponders 9-10, 16 and 27-29.

3	11778-V	CanCom [digital video]
4	11804-V	Shaw [digital video]
5	11839-V	Canadian Parliamentary Access Channel, Youth TV E&W, Vision TV, CHSC Shopping [digital video]
6	11865-V	Moviepix!; The Movie Network [digital video]
7	11900-V	Rogers Network [digital video]
8	11926-V	Rogers Network [digital video]
12	12048-V	Saskatchewan CommunicaNetwork [digital]
15	12144-V	Telesat Canada stationkeeping (GLACS)
17	11730-H	Bravo Canada, MuchMusic Canada [digital video]
18	11756-H	Discovery Channel Canada/Life Network/The Sports Network/ CBC Newsworld [digital]
19	11791-H	Showcase E&W [digital video]
20	11817-H	Superchannel, Moviemax, Family Channel [digital video]
21	11852-H	TV Ontario, TFO (French), Ontario Legislature [digicipher]
30	12122-H	Telesat Canada stationkeeping (GLACS)

Solidaridad 1 S01 109.2° West

No video has been seen on any Solidaridad 1 Ku-band transponder.

Anik E1 (A2) 111° West

Note: Due to the loss of the south solar panel on March 26, 1996, Anik E1 Ku-band transponders 7-8, 11-16, 21-26, and 29-32 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	DirectPC [digital]
6	11865-V	NovaNet FM² Services
9	11961-V	Occ video
10	11987-V	Occ video
17	11730-H	Woman's Television Network E&W [digital video]
18	11756-H	Data transmissions
19	11791-H	Data transmissions
20	11817-H	New Country Network, Access Network of Alberta, Knowledge Network [digital video]
28	12061-H	RDI feeds

Solidaridad 2 (SD2) 112.9° West

Sky TV direct-to-home service uses transponders 1-4, 6-10, 14-16 on Solidaridad 2.

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

This satellite rarely has any Ku-band video transmissions.

7	11900-V	Occ video

Morelos 2 (M2) 116.8° West

No video has been seen on any Morelos 2 Ku-band transponder.

Anik C1 (C1) 118.6° West

32	12183-H	Occ video

EchoStar 1/2 & Tempo 1 119°West

These direct-to-home satellites operate in the 12.2-12.7 GHz BSS band.

SBS 5 (SBS5) 123° West

1	11725-H	Satellite Cinema PPV [digital video]
2	11780-H	SCPC services/Data transmissions
3	11823-H	Data transmissions
5	11921-H	Data transmissions
6	11970-H	Data transmissions
7	12019-H	Data transmissions
8	12068-H	Data transmissions/Unknown user [digital video]
9	12117-H	Data transmissions/Unknown user [digital video]
10	12166-H	Occ video
11	11748-V	Data transmissions
12	11898-V	WMNB Russian-American TV [inverted video]
13	11994-V	Data transmissions
14	12141-V	Data transmissions/USC TV [digital]/CSU-Chico [digital]

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	Spacenet 3R (S3R) 83°	GE-2 (GE2) 85°	GE-3 (GE3) 87°	Telstar 4 (T4) 89°	Galaxy 7 (G7) 91°	Galaxy 3R (G3R) 95°	Telstar 5 (T5) 97°	Galaxy 6 (G6) 99°	Spacenet 4 (S4) 101°	GE-1 (GE1) 103°	Anik E2 (A1) 107.3°
1	(none)	o/v	Associated Press TV [MPEG/DVB]	Natl Jewish TV/o/v	Sega Channel Interactive [digital]	TVN Theatre 1 [V2+]	Telequest DBS [Digicipher]	SCPC services	Data Transmissions	MLB Intl [LEITCH]/Fox Sports Alt/o/v	CBC-H English Eastern
2	(none)	o/v	American Independent Network (AIN) [CLI Spectrumsaver]	Data Transmissions	CBS West [occ VC1]	TVN Theatre 2 [V2+]	Telequest DBS [Digicipher]	Buena Vista TV distribution	STARZ! 2 [V2+]	Data Transmissions/AF-RTS [Powervu]	o/v
3	(none)	o/v	WSBK-UPN Boston [V2+]	XXXplore TV (adult) [V2+]	Action PPV [V2+]	TVN Theatre 3 [V2+]	Telequest DBS [Digicipher]	SCPC services	Data Transmissions	PBS Alaska/Caribbean 7-channel [4DTV]	Unknown user [digital]
4	(none)	La Cadena de Milagro	Nebraska Educational TV (NETV) [4DTV]	Shop at Home	fX East [V2+]	TVN Theatre 4 [V2+]	Telequest DBS [Digicipher]	Data Transmissions	Encore- Westerns [V2+]	FOX Sports Ohio/FOX Sports Cincinnati [V2+]	Cancom [PowerVu]
5	(none)	NASA Contract Channel [Leitch]	Univision [V2+]	FOX feeds [LEITCH]	fX East/West [Wegner]	TVN Theatre 5 [V2+]	Telequest DBS [Digicipher]	4 Media Company feeds	Data Transmissions	Hero Teleport (GEMS/HTV) [4DTV]	Video Catalog Channel
6	(none)	Kuwait TV	Midwest Sports Channel (MSC) [V2+]	Oui TV (adult) [V2+]	Game Show Network [V2+]	TVN Theatre 6/TVN Promo [V2+]	Telequest DBS [Digicipher]	Shepherd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	WNBC-NBC New York (PT24E) [V2+]	o/v
7	(none)	Data Transmissions	Data Transmissions	Adam and Eve/Spice (adult)/Hot Spice [Digicipher]	The Golf Channel [V2+]	Guthy-Renker TV (infomercials)/TV-N Theatre 7 [V2+]	El Comandante Horse Racing/o/v	o/v	Infomercials/Hollo-ywood Treasures HSN	Cornerstone TV (Rel)	CBC-M feeds o/v
8	(none)	Data Transmissions	(none)	ABC feeds East [LEITCH]	o/v	Pandamerica Home Shopping/TVN Theatre 8 [V2+]	ABC NewsOne Channel	Telemundo/Telen-oticias [PowerVu]	KOMO-ABC Seattle (PT24W) [V2+]	Fox Sports Chicago [V2+]	o/v
9	(none)	NASA TV	WPIX-Ind New York [V2+]	Horse Racing [digital video]/o/v	CBS Eye on People Network [PowerVu]	TVN Theatre 9-adulTVision (adult) [V2+]	FOX Feeds [LEITCH]	WB Dom TV/Network	Data Transmissions	Fox Sports South [V2+]	CBC-B English Atlantic
10	(none)	Data Transmissions	Data Transmissions	FOX News Edge	United Arab Emirates TV Dubai	Horse Racing [digital video]/o/v	FOX Feeds [LEITCH]	o/v	FOXNet (PT24E/W) [V2+]	WKRN-ABC Nashville, TN (PT24E) [V2+]	Cancom [PowerVu]
11	(none)	Abu Dhabi TV (UAE)	CNN/SI	Xxxcite (adult) [V2+]	Encore [V2+]	o/v	Exxxtasy (adult) [V2+]	o/v	STARZ! East [V2+]	Univision [digital video]	CBC-A French [Powervu]
12	(none)	Data Transmissions	Data Transmissions	Horse Racing [digital video]	Romance Classics [V2+]	Gem Shopping Channel (o/v)/RAI TV	Exotica (adult) [V2+]	o/v	(none)	Wisdom Network	Cancom [PowerVu]
13	DayStar TV Network	Data Transmissions	SCPC/FM2 services	FOX feeds West [LEITCH]	Ovation/CSN/Kal-eidoscope/Bloom-berg/Box [Digicipher]	Horse Racing [digital video]/o/v	FOX feeds East [LEITCH]	o/v	Data Transmissions	Fox Sports South/Sports Alternate (occ)/o/v	CBC-C English Pacific
14	(none)	USIA Worldnet TV/VOA radio [PowerVu]	CNN Headline News clean feed	ABC feeds East [LEITCH]	Independent Film Channel [V2+]	X!/XXXplore Promo (adult)	True Blue (adult) [V2+]	o/v	WWOR- UPN New York [V2+]	Fox Sports New England [V2+]	Cancom [PowerVu]
15	(none)	Data Transmissions	KTLA-Ind Los Angeles [V2+]	The X! Channel (adult) [V2+]	Your Choice TV [Digicipher]	Infomercials/o/v	Paramount Syndication/o/v	World Harvest TV (Rel)	Data Transmissions	Southern Entertainment TV (SET) [V2+]	o/v
16	(none)	Data Transmissions	CNN International/CNN fN [V2+]	Eurotica (adult) [V2+]	Access Television/The Recovery Network [Digicipher]	HBO 2 East [V2+]	UPN Network/o/v	CBS West [occ VC1]	NPS Promo Channel	Fox Sports Bay Area [V2+]	Global TV [PowerVu]
17	(none)	Data Transmissions	FM2 services	FOX feeds [LEITCH]	Unknown user [digital video]	Cinemax 2 East [V2+]	o/v	CBS feeds [occ VC1]/WB Network	(none)	MuchMusic USA [V2+]	CBC-D feeds o/v
18	o/v	o/v	fXM-Movies from Fox [V2+]	PBS National Schedule	Teleport Minnesota/CBS feeds/o/v	Inforamerica TV (Informercials)	B-Movie Channel (o/v)/o/v	CBS feeds/ Eyemark syndicated feeds	STARZ! West [V2+]	Fox Sports New York [V2+]	Data Transmissions/Un-known user [digital video]
19	Gospel Music Television	Data Transmissions	(none)	X! Promo (adult)	CBS East [occ VC1]	HBO 3 [V2+]	America's Collectibles Network	CBS East [occ VC1]	(none)	America's Voice TV	Telesat [PowerVu]
20	(none)	Saudi TV Channel 1	University Network Dr. Gene Scott	Worldwide TV New (WTN) feeds	FOX News Channel [V2+]	HBO 2 West [V2+]	o/v	CBS East [occ VC1]	(none)	AFRTS [Powervu]	(Inactive)
21	(none)	o/v	Fox Sports World [V2+]	ABC feeds West [LEITCH]	BET on Jazz	Superstar Programming Promo/o/v	ABC West Hot Backup [LEITCH]	CBS feeds/o/v	Data Transmissions	Univision feeds (occ)	Telesat [PowerVu]
22	(none)	Arab Network of America (ANA)	o/v	ABC feeds East [LEITCH]	o/v	Horse Racing [digital video]	ABC East Hot Backup [LEITCH]	o/v	(none)	Deutsche Welle TV	Unknown user [digital video]
23	Home Team Sports (HTS)	o/v	o/v	o/v	(none)	3 Angels Broadcasting	o/v	SCOLA [Wegener]	Data Transmissions	Outlaw Music Channel [V2+]	CBC-E English o/v
24	(none)	o/v	America One	o/v	Intl Channel/Encore Themed Channels [4DTV]	Horse Racing [digital video]/o/v	o/v	CBS Newspath	KPIX-CBS San Francisco (PT24W) [V2+]	WSEE-CBS Erie, PA (PT24E) [V2+]	CTV [PowerVu]

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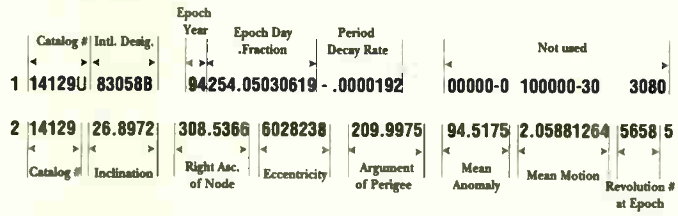
olidaridad 1 D1) 109.2°	Telesat E1 (A2) 111°	Solidaridad 2 (SD2) 112.9°	Morelos 2 (M2) 116.8°	Galaxy 9 (G9) 123°	Galaxy 5 (G5) 125°	Satcom C3 (F3) 131°	Galaxy 1R (G1) 133°	Satcom C4 (F4) 135°	Satcom C1 (F1) 137°	
Data Transmissions	Data Transmissions	Data Transmissions	Data Transmissions	o/v	Disney East [V2+]	Family Channel-E/W/ FIT TV/IFE [PowerVu]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	SSN Extra (various sports Nets) [V2+]	1
Data Transmissions	(Inactive)	Data Transmissions	Unknown User [digital video]	o/v	Playboy (adult) [V2+]	The Learning Channel [V2+]	Univision/Galavision [PowerVu]	Viewers Choice PPV [Digicipher]	KMGH-ABC Denver [V2+]	2
SCPC services	Data Transmissions	Data Transmissions	(none)	NHK TV	Trinity Broadcasting (Rel)	Viewer's Choice PPV [digital video]	Encore Themed Services [4DTV]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2+]	3
Data Transmissions	Data Transmissions	Data Transmissions	Data Transmissions	General Communication [digital video]	Sci-Fi [V2+]	Lifetime West [V2+]	TV Food/Outdoor Life Networks [Digicipher]	Lifetime East [V2+]	Fox Sports Alternates (occ)	4
(none)	Data Transmissions	(none)	Data Transmissions	Showtime/TMC/S-DC(W) [4DTV]/VH-1(W)-[Powervu]	CNN [V2+]	Odyssey (Rel)	Classic Arts Showcase	Product Information Network	KDVR-Fox Denver [V2+]	5
Unknown User [digital video]	(Inactive)	Data Transmissions	Unknown User [digital video]	o/v	WTBS-Ind Atlanta [V2+]	Court TV/NW Cable News [4DTV]	Z-Music	Madison Square Garden [V2+]	KCNC-CBS Denver [V2+]	6
Unknown User [digital video]	Data Transmissions	Unknown user[digital]/Data Transmissions	Data Transmissions	TVN Digital Theaters 1-8 [4DTV]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN FOX Sports West [V2+]	7
Unknown User [digital video]	(Inactive)	Data Transmissions	XHGC canal 5	General Communication [digital video]	HBO West [V2+]	Q2	Cartoon Network [V2+]	Prevue Channel	NBC-East	8
Multivision DBS [Digicipher]	(Inactive)	(none)	Unknown User [digital video]	TVN Digital Theaters 9-16 [4DTV]	ESPN [V2+]	Music Choice [4DTV]	ESPN2 Blackout [V2+]/SAH	QVC Network	FOX Sports Net Base	9
Mexican Government Channel	(Inactive)	(none)	XEIPN canal 11	TVN Digital Theaters 17-24 [4DTV]	MOR Music	America's Store	MSNBC [V2+]	Home Shopping Network (HSN)	SSN FOX Sports SW [V2+]	10
Multivision DBS [Digicipher]	(Inactive)	Data Transmissions	Unknown User [digital video]	TVN Digital Theaters 25-32 [4DTV]	Family Channel East [V2+]	Fox Sports Net Base [V2+]	Eternal Word TV Network (Rel)	SpeedVision	NHK secondary feeds	11
(none)	o/v	(none)	(none)	General Communication [digital video]	Discovery West [V2+]	History Channel [V2+]	Valuevision	Ziff Davis TV (ZDTV)	Data Transmissions	12
(none)	(Inactive)	(none)	Unknown User [digital video]	TVN Digital Theaters 33-35/GRTV [4DTV]	CNBC [V2+]	The Weather Channel [V2+]	Encore Themed Services [4DTV]	Travel Channel [V2+]	Fox Sports Midwest [V2+]	13
(none)	o/v	Data Transmissions	XEW canal 2	Sundance Channel [V2+]	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Alternate [V2+]/SAH	California Channel [PowerVu]/IFE o/v	KUSA-NBC Denver [V2+]	14
Multivision DBS [Digicipher]	(Inactive)	Data Transmissions	Unknown user [digital video]	Showtime West [V2+]	HBO East [V2+]	Viacom Promos [occ V2+]	CNNSI/CNN fn/CNN Intl/T.C.M./CNN Spanish [4DTV]	Animal Planet [V2+]	SC Florida [V2+]	15
Data Transmission	(Inactive)	Data Transmissions	XEIMT Canal 22	General Communication [digital video]	Cinemax West [V2+]	M2: Music Television	Turner Classic Movies [V2+]	Viewers Choice PPV [V2+]	FOX Sports Arizona/Americas [Digicipher]	16
o/v	(Inactive)	(none)	Unknown User [digital video]	Nickelodeon West [V2+]	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	MTV East [V2+]	SSN FOX Sports (alternates) [V2+]	17
o/v	(Inactive)	(none)	o/v	The Movie Channel West [V2+]	TNN [V2+]	TVLand	HBO/Cinemax [4DTV]	Viewer's Choice [Digicipher]	FOX Sports Rocky Mountain [V2+]	18
Data Transmissions	TV Northern Canada [PowerVu]/Data Transmissions	Data Transmissions	(none)	MTV West [V2+]	USA East [V2+]	Showtime/TMC/S-DC (East) [4DTV]	Cinemax East [V2+]	C-SPAN 2 [analog]/CSPAN 3 [digital]	FOXNet [V2+]	19
(none)	(Inactive)	(none)	Data Transmissions	General Communication [digital video]	BET [V2+]	Jones Computer/GAC/P-IN [4DTV]	Home and Garden Network [V2+]	Showtime East 2 [V2+]	Unknown User [digital video]	20
(none)	SCPC services/Data Transmissions	(none)	Mexican Cable [Digicipher]	ESPNews [V2+]	Knowledge TV	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	FOX Sports West 2 [V2+]	21
(none)	(Inactive)	Data Transmissions	XHIMT canal 7	o/v	CNN/HN [V2+]	Animal Planet/Discovery Channel Services [Digicipher]	Nostalgia-Good TV Channel [V2+]	FLIX [V2+]	SSN FOX Sports NW [V2+] (occ)	22
Data Transmissions	(Inactive)	Data Transmissions	Mexican Cable [Digicipher]	(none)	A&E [V2+]	E! Entertainment TV (East) [V2+]/E! (West) [PowerVu]	HBO/Cinemax [4DTV]	VH-1 [V2+]	KWGN-Ind Denver [V2+]	23
Unknown User [digital video]	(Inactive)	(none)	XHDF canal 13	General Communication [digital video]	Showtime (East) [V2+]	Digital Music Express Radio (DMX) [digital audio]	Outdoor Channel	CMT [V2+]	SSN Sunshine Network [V2+]	24

crambled/non-video ☐ Subscription ☐ Not available in U.S. ☐ o/v = occasional video

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
AMSAT OSCAR 10 (Phase 3B, AO-10)
1 14129U 83058B 98137.98838046 -.00000050 00000-0 10000-3 0 5508
2 14129 26.7902 87.5357 6000648 217.4899 79.5295 2.05882477 84286
UoSAT OSCAR 11 (UoSAT-B, UO-B, UoSAT 2, UO-2, UoSAT 11, UO-11)
1 14781U 84021B 98141.48528155 .00000356 00000-0 67652-4 0 598
2 14781 97.8800 115.0424 0012351 7.8187 352.3210 14.69758244760947
Russian *Mir* Space Station
1 16609U 86017A 98140.93799848 .00010114 00000-0 10867-3 0 5058
2 16609 51.6571 184.5986 0005452 22.0577 338.0657 15.64437542699792
Pacsat OSCAR 16 (Microsat-A/Pacsat)
1 20439U 90005D 98138.82234431 .00000064 00000-0 41627-4 0 1488
2 20439 98.5120 221.4860 0010951 305.5836 54.4325 14.30061104434200
DOVE OSCAR 17 (Microsat-B, DO-17)
1 20440U 90005E 98140.73339054 .00000065 00000-0 41812-4 0 1465
2 20440 98.5176 224.4758 0010996 299.8856 60.1233 14.30207093434513
Webersat OSCAR 18 (Microsat-C, WO-18)
1 20441U 90005F 98138.78041317 .00000069 00000-0 43466-4 0 1540
2 20441 98.5170 222.4197 0011737 305.8066 54.2024 14.30169825434239
Lusat OSCAR 19 (Microsat-D, LO-19)
1 20442U 90005G 98138.79004736 .00000078 00000-0 46845-4 0 1517
2 20442 98.5212 223.3034 0011940 304.2996 55.7055 14.30290480434263
Fuji OSCAR 20 (JAS-1B, Fuji-2, FO-20)
1 20480U 90013C 98141.24775681 .00000017 00000-0 11598-3 0 536
2 20480 99.0723 44.7854 0540499 332.3585 24.9707 12.83244316388066
Radio Sputnik-12/13 (Cosmos 2123, RS-12/13)
1 21089U 91007A 98141.15988055 .00000090 00000-0 79222-4 0 683
2 21089 82.9249 28.0025 0030700 76.0448 284.4134 13.74099194365571
UoSAT OSCAR 22 (UoSAT-F, UoSAT-5, UO-22)
1 21575U 91050B 98140.64777711 .00000098 00000-0 46947-4 0 8571
2 21575 98.2538 193.3797 0007383 328.2111 31.8628 14.37142313358952
KITSAT OSCAR 23 (Uribyol, KITSAT-A, KITSAT-1, KO-23)
1 22077U 92052B 98136.60238259 -.00000037 00000-0 10000-3 0 7452
2 22077 66.0794 167.1364 0010091 318.4977 41.5274 12.86310092270633
AMRAD OSCAR 27 (EYESAT-A, EYESAT-1, AO-27)
1 22825U 93061C 98140.71103427 .00000113 00000-0 63151-4 0 6414
2 22825 98.5023 211.7439 0008706 338.7708 21.3106 14.27775911242232
ITAMSAT OSCAR 26 (IO-26)
1 22826U 93061D 98137.71023237 .00000110 00000-0 61603-4 0 6362
2 22826 98.5073 209.1631 0010013 346.1400 13.9503 14.27887628241820
KITSAT OSCAR 25 (KITSAT-B, KITSAT-2, KO-25)
1 22828U 93061F 98139.20472776 .00000106 00000-0 59541-4 0 6167
2 22828 98.5029 210.7232 0009894 323.7036 36.3456 14.28238440210172
POSAT OSCAR 28 (PO-28) Not in amateur service at presstime
1 22829U 93061G 98141.26074647 .00000070 00000-0 45338-4 0 6329
2 22829 98.5044 212.8500 0010046 319.6968 40.3454 14.28227284242385
Radio Sputnik 15 (RS-15)
1 23439U 94085A 98134.87586917 -.00000039 00000-0 10000-3 0 3006
2 23439 64.8173 336.5035 0146901 67.6045 294.0369 11.27530064139337
Fuji OSCAR 29 (JAS-2, Fuji-3, FO-29)
1 24278U 96046B 98137.99943092 -.00000057 00000-0 -23424-4 0 1626
2 24278 98.5169 138.0493 0352343 38.3091 324.2523 13.52641133 86380
Radio Sputnik 16 (RS-16)
1 24744U 97010A 98140.75197734 .00009834 00000-0 28467-3 0 2024
2 24744 97.2540 44.7791 0006148 345.4856 14.6211 15.35773081 67802

WEATHER/IMAGING SATELLITES
Geostationary Satellites
GOES 2 (Standby spacecraft-US 136.860 MHz on continuously, high power)
1 10061U 77048A 98138.48362269 .00000051 00000-0 10000-3 0 9780
2 10061 13.1837 29.3571 0005661 178.0304 26.5275 1.00286211 21462
GOES 3 (Standby spacecraft-US 137.190 MHz on continuously, high power)
1 10953U 78062A 98139.72223121 -.00000115 00000-0 00000+0 0 9190
2 10953 12.2262 32.4946 0003736 244.0922 115.8151 1.00280992 26095
GOES 7 (Standby spacecraft-US)
1 17561U 87022A 98138.43971169 -.00000152 00000-0 10000-3 0 5111
2 17561 4.4024 64.9270 0000661 17.5168 215.4778 1.00273774 24321
GOES 8 (Operational East-US)
1 23051U 94022A 98139.40878157 -.00000253 00000-0 10000-3 0 1568
2 23051 0.0750 273.7874 0002527 180.1744 214.4101 1.00258183 22391
GOES 9 (Operational West-US)
1 23581U 95025A 98138.36407756 .00000084 00000-0 00000+0 0 9381
2 23581 0.3038 93.7755 0002208 265.2916 232.4814 1.00269747 10948
GOES 10 (Standby spacecraft-US post launch testing continues)
1 24786U 97019A 98139.20604817 -.00000103 00000-0 00000+0 0 1964
2 24786 0.3190 90.0437 0004149 265.4354 211.2566 1.00279484 3924
ELEKTRO (Operational Russian spacecraft)
1 23327U 94069A 98137.69116106 -.00000099 00000-0 10000-3 0 5879
2 23327 1.4729 87.7702 0000308 158.2820 313.8367 1.00267473 13016
Feng Yun 2B (Operational Chinese spacecraft)
1 24834U 97029A 98131.78422382 -.00000329 00000-0 00000+0 0 1453
2 24834 0.5896 248.6027 0002171 168.5286 199.3140 1.00265767 3359
Meteosat 5 (Operational ESA spacecraft moving to 65 deg East, aka MOP-2)
1 21140U 91015B 98138.98645468 -.00000018 00000-0 00000+0 0 4571
2 21140 1.9646 77.8927 0001243 87.2533 129.3438 1.00448768 28631
Meteosat 6 (Operational ESA spacecraft)
1 22912U 93073B 98137.06053898 -.00000008 00000-0 00000+0 0 1298
2 22912 0.1951 2.2505 0001260 107.4686 146.6927 1.00268908 14867
Meteosat 7 (Operational ESA spacecraft)
1 24932U 97049B 98133.04300926 -.00000073 00000-0 00000+0 0 1337
2 24932 1.3232 290.3473 0002247 21.5275 285.2134 1.00277019 2541
GMS 4 (Standby Japanese spacecraft, aka Himawari 4)
1 20217U 89070A 98139.26808324 -.00000370 00000-0 00000+0 0 7751
2 20217 3.1839 71.6487 0001001 180.2564 201.6153 1.00270146 32452
GMS 5 Operational Japanese spacecraft, aka Himawari 5)
1 23522U 95011B 98139.58026530 -.00000290 00000-0 00000+0 0 7224
2 23522 0.3828 357.3213 0001100 49.0765 179.5687 1.00264276 11489

Near Polar/Polar Orbiting Imaging Spacecraft
NOAA 12 (Operational morning US spacecraft 137.500 MHz APT)
1 21263U 91032A 98140.78325456 .00000111 00000-0 68289-4 0 8136
2 21263 98.5294 149.5726 0013835 36.0289 324.1818 14.22821750364366
NOAA 14 (Operational afternoon US spacecraft 137.620 MHz APT)
1 23455U 94089A 98140.81917869 .00000122 00000-0 91898-4 0 4674
2 23455 99.0393 98.7117 0010678 62.2161 298.0092 14.11773015174582
Meteor 2-21(Russian spacecraft off at last report)
1 22782U 93055A 98138.12420004 .00000060 00000-0 40848-4 0 6457
2 22782 82.5503 152.4274 0022076 172.7808 187.3673 13.83101340237888
Meteor 3-5 (Operational Russia spacecraft 137.850 MHz APT)
1 21655U 91056A 98136.67940857 .00000051 00000-0 10000-3 0 657
2 21655 82.5585 187.1387 0012765 220.8214 139.1950 13.16861924324603
DMSP B5D2-7 (DoD meteorological polar orbiter: downlink encrypted)
1 23233U 94057A 98140.83210512 .00000202 00000-0 13177-3 0 6580
2 23233 98.7307 196.6956 0012558 350.1586 9.9327 14.12923011192040
DMSP B5D2-8 (DoD meteorological polar orbiter: downlink encrypted)
1 23533U 95015A 98140.84084358 .00000241 00000-0 15322-3 0 4109
2 23533 98.8517 145.8294 0006270 220.2787 139.7912 14.12866356162847
DMSP B5D2-9 (DoD meteorological polar orbiter: downlink encrypted)
1 24753U 97012A 98140.79825025 .00000138 00000-0 97869-4 0 4596
2 24753 98.8877 188.4745 0008811 165.7099 194.4312 14.13066727 58062
NOAA 15
1 25338U 98030A 98140.52783793 .00000187 00000-0 10289-3 0 111
2 25338 98.7153 170.3565 0010467 320.4950 39.5463 14.22767486 977

EARTH RESOURCES IMAGING SATELLITES
OKEAN 1-7 (Russian Okean 4 137.400 MHz)
1 23317U 94066A 98139.15632629 .00000157 00000-0 20308-4 0 3292
2 23317 82.5439 134.0889 0024861 325.3805 34.5785 14.74269789193809
SICH-1 (Russian Oceanographic spacecraft 137.400 MHz)
1 23657U 95046A 98139.37692285 .00000511 00000-0 74538-4 0 2563
2 23657 82.5300 275.0509 0026182 294.5014 65.3468 14.73715898146090
SPOT 4
1 25260U 98017A 98141.10822759 .00000456 00000-0 23474-3 0 389
2 25260 98.7351 216.0350 0001170 93.9645 266.1405 14.20033393 8248

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

1983-058B/14129 AMSAT OSCAR 10 (Phase 3B, AO-10)
Communications transponder (linear/inverting): Uplink 435.027-435.179 MHz (CW/LSB)/ Downlink 145.825-145.977 MHz (CW/USB)/ Beacon: 145.810 MHz (Steady unmodulated carrier)

1984-021B/14781 UoSAT OSCAR 11 (UoSAT-B, UO-B, UoSAT-2, UO-2, UoSAT 11, UO-11)
Downlink 145.825 MHz FM (1200 Baud PSK)/Beacon 2401.500 MHz. The operating schedule: ASCII status–210 seconds, ASCII bulletin–60 seconds, BINARY SEU–30 seconds, ASCII TLM–(90 seconds, ASCII WOD–120 seconds, ASCII bulletin–60 seconds, and BINARY ENG–30 seconds.

1990-005D/20439 Pacsat OSCAR 16 (Microsat-A, Pacsat)
Uplinks 145.900, 145.920, 145.940, and 145.960 MHz FM (1200 bps Manchester FSK) /Downlinks 437.0513 (1200 bps RC-BPSK) and 437.026 secondary (1200 baud PSK) MHz SSB/Beacon 2401.1428 MHz (BPSK). Connect Address: Pacsat-1.

1990-005E/20440 DOVE OSCAR 17 (Microsat-B, DO-17)
Downlink 145.825 MHz FM (1200 baud AFSK)/Beacon 2401.220 MHz. DOVE is presently sending 1200 baud AX.25 (standard packet) and ASCII telemetry about every minute on 2-meters. On S-band it transmits PSK flags continuously and also the same data that is sent on 2-meters. At presstime, the 145.825 MHz and 2401.220 MHz downlinks are off the air. Command stations are working on the problem.

1990-005F/20441 Webersat OSCAR 18 (Microsat-C, WO-18)
Downlink 437.104 MHz SSB (1200 baud PSK AX.25). At presstime WO-18 was non-operational. WO-18 is in MBL mode after a software crash. Attempts are being made to find and correct the cause of these suspected seasonal crashes.

1990-005G/20442 Lusat OSCAR 19 (Microsat-D, LO-19)
Uplink 145.840, 145.860, 145.880 and 145.900 (1200 bps Manchester FSK)/Downlinks 437.125 and 437.153 (secondary) MHz SSB (1200 bps RC-BPSK)

1990-13C/20480 Fuji OSCAR 20 (JAS-1B, Fuji-2, FO-20)
JA mode (linear/inverting): Uplink 145.900-146.000 MHz (CW/ LSB)/Downlink 435.800-435.900 MHz (CW/USB). FO-20 in mode JA continuously. Callsign: 8J1JBS

1991-050B/21575 UoSAT OSCAR 22 (UoSAT-F, UoSAT-5, UO-22)
JD Mode: Uplink 145.900 or 145.975 MHz FM/Downlink 435.120 MHz FM (9600 baud FSK)

1992-052B/22077 KITSAT OSCAR 23 (Uribyol, KITSAT-A, KITSAT-1, KO-23)
JD Mode: Uplink 145.850 and 145.900 MHz FM/Downlink 435.175 MHz FM (9600 baud FSK), Callsigns: HL01-11 (Broadcast) and HL01-12 (BBS)

1993-061C/22828 KITSAT OSCAR 25 (KITSAT-B, KITSAT-2, KO-25)
JD Mode: Uplink 145.870 and 145.980 MHz FM/Downlink 435.175 and 436.5 MHz FM (9600 baud FSK). Callsigns: HL02-11 (Broadcast) and HL02-12 (BBS)

1993-061F/22826 ITAMSAT OSCAR 26 (IO-26)
Uplink 145.875, 145.900, 145.925 and 145.950 MHz FM/Downlink 435.822 MHz SSB (1200 baud PSK). Callsign: ITMSAT

1993-061G/22829 AMRAD OSCAR 27 (Eyesat-A, Eyesat-1, AO-27)
Uplink 145.850 MHz FM/Downlink 436.792 MHz FM

1996-046B/24278 Fuji OSCAR 29 (JAS-2, Fuji-3, FO-29)
JA Mode (Voice/CW): Uplink 145.900-146.000 MHz (CW/LSB)/ Downlink 435.800-435.900 MHz (CW/USB).
JD mode (digital): Uplink 145.850, 145.870, 145.890 and 145.910 MHz FM/Downlink 435.910 MHz FM (9600 baud BPSK)

1991-007A/21089 Radio Sputnik 12/13 (Cosmos 2123, RS-12/13)
KA mode: Uplink 145.910-145.950 MHz (CW/SSB)/Downlink 29.410-29.450 MHz (CW/SSB). The 15-meter ROBOT is operational. This communication package was carried by Cosmos 2123 as secondary payload.

1994-085A/23439 Radio Sputnik 15 (Radio-Rosto, RS-15)
Mode A: Uplink 145.858-145.898 MHz (CW/SSB)/Downlink 29.354-29.394 MHz (CW/SSB)

1997-010A/24744 Radio Sputnik 16 (RS-16)
At press time, the 435 MHz beacon (only) is operational. Recent attempts to command the Mode A transponder on have been unsuccessful. Communications transponder: Uplink 145.915-145.948 MHz/Downlink 29.415-29.448 MHz. Beacons: HF Beacons–29.408 and 29.451 MHz/ UHF Beacon 1–435.504 MHz/UHF Beacon 2–435.548 MHz

1986-017A/16609 *Mir* Space Station (*Mir*/SAFEX)
SAFEX II 70-cm repeater: Uplink 435.750 MHz FM with subaudible tone 141.3 Hz/Downlink 437.950 MHz FM
QSO Mode: Uplink 435.725 MHz FM w/subaudible tone 151.4 Hz/ Downlink 437.925 MHz FM
PMS: 145.985 MHz FM, 1200 Baud AFSK/Occasional FM voice contacts are made on this frequency.

Geostationary Satellite Locator Guide

By TS Kelso and Larry Van Horn

This guide shows the orbital locations of 247 active geostationary/geosynchronous satellites as of June 1, 1998. Orbital parameters are based on current two-line element sets and satellite names come from the latest Satellite Situation Report.

We are particularly grateful to the following individuals for providing payload information and analysis: Earth News—Philip Chien; Molniya Space Consultancy—Phillip Clark; Baylin Publications—Dr. Frank Baylin; Harvard-Smithsonian Center for Astrophysics—Jonathan McDowell; US Space Command/Public Affairs; Naval Space Command/Public Affairs; NASA NSSDC/WDC-A, Goddard Space Flight Center; and the *Satellite Times* staff.

Orbit Codes

- d satellite is drifting (moving into a new orbital slot or at end of life)
- # satellite has started into an inclined orbit
- i orbital inclination greater than 2 degrees

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
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

AOR	Atlantic Ocean Region
APR	Asia/Pacific Ocean Region
BSS	Broadcast Satellite Service
DARS	Digital Audio Radio Service
FSS	Fixed Satellite Service
Gov	Government
Intl	International
IOR	Indian Ocean Region
MSS	Mobile Satellite Service
MET	Meteorological Satellite Serv.
Mil	Military
POR	Pacific Ocean Region

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
24808	1997-025A THOR 2A [NOR]	0.2E	BSS (Ku)
20771	1990-077A BS-3A (YURI 3A) [JPN]	0.8Ed	BSS (S/Ku)
23730	1995-067A TELECOM 2C [FR]	3.4E	FSS-Gov/Mil (S/C/X/Ku)
24932	1997-049B METEOSAT 7 [ESA]	4.8E#d	MET (P/L/S) In-orbit spare
25049	1997-071A SIRIUS 2 [SWED]	5.1E	BSS (Ku)
20193	1989-067A SIRIUS (MARCOPOLO 1) [SWED]	5.5E	BSS (Ku)
22028	1992-041B EUTELSAT 2-F4 [EUTE]	7.5E	FSS (S/Ku)
21056	1991-003B EUTELSAT 2-F2 [EUTE]	10.5E	FSS (S/Ku)
19596	1988-095A RADUGA 22 [CIS]	11.8Ei	FSS-Gov/Mil (X/C)
22269	1992-088A COSMOS 2224 [CIS]	12.0E#	FSS-Mil Early Warning (X)
22557	1993-013A RADUGA 29 [CIS]	12.0Ei	FSS-Gov/Mil (X/C)
24931	1997-049A HOT BIRD 3 [EUTE]	13.0E	BSS (Ku)
25237	1998-013A HOT BIRD 4 [EUTE]	13.0E	BSS (Ku)
20777	1990-079B EUTELSAT 2-F1 [EUTE]	13.0E	FSS (S/Ku)
23537	1995-016B HOT BIRD 1 [EUTE]	13.0E	BSS (Ku)
24665	1996-067A HOT BIRD 2 [EUTE]	13.1E	BSS (Ku)
21055	1991-003A ITALSAT 1 [IT]	13.4E#	FSS/MSS (S/K/Ka)
24208	1996-044A ITALSAT 2 [IT]	13.9E#	FSS/MSS (L/S/K/Ka)
21803	1991-083A EUTELSAT 2-F3 [EUTE]	16.1E	FSS (S/Ku)
21139	1991-015A ASTRA 1B [LUXE]	19.3E	BSS (Ku)
19688	1988-109B ASTRA 1A [LUXE]	19.3E	BSS (Ku)
22653	1993-031A ASTRA 1C [LUXE]	20.3E	BSS (Ku)
23842	1996-021A ASTRA 1F [LUXE]	20.3E	BSS (Ku)
23686	1995-055A ASTRA 1E [LUXE]	20.7E	BSS (Ku)
25071	1997-076A ASTRA 1G [LUXE]	20.7E	BSS (Ku)
19331	1988-063B EUTELSAT 1-F5 (ECS 5) [EUTE]	22.0Ei	FSS (VHF/Ku)
22175	1992-066A DFS 3 [FRG]	23.5E	BSS (S/Ku/K)
25153	1998-006B INMARSAT 3-F5 [IM]	25.0Ei	Intl MSS on-orbit spare (L/C)
18351	1987-078B EUTELSAT 1-F4 (ECS 4) [EUTE]	25.9Ei	FSS (VHF/Ku)
23948	1996-040A ARABSAT 2A [AB]	26.1E	BSS/FSS (C/Ku)
23331	1994-070A ASTRA 1D [LUXE]	28.4E	BSS (Ku)
20706	1990-063B DFS 2 [FRG]	28.9E	BSS (S/Ku/K)
24652	1996-063A ARABSAT 2B [AB]	31.1E	BSS/FSS (C/Ku)
23200	1994-049B TURKSAT 1B [TURK]	32.0E	FSS (Ku)
15629	1985-025A INTELSAT 510 [ITSO]	33.2Ei	Intl FSS IOR (C/Ku)
22963	1994-002A GALS 1 [CIS]	36.1E#	BSS (Ku)
21821	1991-087A RADUGA 28 [CIS]	36.5Ei	FSS-Gov/Mil (X/C)
23717	1995-063A GALS 2 [CIS]	36.9E#	BSS (Ku)
23775	1996-005A GORIZONT 31 [CIS]	39.8E#	FSS (C/Ku) Statsionar 12
20659	1990-054A GORIZONT 20 [CIS]	42.6Eid	FSS (C/Ku)
23949	1996-040B TURKSAT 1C [TURK]	42.9E	FSS (Ku)
22981	1994-008A RADUGA 1-3 [CIS]	49.1E#	FSS-Gov/Mil (X/C) Statsionar 24
23880	1996-034A GORIZONT 32 [CIS]	52.9E	FSS (C/Ku) Statsionar 5
19687	1988-109A SKYNET 4B [UK]	53.3Ei	FSS-Milcomsat (P/S/X/Ka)
21894	1992-010B ARABSAT 1C [AB]	55.2E	BSS/FSS (S/C)
23305	1994-064A INTELSAT 703 [ITSO]	57.2E	Intl FSS IOR (C/Ku)
20667	1990-056A INTELSAT 604 [ITSO]	61.1E	Intl FSS IOR (C/Ku)
20315	1989-087A INTELSAT 602 [ITSO]	62.4E	Intl FSS IOR (C/Ku)
23839	1996-020A INMARSAT 3-F1 [IM]	64.1E#	Intl MSS IOR (L/C)
25110	1997-083A INTELSAT 804 [ITSO]	64.3E	Intl FSS IOR (C/Ku)
21814	1991-084B INMARSAT 2-F3 [IM]	65.2E#	Intl MSS IOR (L/C)
18922	1988-014A STTW-2 [PRC]	65.5Ei	FSS (C)
23461	1995-001A INTELSAT 704 [ITSO]	66.3E	Intl FSS IOR (C/Ku)
23636	1995-040A PAS 4 [US]	68.7E	FSS/BSS IOR (C/Ku)
23448	1994-087A RADUGA 32 [CIS]	70.4E#	FSS-Gov/Mil (X/C) Statsionar 20
22787	1993-056A UFO 2 (USA 95) [US]	70.9Ei	FSS-Milcomsat IOR (P/S)
23589	1995-027A UFO 5 (USA 111) [US]	71.2Ei	FSS-Milcomsat IOR (P/S/K)
21140	1991-015B METEOSAT 5 (MOP 2) [ESA]	71.8E#d	MET (P/L/S)
10669	1978-016A OPS 6391 (FLTSATCOM 1) [US]	71.9Ei	FSS-Milcomsat IOR (P/S)
13595	1982-097A INTELSAT 505 [ITSO]	72.0Ei	Intl FSS/MSS APR (L/C/Ku)
22027	1992-041A INSAT 2A [IND]	74.3E#	FSS/MET (S/C)
25134	1998-002A SKYNET 4D [UK]	75.2Eid	FSS-Milcomsat (P/S/X/Ka)
23327	1994-069A ELEKTRO (GOMS) [CIS]	75.7E#	MET (L)
25010	1997-062A APSTAR 2R [PRC]	76.5E	FSS (C/Ku)
23680	1995-054A LUCH 1 [CIS]	77.4E#	FSS-SDRN2 (Ku)
24768	1997-016A THAICOM 3 [THAI]	78.4E	FSS/BSS (C/Ku)
23314	1994-065B THAICOM 2 [THAI]	78.5E	FSS (C/Ku)
24435	1996-058A EXPRESS 2 [CIS]	80.0E#	Intl FSS (C/Ku)
23653	1995-045A COSMOS 2319 [CIS]	80.2E#	FSS-Data Relay (C)
20643	1990-051A INSAT 1D [IND]	82.6E#	BSS/FSS/MET (S/C)
19548	1988-091B TDRS 3 [US]	84.1Ei	FSS-Gov (C/S/Ku)
22836	1993-062A RADUGA 30 [CIS]	85.9Ei	FSS-Gov/Mil (X/C) Statsionar 3
22880	1993-069A GORIZONT 28 [CIS]	90.0Ei	FSS (C/Ku) Statsionar 6
23765	1996-002B MEASAT 1 [MALA]	91.4E	FSS (C/Ku)
23731	1995-067B INSAT 2C [IND]	92.3E	BSS/FSS/MET (S/C/Ku)
22724	1993-048B INSAT 2B [IND]	93.3E	BSS/FSS/MET (S/C)
22245	1992-082A GORIZONT 27 [CIS]	96.2Ei	FSS (C/Ku) Statsionar 14
20473	1990-011A STTW-4 [PRC]	97.7Ei	FSS (C)
22210	1992-074A EKRAN 20 [CIS]	99.3Ei	BSS (P) Statsionar-T
23723	1995-064A ASIASAT 2 [AC]	100.3E	BSS (C/Ku)
21922	1992-017A GORIZONT 25 [CIS]	102.8Ei	FSS (C/Ku) Statsionar 21
24834	1997-029A FY-2 [PRC]	103.9E#	MET (L)
20558	1990-030A ASIASAT 1 [AC]	105.4E	BSS (C)
25050	1997-071B INDOSTAR 1 [INDO]	107.7E	BSS/DARS (L/S)
20570	1990-034A PALAPA B2R [INDO]	107.7E	FSS (C)
24769	1997-016B B-SAT 1A [JPN]	107.8E	BSS (Ku)
23176	1994-040B BS-3N [JPN]	108.5E	BSS (Ku)
21668	1991-060A BS-3B (YURI 3B) [JPN]	109.4E	BSS (S/Ku)
25312	1998-024B B-SAT 1B [JPN]	110.0E	BSS (Ku)
19710	1988-111A STTW-3 [PRC]	110.1Ei	FSS (C)
23864	1996-030A PALAPA C2 [INDO]	112.6E	FSS (C/Ku)
23639	1995-041A KOREASAT 1 [KOR]	114.0E	BSS/FSS (Ku)
23768	1996-003A KOREASAT 2 [KOR]	115.2E	BSS/FSS (Ku)
14985	1984-049A CHINASAT 5 (SPACENET 1) [PRC]	115.5E#	FSS (C/Ku)
21964	1992-027A PALAPA B4 [INDO]	117.9E	FSS (C)
20217	1989-070A HIMAWARI 4 (GMS 4) [JPN]	120.0Ei	MET (P/L/S)
22931	1993-078B THAICOM 1 [THAI]	120.1E	FSS (C/Ku)
23108	1994-030A GORIZONT 30 [CIS]	122.3E#	FSS (C/Ku)
21759	1991-074A GORIZONT 24 [CIS]	123Ei	FSS (C/KU)
24798	1997-021A DFH-3 2 [PRC]	125.0E	FSS (C)
23649	1995-043A JCSAT 3 [JPN]	127.1E	FSS/BSS (C/Ku)
21132	1991-014A RADUGA 27 [CIS]	128.0Ei	FSS-Gov/Mil (X/C)
23651	1995-044A NSTAR 1 [JPN]	131.6E	FSS (S/C/Ku/K)
23943	1996-039A APSTAR 1A [PRC]	134.0E	BSS (C)
23781	1996-007A NSTAR 2 [JPN]	135.9E	FSS (S/C/Ku/K)
23185	1994-043A APSTAR 1 [PRC]	137.8E	BSS (C)
23522	1995-011B GMS 5 [JPN]	139.5E#	MET (P/L/S)
20953	1990-102A GORIZONT 22 [CIS]	140.1Ei	FSS (C/Ku) Statsionar 7
12994	1981-119A INTELSAT 503 [ITSO]	142.7Eid	Intl FSS APR (C/Ku)
24880	1997-036A SUPERBIRD C [JPN]	143.6E	FSS (Ku/K)
20923	1990-094A GORIZONT 21 [CIS]	144.8Ei	FSS (C/Ku) Statsionar 16
24901	1997-042A AGILA 2 [RP]	145.6E	FSS (C/Ku)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
24653	1996-063B MEASAT 2 [MALA]	147.9E	FSS (C/Ku)
24732	1997-007A JCSAT 4 [JPN]	149.7E	FSS (Ku)
25067	1997-075A JCSAT 5 [JPN]	149.8E	FSS (Ku)
23779	1996-006A PALAPA C1 [INDO]	150.2E	FSS (C/Ku)
18350	1987-078A OPTUS A3 (AUSSAT 3) [AUS]	151.4E#	FSS (Ku)
20402	1990-001B JCSAT 2 [JPN]	153.9E	FSS (Ku)
23227	1994-055A OPTUS B3 [AUS]	156.0E	BSS/MSS (L/Ku)
22253	1992-084A SUPERBIRD A1 [JPN]	158.0E	FSS (Ku/K)
22087	1992-054A OPTUS B1 (AUSSAT B1) [AUS]	160.0E	BSS/MSS (L/Ku)
22907	1993-072A GORIZONT 29 [CIS]	161.0E#	FSS (C/Ku)
21893	1992-010A SUPERBIRD B1 [JPN]	162.0E	FSS (Ku/K)
16275	1985-109C OPTUS A2 (AUSSAT 2) [AUS]	164.0Ei	FSS (Ku)
23175	1994-040A PAS 2 [US]	169.0E	Intl FSS POR (C/Ku)
12046	1980-087A OPS 6394 (FLTSATCOM 4) [US]	171.8Ei	FSS-Milcomsat POR (P/S/X)
24846	1997-031A INTELSAT 802 [ITSO]	173.9E	Intl FSS POR (C/Ku)
23124	1994-034A INTELSAT 702 [ITSO]	177.4E	Intl FSS POR (C/Ku)
24674	1996-070A INMARSAT 3-F3 [IM]	178.0E#	Intl MSS POR (L/C)
20918	1990-093A INMARSAT 2-F1 [IM]	179.4E#	Intl MSS POR (L/C)
22871	1993-066A INTELSAT 701 [ITSO]	179.3W	Intl FSS POR (C/Ku)
23467	1995-003A UFO 4 (USA 108) [US]	176.7Wi	FSS-Milcomsat POR (P/S/K)
19121	1988-040A INTELSAT 513 [ITSO]	176.5Wi	Intl FSS POR (C/Ku)
25258	1998-016A UFO 8 (USA 138) [US]	174.4Wi	FSS-Milsatcom POR (P/S/K/Ka)
21639	1991-054B TDRS 5 [US]	174.1W#	Intl FSS-Gov (C/S/Ku)
23613	1995-035B TDRS F7 [US]	171.0Wi	FSS-Gov (C/S/Ku)
20410	1990-002B LEASAT 5 [US]	155.0Ei	FSS-milcomsat Australia (P/S)
21392	1991-037A AURORA 2 [US]	138.3W	FSS (C)
20945	1990-100A SATCOM C1 [US]	136.6W	FSS (C)
23581	1995-025A GOES 9 [US]	135.3W#	MET (P/L/S)
22096	1992-057A SATCOM C4 [US]	134.3W	FSS (C)
23016	1994-013A GALAXY 1R [US]	132.7W	FSS (C)
22117	1992-060B SATCOM C3 [US]	130.9W	FSS (C)
13637	1982-106B DSCS III-1 [US]	130.1Wi	FSS-Milcomsat EPAC (P/S/X)
21906	1992-013A GALAXY 5 [US]	124.7W	FSS (C)
23877	1996-033A GALAXY 9 [US]	122.9W	FSS (C)
19484	1988-081B SBS 5 [US]	122.7W	FSS (Ku)
15826	1985-048D TELSTAR 303 [US]	119.9Wi	FSS (C)
25331	1998-028A ECHOSTAR IV [US]	119.0W	BSS (Ku)
24748	1997-011A TEMPO 2 [US]	118.9W	BSS (Ku)
24313	1996-055A ECHOSTAR II [US]	118.9W	BSS (Ku)
23754	1995-073A ECHOSTAR 1 [US]	118.6W	BSS (Ku)
16274	1985-109B MORELOS 2 [MEX]	116.7W	FSS (C/Ku)
23313	1994-065A SOLIDARIDAD 2 [MEX]	112.8W	FSSMSS (L/C/Ku)
21726	1991-067A ANIK E1 [CA]	111.0W	FSS (C/Ku)
22911	1993-073A SOLIDARIDAD 1 [MEX]	109.1W	FSS/MSS (L/C/Ku)
21222	1991-026A ANIK E2 [CA]	107.2W	FSS (C/Ku)
23696	1995-057A UFO 6 (USA 114) [US]	107.0Wi	FSS-Milcomsat CONUS (P/S/K)
23846	1996-022A MSAT M1 [CA]	106.4W	MSS (L/X)
03029	1967-111A ATS 3 [US]	105.3Wi	Experimental communications (VHF/C)
15677	1985-035A GSTAR 1 [US]	105.2W#	FSS (Ku)
19483	1988-081A GSTAR 3 [US]	105.2Wi	FSS/MSS (L/Ku)
08747	1976-023B LES 9 [US]	105.0Wi	Experimental Milcomsat (P/Ka)
20946	1990-100B GSTAR 4 [US]	104.9W	FSS (Ku)
24786	1997-019A GOES 10 [US]	103.7W#	MET (P/L/S) In-orbit spare
24315	1996-054A GE 1 [US]	103.0W	FSS (C/Ku)
08746	1976-023A LES 8 [US]	101.4Wi	Experimental Milcomsat (P/Ka)
22930	1993-078A DBS 1 [US]	101.2W	BSS (Ku)
21227	1991-028A SPACENET 4 (ASC 2) [US]	101.0W	FSS (C/Ku)
23553	1995-019A AMSC 1 [US]	100.9W	MSS (L/X)
23598	1995-029A DBS 3 [US]	100.9W	BSS (Ku)
23192	1994-047A DBS 2 [US]	100.7W	BSS (Ku)
22796	1993-058B ACTS [US]	100.0W	Experimental communications (S/C/K)
17181	1986-096A FLTSATCOM 7 (USA 20) [US]	99.6Wi	FSS-Milcomsat CONUS (P/S/X/K)
22694	1993-039A GALAXY 4 [US]	99.0W	FSS (C/Ku) Comm package deactivated
20873	1990-091B GALAXY 6 [US]	99.0W	FSS (C)
24812	1997-026A TELSTAR 5 [US]	97.0W	FSS (C/Ku)
17561	1987-022A GOES 7 [US]	96.2Wi	MET (P/L/S)
23741	1995-069A GALAXY 3R [US]	95.1W	FSS (C/Ku)
25086	1997-078A GALAXY 8 [US]	95.0W	BSS (Ku)
16650	1986-026B BRAZILSAT 2 [BRAZ]	92.2W#	FSS (C)
22205	1992-072A GALAXY 7 [US]	91.2W	FSS (C/Ku)
23670	1995-049A TELSTAR 402R [US]	89.1W	FSS (C/Ku)
24936	1997-050A GE 3 [US]	87.2W	FSS (C/Ku)
25152	1998-006A BRAZILSAT B3 [BRAZ]	86.0Wd	FSS (C/X)
24713	1997-002A GE 2 [US]	84.9W	FSS (C/Ku)
18951	1988-018A SPACENET 3R [US]	83.2W	FSS (L/C/Ku)
16276	1985-109D SATCOM K2 [US]	81.0W#	FSS (Ku)
15561	1985-015B BRAZILSAT 1 [BRAZ]	79.0Wi	FSS (C)
15235	1984-093B SBS 4 [US]	77.3Wi	FSS (Ku)
20872	1990-091A SBS 6 [US]	76.4W	FSS (Ku)
23051	1994-022A GOES 8 [US]	76.4W	MET (P/L/S)
12309	1981-018A COMSTAR 4 [US]	76.2Wi	FSS (C)
24714	1997-002B NAHUEL 1A [ARGN]	72.2W	FSS (Ku)
23199	1994-049A BRAZILSAT B1 [BRAZ]	70.1W	FSS (C/X)
23536	1995-016A BRAZILSAT B2 [BRAZ]	65.1W	FSS (C/X)
25004	1997-059A ECHOSTAR 3 [US]	61.6W	BSS (Ku)
24916	1997-046A PAS 5 [US]	58.1W	BSS (C/Ku)
16101	1985-087A INTELSAT 512 [ITSO]	55.9Wi	Intl FSS AOR (C/Ku)
21149	1991-018A INMARSAT 2-F2 [IM]	55.1Wi	Intl MSS AOR-W (L/C)
24819	1997-027A INMARSAT 3-F4 [IM]	54.6W	Intl MSS AOR-W (L/C)
23571	1995-023A INTELSAT 706 [ITSO]	53.3W	Intl FSS AOR (C/Ku)
23915	1996-035A INTELSAT 709 [ITSO]	50.3W	Intl FSS AOR (C/Ku)
13969	1983-026B TDRS 1 [US]	49.1Wi	FSS-Gov (S/C/Ku)
22314	1993-003B TDRS F6 [US]	47.3W	Intl FSS-Gov (S/C/Ku)
19217	1988-051C PAS 1 [US]	45.1W	FSS AOR (C/Ku)
24891	1997-040A PAS 6 [US]	44.6W	FSS AOR (C/Ku)
23764	1996-002A PAS 3R [US]	43.5W	BSS (Ku)
19883	1989-021B TDRS 4 [US]	41.1W#	FSS-Gov (C/S/Ku)
25239	1998-014A INTELSAT 806 [ITSO]	40.8W	Intl FSS AOR (C/Ku)
19772	1989-006A INTELSAT 515 [ITSO]	37.8W#	Intl FSS AOR (C/Ku)
23413	1994-079A ORION 1 [US]	37.7W	Intl FSS (Ku)
21765	1991-075A INTELSAT 601 [ITSO]	34.7W	Intl FSS AOR (C/Ku)
20401	1990-001A SKYNET 4A [UK]	34.1Wi	FSS-Milcomsat (P/S/X/Ka)
17706	1987-029A AGILA 1 (PALAPA B2P) [INDO]	32.8W#d	FSS (C)
24742	1997-009A INTELSAT 801 [ITSO]	31.7W	Intl FSS IOR (C/Ku)
22723	1993-048A HISPASAT 1B [SPN]	30.7W	BSS/FSS (S/Ku)
22116	1992-060A HISPASAT 1A [SPN]	30.0W	BSS/FSS (S/Ku)
14077	1983-047A INTELSAT 506 [ITSO]	29.5Wi	Intl FSS/MSS AOR (L/C/Ku)
21653	1991-055A INTELSAT 605 [ITSO]	27.6W	Intl FSS AOR (C/Ku)
15386	1984-114B MARECS B2 [ESA]	26.1Wi	MSS AOR (L)
23967	1996-042A UFO 7 (USA 127) [US]	25.3Wi	FSS-Milcomsat AOR (P/S/K)
20523	1990-021A INTELSAT 603 [ITSO]	24.5W	Intl FSS AOR (C/Ku)
20253	1989-077A FLTSATCOM 8 (USA 46) [US]	24.5Wi	FSS-Milcomsat AOR (P/S/X/K)
24957	1997-053A INTELSAT 803 [ITSO]	21.6W	Intl FSS AOR (C/Ku)
21989	1992-032A INTELSAT K [ITSO]	21.5W	Intl FSS AOR (Ku)
22921	1993-076A NATO 4B [NATO]	20.5W#	FSS-Milcomsat (P/S/X)
15391	1984-115A NATO 3D [NATO]	19.1Wi	FSS-Milcomsat (P/S/X)
23528	1995-013A INTELSAT 705 [ITSO]	18.0W	Intl FSS AOR (C/Ku)
21047	1991-001A NATO 4A [NATO]	17.7Wi	FSS-Milcomsat (P/S/X)
21940	1992-021B INMARSAT 2-F4 [IM]	17.1Wi	Intl MSS AOR-E (L/C)
23426	1994-082A LUCH [CIS]	16.0W#	FSS-Gov CSDRN (Ku)
24307	1996-053A INMARSAT 3-F2 [IM]	15.6W#	Intl MSS AOR-E (L/C)
23132	1994-035A UFO 3 (USA 104) [US]	15.1Wi	FSS-Milcomsat AOR (P/S)
23319	1994-067A EXPRESS 1 [CIS]	14.0W	Intl FSS (C/Ku) Statsionar 4
23267	1994-060A COSMOS 2291 [CIS]	13.7W#	FSS-Data Relay (C)
22041	1992-043A GORIZONT 26 [CIS]	10.9Wi	FSS (C/Ku) Statsionar 11
21813	1991-084A TELECOM 2A [FR]	7.9W	FSS-Gov/Mil (S/C/X/Ku)
25311	1998-024A NILESAT-1 [EGYPT]	7.0W	FSS (Ku)
21939	1992-021A TELECOM 2B [FR]	4.7W	FSS-Gov/Mil (S/C/X/Ku)
24209	1996-044B TELECOM 2D [FR]	4.6W	FSS-Gov/Mil (S/C/X/Ku)
23865	1996-030B AMOS [ISRA]	3.8W	FSS (Ku)
20776	1990-079A SKYNET 4C [UK]	0.9W#	FSS-Milcomsat (P/S/X/Ka)
23816	1996-015A INTELSAT 707 [ITSO]	0.7W	Intl FSS AOR (C/Ku)
20168	1989-062A TVSAT 2 [FRG]	0.6W	BSS (Ku)
20762	1990-074A THOR 1 (MARCOPOLO 2) [NOR]	0.5W	BSS (Ku)
22912	1993-073B METEOSAT 6 [ESA]	0.0W	MET (P/L/S) Operational Metsat

Satellite Launch Schedules

By Keith Stein

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
August 1998	Ariane 44P	Kourou	Eutelsat W1

Ariane 4	Downlink Frequency Assignments
S-band	2203.0, 2206.0 and 2218.0 MHz
C-band	5400-5900 MHz

Eutelsat W1	Downlink Frequency Assignments
Ku-band	10.95-11.70 and 12.70-12.75 GHz

Japanese Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
July 1998	M-5	Kagoshima	Planet-B

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
July 1998	Zenit-2	Baikonur	Globalstar (12)
August 1998	Proton	Baikonur	Meteor 3M-1 and SAGE 3

Globalstar	Downlink Frequency Assignments
S-band	2483.5-2500.0 MHz

Proton	Downlink Frequency Assignments
VHF-band	132.400, 136.750 and 192.000 MHz
UHF-band	232.000 and 240.000 MHz
L-band	915-930.000 MHz
S-band	2800.0-2810.0 MHz

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
July 1998	Pegasus XL	Wallops	Orbcomm-2
July 1998	Delta 3	CCAS	Galaxy-10
July 1998	Titan 4	CCAS	Classified
July 1998	Atlas 2AS	CCAS	JCSAT-6
August 1998	Atlas 2A	CCAS	UHF F/O F9
August 1998	Atlas 2AS	CCAS	Eutelsat W1
August 1998	Delta 2	VAFB	ARGOS, SUNSAT and ORSTED
August 1998	Delta 2	VAFB	Landsat-7
August 1998	Delta 2	VAFB	Iridium-10

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

Orbcomm-2	Downlink Frequency Assignments
VHF-band	137.000-138.000 MHz
UHF-band	400.100 MHz

Delta 3	Downlink Frequency Assignments
S-band	2241.5, 2252.5 and 2272.5 MHz

Galaxy 10	Downlink Frequency Assignments
C-band	3.70-4.20 GHz
Ku-band	11.70-12.20 GHz

Titan 4	Downlink Frequency Assignments
S-band	2217.5, 2255.5, 2272.5 and 2287.5 MHz

Atlas 2A/AS	Downlink Frequency Assignments
S-band TLM	2202.5, 2206.5, 2210.5, 2211.0 and 2215.5 MHz
C-band TRK	5765.0 MHz

UHF F/O F9	Downlink Frequency Assignments
UHF-band	243.915-269.950 MHz

Delta 2	Downlink Frequency Assignments
S-band TLM	2244.5, 2241.5 and 2252.5 MHz
C-band TRK	5765.0 MHz

Landsat-7	Downlink Frequency Assignments
S-band	2287.5 MHz
X-band	8082.5, 8212.5, 8342.5 MHz

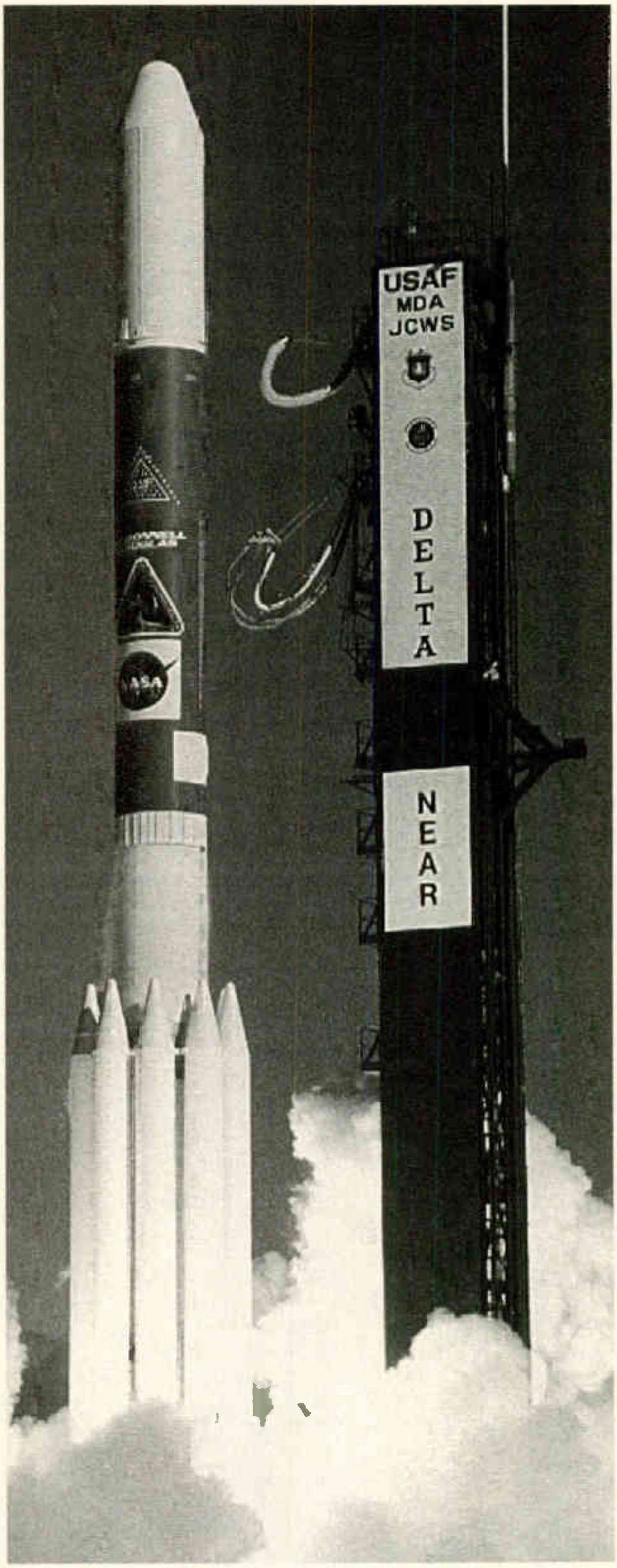
Iridium	Downlink Frequency Assignments
L-band	1616.0-1626.5 MHz
Ka-band	19.40-19.60 GHz
	23.18-23.38 GHz
	29.10-29.30 GHz

Satellite Launch Schedules

By Keith Stein

List of Abbreviations and Acronyms

A/C	Aircraft
Argos	The Advanced Research and Global Observation Satellite will conduct global imaging of the ionosphere with eight experiments during a 3 year mission.
C-band	3700 to 6500 MHz
CCAS	Cape Canaveral Air Station, FL
Eutelsat	European commercial geostationary telecommunications satellite owned by Eutelsat.
Galaxy	Hughes telecommunications satellite with principal applications including network TV, radio, VSAT, business video and data services.
GHz	Gigahertz
Globalstar	Globalstar is a low-Earth-orbiting (LEO) satellite-based digital telecommunications system that will offer wireless telephone and other telecommunications services worldwide beginning in 1999. Owned by Globalstar and satellites built by Space Systems/Loral.
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	Geostationary telecommunications satellite for Japan.
K-band	10.90 to 17.15 GHz
Landsat-7	Advanced U.S. remote imaging satellite.
L-band	500-1549 MHz
MHz	Megahertz
ORBCOMM	Orbcomm will provide low-cost alpha numeric data communications and position determination for emergency assistance, data acquisition and messaging services using pocket portable and mobile subscriber terminals.
Orsted	This satellite from Denmark will map Earth's magnetic field and charged particle environment.
Planet-B	Developed by Japan's Institute of Space and Astronautical Science (ISAS) this mission will carry 15 instruments to study the upper atmosphere of Mars and its interaction with solar winds.
S-band	2000 to 2300 MHz
SUNSAT	A South African amateur radio satellite designed to provide Earth imaging, voice and digital communications.
TLM	Telemetry
TRK	Tracking
UHF F/O F9	U.S. Navy geostationary communications satellite.
UHF	Ultra High Frequency (300 to 1000 MHz)
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
X-band	8000 and 10,999 MHz
XL	Extra Large



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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 April 1998. 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, 25 Redfern Avenue, Whitton, Middx TW4 5NA United Kingdom.

Launch Date/Time Ref Epoch	Intl Designator Inclination	Satellite Name Period	Perigee	Mass Apogee
1998 Apr 2/0242	1998-020A	TRACE		250 kg
1998 Apr 2.29	97.80 deg	97.10 min	599 km	641 km

Transition Region And Coronal Explorer (TRACE) is a science payload, with the instruments supplied by Stanford Lockheed Institute for Science Research. Instruments permit the study of the interaction between fine scale magnetic fields on the solar surface and features in the photosphere, chromosphere, transition region and the corona. Spacecraft is an octagonal prism: 0.86 meters diameter and 1.5 meters long at launch. The outer surface is covered in solar cells. Launched from WTR using Pegasus-XL.

1998 Apr 7/0213	1998-021A	Iridium 62		657 kg
1998 Apr 7.47	86.66 deg	94.84 min	500 km	522 km
1998 Apr 30.19	86.39 deg	100.39 min	776 km	779 km
1998 Apr 7/0213	1998-021B	Iridium 63		657 kg
1998 Apr 24.97	86.39 deg	100.39 min	776 km	779 km
1998 Apr 7/0213	1998-021C	Iridium 64		657 kg
1998 Apr 27.49	86.39 deg	100.39 min	775 km	779 km
1998 Apr 7/0213	1998-021D	Iridium 65		657 kg
1998 Apr 28.12	86.39 deg	100.39 min	775 km	778 km
1998 Apr 7/0213	1998-021E	Iridium 66		657 kg
1998 Apr 29.17	86.39 deg	100.39 min	772 km	782 km
1998 Apr 7/0213	1998-021F	Iridium 67		657 kg
1998 Apr 29.18	86.39 deg	100.39 min	774 km	780 km
1998 Apr 7/0213	1998-021G	Iridium 68		657 kg
1998 Apr 23.53	86.40 deg	100.39 min	775 km	778 km

Thirteenth cluster of Iridium satellites, third and final (planned) launch in the series using a four-stage Proton-K vehicle from Baikonur. Dry mass of each satellite is 556 kg. This launch opened the sixth and final orbital plane of the Iridium system (see orbital planes for Iridium satellites below).

Launch Date/Time Ref Epoch	Intl Designator Inclination	Satellite Name Period	Perigee	Mass Apogee
1998 Apr 17/1819	1998-022A	Columbia (STS-90)		105,500 kg
1998 Apr 17.75	39.01 deg	89.95 min	257 km	286 km

Seven astronauts flying the "Neurolab" mission: R A Searfoss (commander), S D Altman (pilot), R M Linnehan (payload commander, mission specialist MS-1 and EV-1 EVA astronaut if required), K P Hire (MS-2), D R Williams (Canadian Space Agency, MS-3 and EV-2 if required), J C Buckey Jr (payload specialist, PS-1) and J A Pawelczyk (PS-2). Payload bay carried SPACELAB module, mass 10,788 kg, fitted out for the "Neurolab" experiments both on the crew members and also various other animals carried into orbit. The prime mission objective for the mission is to undertake research which will contribute to a better understanding of the human nervous system. Mass quoted is that projected at the time of landing. Launched from and landed at Kennedy Space Center: main gear touchdown was May 3 at 1608:59 UTC.

1998 Apr 24/2238	1998-023A	Globalstar FM 5		450 kg
1998 Apr 24.94	51.97 deg	99.13 min	194 km	1,240 km
1998 Apr 25.08	52.01 deg	110.53 min	1,243 km	1,259 km
1998 Apr 30.07	52.02 deg	110.75 min	1,258 km	1,265 km
1998 Apr 24/2238	1998-023B	Globalstar FM 6		450 kg
1998 May 1.29	52.03 deg	110.78 min	1,256 km	1,270 km
1998 Apr 24/2238	1998-023C	Globalstar FM 7		450 kg
1998 May 1.29	52.02 deg	110.76 min	1,260 km	1,263 km
1998 Apr 24/2238	1998-023D	Globalstar FM 8		450 kg
1998 May 1.29	52.03 deg	110.81 min	1,259 km	1,269 km

Second launch of a cluster of four Globalstar communications satellites from Cape Canaveral using the new Delta-2 (7420) variant. Launched for the Globalstar Ltd Partnership: mass quoted is at launch–dry mass is 400 kg. Planned operational system will have eight orbital planes, with each plane containing six active satellites plus one spare: orbital plane of second cluster is ~49 deg to the east of the first cluster. First orbit shown for Globalstar FM 5 is the transfer orbit, prior to the burn to the circular deployment orbit.

1998 Apr 28/2353	1998-024A	NILESAT 101		1,840 kg
1998 Apr 28.75	7.09 deg	630.15 min	205 km	35,734 km
1998 Apr 28/2353	1998-024B	B-SAT 1B		1,230 kg
1998 Apr 28.76	6.95 deg	630.72 min	209 km	35,759 km

NILESAT 101 is the first satellite to be launched for a country on the African continent: telecommunications satellite to be operated by NILESAT in Egypt. Mass quoted is at launch: mass on-station at the beginning of operations is 1,100 kg, dry mass is 795 kg. To be operated over 353 deg E.

B-SAT 1B is a telecommunications satellite, launched for B-SAT Corporation (Japan). Mass quoted is at launch: on-station at the beginning of operations the mass is 708 kg and the dry mass is 500 kg. To be operated over 110 deg E.

Both satellites launched from Kourou aboard an Ariane-44P.

Launch Date/Time Ref Epoch	Intl Designator Inclination	Satellite Name Period	Perigee	Mass Apogee
1998 Apr 29/0437 1998 Apr 29.75	1998-025A 2.30 deg	Cosmos 2350 1,448.22 min	35,958 km	2,500 kg? 36,089 km

At the time of preparing this listing, it is unclear whether this is a "Geizer" data-relay satellite in the "Potok" system or a "Prognoz" early warning satellite. Both satellite systems have a standard orbital slot over 80 deg E. Launched from Baikonur using a four-stage Proton-K vehicle.

Updates for Previous Launches

International Designation	Comment
1980-098A	INTELSAT 502 was maneuvered off-station over 319-320 deg E into a retirement orbit approximately Apr 12-13, 1998. Add the following orbital data: 1998 Apr 22.19 7.48 deg 1,456.25 min 36,100 km 36,260 km
1990-002B	Leasat 5 was relocated over 155 deg E approximately Apr 3, 1998.
1990-016A	Raduga 25 performed its last station keeping over 190 deg E during Dec 26-27, 1997 and subsequently drifted off-station indicating that it was no longer operational.
1990-077A	Yuri 3A was maneuvered off-station over 109 deg E approximately Apr 13, 1998.
1991-074A	Gorizont 24 was relocated over 123-124 deg E approximately Apr 18-19, 1998.
1997-009A	INTELSAT 801 was relocated over 328 deg E approximately Apr 24, 1998.
1997-061A	Cassini performed a fly-by of Venus Apr 26.56, 1998 (1346 UTC) at a distance of 284 km.
1997-080A	Cosmos 2348 was de-orbited on Apr 14, 1998: if the de-orbiting took place to permit a nominal final equator crossing then the descent module will have returned to Earth approximately Apr 14.1, 1998, giving a lifetime of 119.5 days—the longest for this class of satellite to date.
1997-086A	Following settlement of the insurance claim as a result of the launch malfunction, ownership of AsiaSat 3 reverted to Hughes, and the satellite has been re-named HGS 1 (Hughes Global Services) on a temporary basis. Hughes have started to maneuver the satellite towards a circumlunar trajectory, as follows: 1998 Apr 13.06 51.25 deg 638.51 min 392 km 35,977 km 1998 Apr 14.00 51.28 deg 1,244.05 min 402 km 63,475 km 1998 Apr 15.62 51.33 deg 1,512.05 min 397 km 74,124 km 1998 Apr 16.85 51.36 deg 1,882.60 min 399 km 87,854 km 1998 Apr 16.85 51.36 deg 1,881.36 min 399 km 87,810 km 1998 Apr 18.31 51.17 deg 2,479.12 min 425 km 108,173 km 1998 Apr 23.50 51.22 deg 3,800.17 min 433 km 148,145 km 1998 Apr 26.20 51.48 deg 6,078.06 min 365 km 207,527 km 1998 Apr 30.34 52.07 deg 11,257.84 min 240 km 319,786 km A final maneuver due May 7, 1998 should place the spacecraft on a lunar fly-by trajectory: if the lunar fly-by on May 13, 1998 is successful in terms of accuracy, the satellite should be in a near geosynchronous orbit by the end of May 1998.
1998-006A	No orbital data was issued for BRASILSAT B3 between Mar 1 and Apr 1, 1998: on the former date the satellite was located over 295 deg E and on the latter date the satellite had maneuvered off-station and was drifting to the west. This drift continued through to the beginning of May 1998.
1998-018B	Add the following orbital data for Iridium 61: 1998 Apr 14.17 86.54 deg 98.66 min 694 km 696 km
1998-019A	Add the following orbital data for Iridium 55: 1998 Apr 14.96 86.41 deg 100.39 min 773 km 781 km
1998-019B	Add the following orbital data for Iridium 57: 1998 Apr 11.24 86.41 deg 100.39 min 774 km 781 km
1998-019C	Add the following orbital data for Iridium 58: 1998 Apr 15.15 86.39 deg 100.39 min 776 km 777 km
1998-019D	Add the following orbital data for Iridium 59: 1998 Apr 16.90 86.39 deg 100.39 min 775 km 779 km
1998-019E	Add the following orbital data for Iridium 60: 1998 Apr 13.98 86.40 deg 100.39 min 775 km 779 km

Orbital Data for Lunar Prospector

The following orbital data have been derived from data supplied by NASA Ames Research Center.

Earth-Moon system orbits

1998 Jan 7.15	29.20 deg	12,963.44 min	197 km	353,645 km
1998 Jan 7.52	29.27 deg	14,525.35 min	76 km	382,571 km
1998 Jan 8.36	29.26 deg	14,418.20 min	-268 km	380,973 km

Selenocentric orbit

1998 Jan 11.51	89.72 deg	697.62 min	84 km	8,470 km
1998 Jan 12.50	89.87 deg	211.25 min	87 km	1,861 km
1998 Jan 13.51	90.01 deg	120.01 min	92 km	153 km
1998 Jan 16.00	90.55 deg	117.88 min	99 km	101 km

Orbital Planes for Iridium Satellites

A software "bug" in the program written to prepare Iridium satellite reports meant that the orbital planes of the Iridium satellites were wrongly given in last month's issue of *Satellite Times* The correct orbital planes based upon the ascending node longitudes (RAAN) for May 1.0, 1998 are as follows:

RAAN	Plane	Iridium Clusters
263 deg	A	Cluster 13 (1998-021)
295 deg	B	Cluster 4 (1997-043) Cluster 9 (1997-082) Cluster 11 (1998-018) Cluster 14 (1998-026)*
327 deg	C	Cluster 5 (1997-051)
358 deg	D	Cluster 1 (1997-020) Cluster 6 (1997-056)
30 deg	E	Cluster 2 (1997-030) Cluster 10 (1998-010) Cluster 12 (1998-019)
61 deg	F	Cluster 3 (1997-034) Cluster 7 (1997-069) Cluster 8 (1997-077)

* Launched May 2, 1998.

The following four Iridium satellites have malfunctioned and are believed to have been abandoned: Iridium 11 (1997-030G), Iridium 20 (1997-034D), Iridium 21 (1997-034E) and Iridium 27 (1997-051D).

ST

THE BEGINNER'S COLUMN

By Ken Reitz, KS4ZR
KS4ZR@compuserve.com

Finding Argentina's Radio Nacional and Other Mysteries Explored

The world of electronics is screaming along at an accelerating pace that leaves most of us dizzy. This speed-of-light progress has brought increased capability and tremendous benefits most notably in the field of personal computers. Among these benefits is e-mail which, as we've all found out is both a blessing and a curse. The curse is junk e-mail: "Russian ladies are wanting to meet you!" or "I made a million dollars peddling junk e-mail and I'll share my secrets with you!" And, then there's the blessing: Your *Beginner's Column* questions! So, let's get right to it.

International TV on Satellites

Among the more frequently asked questions is "Where can I find programming from France, the BBC, etc." One of the more interesting things about having a big dish is discovering the broadcasts of foreign countries in the nooks and crannies of the Clarke Belt.

If you're lucky enough to be able to "see" from horizon to horizon with your dish you should be able to tune into some interesting foreign broadcasts in that region east of the satellites usually seen by North American viewers. The age of digital video transmissions has dramatically reduced the number of analog (non-digital, in-the-clear) transmissions. As recently as a few years ago dozens of analog transmissions from all across Europe were visible with receivable signals to those of us on the East Coast. A few of these remain and are worth trying for.

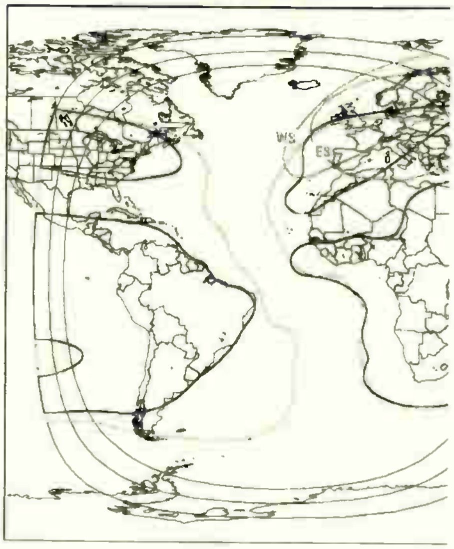
Analog programming on both C and Ku-band in our region of the Clarke Belt is still easily found. Day long programming from Japan, Portugal, China, Mexico, Kuwait, UAE, Canada, and Germany, as well as Russian and Arabic programming, are all in the clear, easily received and require no special equipment. For the most part these channels are intended for the niche market of immigrants who have settled across the U.S. and are eager for programming from their homelands.

Digital programming from many more countries can be seen using three or four specialized receivers. For instance, Taiwanese and Filipino programming use Oak/Orion encryption while Hong Kong's TVB uses VideoCrypt encryption. The International Channel, a collection of several international broadcasters, uses General Instrument's DigiCipher system which requires a General Instrument 4DTV receiver. French Canadian programming via their Anik E2 satellite uses Scientific-Atlanta's PowerVu encryption system.

A number of foreign broadcasters in analog format can be found among the scattered C- and Ku-band satellites east of Galaxy 6 (North America's easternmost bird). Try looking for Panamsat 5 at 58° west which has occasional feeds. Often there is a slate on channel 23 which makes this satellite easy to ID. If there are no feeds on it try for Intelsat 806 at 40.5° west which was just launched at the end of February and came on line in March of this year.

Intelsat 605 at 27.5º west was launched in August of 1991 with a design lifespan of 10 years. It's home to ABC-TV's feed of BBC's Nine O'Clock News and relay of Jazz FM from London.

IS-605 at 332.5°E



Televisa España (TVE) is often found in analog on Hispasat, a Ku-band workhorse satellite for Spain. TVE Internationale is aimed at the former colonies this side of the Atlantic.

As I'm writing this, I'm watching a feed on 806 from Argentina's state television network, Argentina Televisora Color (ATC), which is showing Tele Gaceta, their nightly news program. During the daytime they show adult education programming and chat shows with commercials shown between programs. The feed is actually television station LS82 Channel 7 from Buenos Aires and is transmitted in the PAL format (the broadcast standard in Argentina).

At first glance it appears to be scrambled. The image is black and white, elongated and rolling out of control. The audio is fine, though in this case a non-standard 7.40 MHz channel. A viewable image can be easily restored by slowly adjusting the vertical hold on your TV set. The image will remain black and white because American NTSC standard sets don't recognize the PAL color standard. The elongated picture is because PAL sends 625 lines per screen to our 525 lines per screen sets.

Tuning through the audio subcarriers reveals an Argentine radio station (Radio Nacional) broadcasting news, chat, pop music and (what else?) tango! There appears to be some activity in the vertical blanking interval (VBI) which would suggest the presence of a teletext signal of some kind. There are no other analog video signals here nor any analog SCPC on this satellite, yet.

Both Hispasat birds at 30º west, are Ku-band satellites and often provide a full time NTSC analog version of their digital feed from Televisa España (TVE) which is sent to their former colonies in South and Central

America. Program audio is on 6.60 MHz with two additional audio subcarriers at 7.55, Radio Exterior de España (REE) and 7.35 MHz, Radio Nacional de España 1 (RNE).

Incidently, REE has an identification which features their entire call sent in crisp 20 plus words per minute CW (Morse code). To systems equipped only with analog receiving equipment Hispasat appears to have no other programming. However, on the digital side, this bird is packed! Dozens of video and audio channels are here in digitally encrypted formats, most beamed to Spain.

Whatever Happened to the BBC?

Through the years big dish viewers have enjoyed various feeds from the BBC. Their superb news programs are highly sought after and, for a while, it was possible to catch the *BBC Breakfast News*, a noon feed of *BBC World Report*, and an evening feed of the *6 O'clock News* or *News at Nine* every weekday.

Today, the only BBC feed that I have seen recently is found on Intelsat 605 at 27.5º west. This will be nearly impossible for most viewers west of the eastern coast of the U.S. The feed is found on channel 14 which is used by the London bureau of ABC-TV to beam British news to that network. Sometime around 1700 Eastern Time they feed the BBC *News at Nine*.

When there is not a video feed on this channel a test slate with ABC ID is up and the audio is Jazz FM from London, the highlight of which is *Dinner Jazz* which runs from 1400 until 1700 ET.

This satellite uses circular polarity and, while it can be received on linear feeds used on all North American satellite dishes, the signal can be greatly enhanced by using a

Chaparral makes a Teflon insert which, when inserted into the feed horn, allows a linear polarity feed horn to receive circularly polarized signals. This insert was modified to accommodate a C/Ku-band feed (note large notch).

Teflon insert in the throat of the feed horn. This small block of Teflon acts on the incoming microwaves to cause them to become circular and thereby increase your signal by several dB. If you are using a C/Ku-band feed horn, you'll have to modify your insert to accommodate the Ku portion of the feed (see photos). The insert has no apparent effect on linear C or Ku-band feeds when left in and appears to improve reception on Morelos 2, the Mexican satellite at 116.8º west. Teflon inserts can be bought at Skyvision whose advertisements are found elsewhere in this magazine.

The modified Teflon insert installed in a C/Ku-band feed horn can improve circularly polarized signals by several dB. (All photos by the author.)

Scanners as Tuners

Another of the more common questions asked involves the use of scanning receivers as audio tuners for satellite radio programming. Here is another place where the advances of the Silicon Age have benefitted all of us. Scanning radios with electronic tuning and extraordinary frequency range, as well as memory storage facility, have greatly advanced our monitoring capabilities.

Still, using a US$400 computer program, such as WINRADIO, on a US$1,500 dollar computer to receive audio subcarriers on satellites is overkill. In most cases the programming you may be trying to receive can be heard just as well, if not better, on an old satellite receiver costing under US$100.

While scanning receivers will tune analog subcarriers and SCPC (Single Channel Per Carrier) transmissions, there's simply no advantage in using scanners in this application. In addition, you may find that the audio subcarrier, when tuned through a scanning receiver, leaves something to be desired. Most scanners have difficulty reproducing the HiFi audio transmitted by satellites. And, finally, many subcarriers such as KLON-FM (the jazz station from California) are in stereo and would require two scanning receivers to tune the two subcarriers.

A better idea for using extended range scanning receivers is to tune Inmarsat or other non-broadcast satellite transmissions which require tuning odd frequencies not accessible by C- or Ku-band receivers. Plans for building an antenna for tuning these satellites just happen to be found in this issue!

Digital Satellite TV Receivers

Here is another popular question: "How can I receive digital video and/or audio services?" The answer depends on what it is you would like to receive. There are many digital formats in both audio and video. Most are also encrypted. There are, however, a number of digital transmissions which are unencrypted. The most popular of these are in the aforementioned GI 4DTV (also available from Skyvision) and the so-called "World Standard" MPEG 2 system receiver such as the Hyundai HSS-100C (available from Digiear at 800-484-3156). Both can tune in a number of digitized but unencrypted services.

This means that any digital receiver, tuned to the proper digital channel which is not encrypted, may receive the programming. But, before you get too excited, this is all subject to change and any "free" channels may be unceremoniously encrypted leaving you in the dark, so to speak. In addition, only DigiCipher channels can be viewed by a 4DTV and only MPEG 2 standard may be viewed by Hyundai 100C.

And now a word about "user friendly" digital receivers. GI's 4DTV is designed for home use by regular consumers. It is extremely easy to use. With small dish style scroll and click access, consumers can be up and running with this receiver in no time.

The HSS-100C is the opposite. It is primarily designed for commercial use and is not very agile. There is no scroll and click convenience. Each satellite has to be set up by entering individual channel frequency assignments and Forward Error Correction data in addition to other items. Also, subscription modules may not be available for consumer use so that once currently "free" programming is encrypted, it may no longer be available. GI's 4DTV, by contrast, makes most encrypted services available.

Now It's Your Turn

These are just a few of the questions recently asked by *Satellite Times* readers. You probably have a question that's been nagging you and, with any luck, I might have an answer. The *Beginner's Corner* is your window to understanding the world of satellite communications. As the *ST* Managing Editor always says, "The only dumb question is the one you didn't ask." So, drop me an e-mail to the address above or, if you're not on-line, a note in care of the address in the front of this magazine.

By Doug Jessop

The Day the Satellite Died

October 29, 1929, is known forever as "Black Tuesday," the day of the Great Stock Market Crash. February 3, 1959, is immortalized in rock history as the *The Day the Music Died*, when a plane crash killed Buddy Holly, The Big Bopper and Richie Valens. Add May 19, 1998, to the list as "The Day the Satellite Died."

On May 20, Robert Bednarek, PanAmSat Senior VP and Chief Technology Officer issue the following statement:

"At approximately 6:00 p.m. Eastern time on May 19, the Galaxy IV satellite experienced an anomaly within its on-board spacecraft control processor (SCP), the primary system responsible for pointing the spacecraft relative to earth. The automatic switch to a backup unit failed as well. As a result of the SCP anomalies, the satellite began to rotate, thereby losing its fixed orientation. While PanAmSat is able to receive telemetry from and send commands to the satellite, full operation of the satellite's attitude control system has not been achieved at this time. PanAmSat has deactivated the communications payload at this time to conserve power. The satellite is in a stable, safe mode, and engineers at Hughes Space and Communications Co., which built the spacecraft, are examining all pertinent data to determine the causes of and potential solutions to the anomalies."

Two days later, Mr. Bednarek issued another statement regarding the status of the Galaxy IV satellite and its customers.

"PanAmSat has restored services to its Galaxy IV video and telecommunications customers, including the paging services, through the use of alternative capacity on the PanAmSat satellite fleet. Many of the Ku-band customers have sizable telecommunications networks and are completing the re-pointing of thousands of antennas to the neighboring Galaxy III-R satellite.

"PanAmSat has not transmitted any communications traffic on Galaxy IV since the on-board spacecraft control processor (SCP) anomalies of May 19. We do not expect to be able to use the satellite for communications services again. Last night, we moved Galaxy IV from its orbital location of 99 degrees West Longitude to a safe, higher orbit, where it will remain for the near future. The C-band Galaxy VI satellite is currently moving in space and will be available for customer service at the 99 degree orbital location on Wednesday, May 27.

"PanAmSat and Hughes Space and Communications Co., which built the satellite, are continuing an extensive analysis of the cause of the SCP failures. We have ruled out any external causes and believe the satellite failure was due to a spacecraft component problem. Completion of the investigation may take several weeks."

When I was an executive in the satellite industry I had the unfortunate experience of going through a couple of major satellite failures, but nothing quite this big.

So what is the big deal about this particular bird going to satellite heaven? Location, location and location. Galaxy IV was located at the best piece of prime real estate on the satellite arc–99° west longitude. This position in the Clarke belt covers the largest possible territory in the United States. Because of this, the big boys like to play in your sandbox. Kids like CBS with six transponders, along with my old alma mater, the king of syndication feeds, Globecast with four transponders.

As a broadcaster, having a live network feed "go bye-bye" with no warning is not a good feeling. CBS affiliates across the country found themselves scrambling. Fortunately for them, CBS has what is called a "Gold Level" satellite protection contract with PanAmSat. What that means in simple terms is that they go to the head of the line for new satellite capacity, bumping whom-

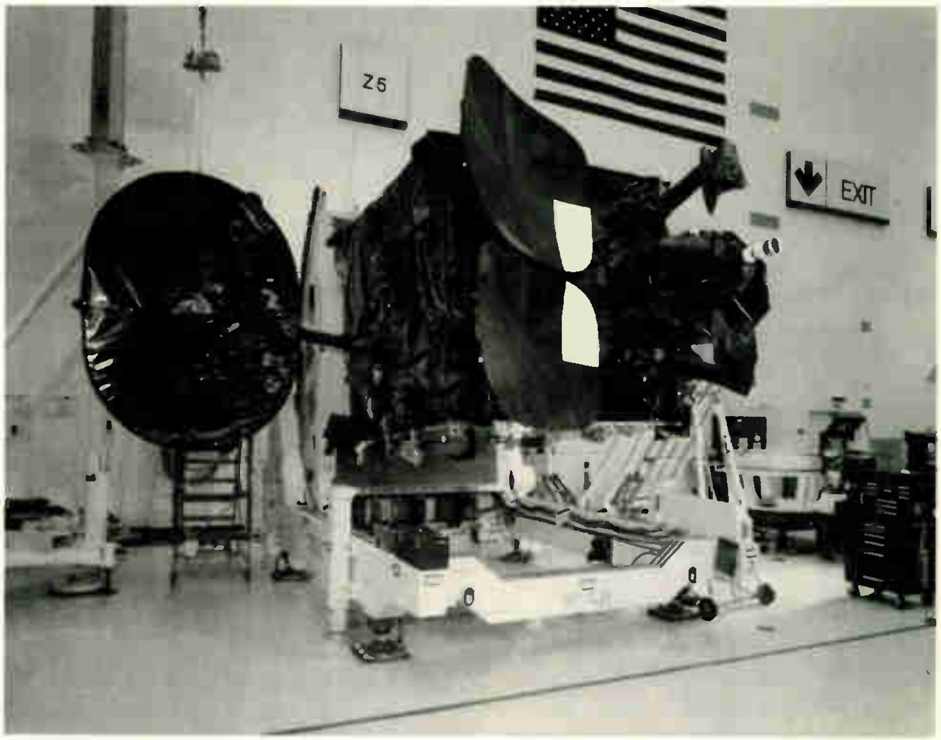


Photo of Galaxy IV during its construction at High Bay, Hughes Space and Communications Co.'s satellite factory in El Segundo, CA. (Photo courtesy: Hughes Communications, Inc.)

ever they need to in the process.

The thing that is kind of scary about this whole satellite failure is how big an impact it had. When I got home from work at a local television station my wife and kids commented that three of the local TV stations had gone dark at the same time. Television stations typically have fairly heavy duty security to make sure some nut case doesn't come and take over the station and want to broadcast some wacko message. But with one fell swoop, the failure of Galaxy IV found everyone off guard wondering what happened.

Imagine losing TV and radio signals across the country. Television stations use Galaxy IV to transmit feeds of advance shows, said Marguerite Sullivan, satellite coordinator for KCAL-TV in Los Angeles. "Hopefully, TV stations will be able to work around it," she said. "It's just satellite space is going to be very tight. It's going to be a problem for syndication. ... Thank God most stuff is done two days in advance. We're not too bad off."

Now add that your pager doesn't work, which is just fine if you are a teenager waiting for a call from your best friend, but quite another thing if you are a doctor on call. A spokesman for PageNet, one of several paging companies who services were interrupted, estimated that between 80 percent and 90 percent of all U.S. pager users were affected.

How about adding a problem with weather feeds to the equation? Your local weatherperson no longer has his/her Accuweather feed...not that big of a deal, just take a look out the window. But what if you are a airport control tower that no longer has weather information to give to pilots? Seeing a tornado out a window is one thing, but wind sheer isn't exactly colored coded when you're piloting a 747.

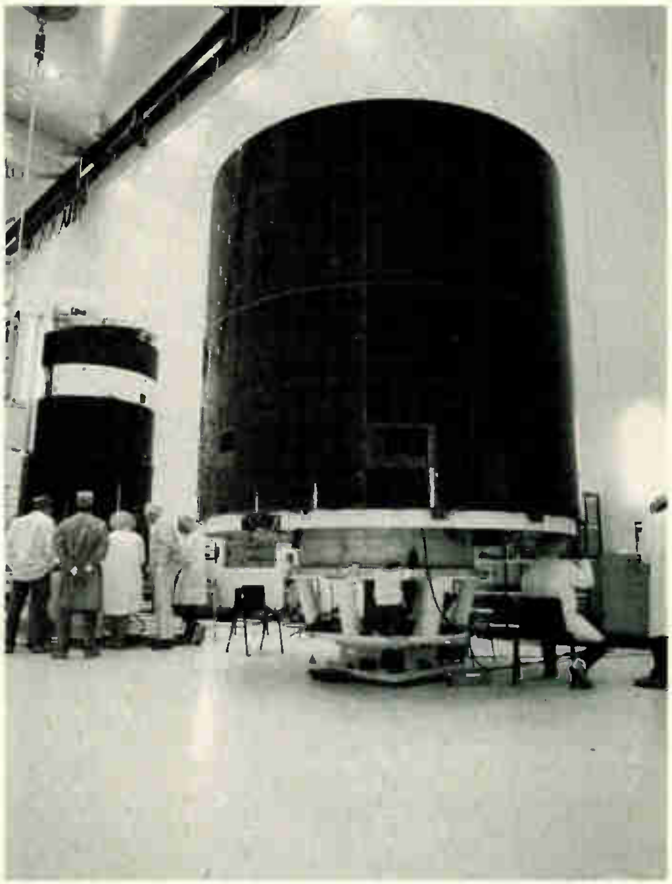
Shall we go on? How about communications in the field knocked out for the Los Angeles Fire Department? It was amazing to hear people say "they use a satellite for that?" If you were trying to use a credit card at your local Chevron station or your neighborhood Wal Mart you found out really fast the answer is "yes."

The fun part was talking to my friends at Globecast. Imagine it is Thurday and four days later, on Memorial Day, you have the grandaddy of telethons going on the air. You are scrambling for capacity for the Children's Miracle Network Telethon. Oh what fun!

Who Lost Service on Galaxy IV?

The list of broadcasters affected by the failure of Galaxy IV is impressive including CBS TV and radio network feeds, CBS Newspath affiliate feeds, China Central Television Network, Chinese Television Network, CNN Airport Network, Telemundo, Telenoticias, UPN Network, Warner Brothers (WB) Domestic TV and Syndication Network.

Other video services that went off the air included 4MC-Four Media company feeds, Bob Jones University home education, Buena Vista/Disney program services, Familynet, Fordstar, Jade Channel Satellite Service, MCET Educational Network, Paramount Syndication, The Filipino Channel, Sarimanok News Networks, SCOLA, Sky 1, The Shepherds Chapel (Rel), World Harvest Television and Radio, various syndicated TV program producers.

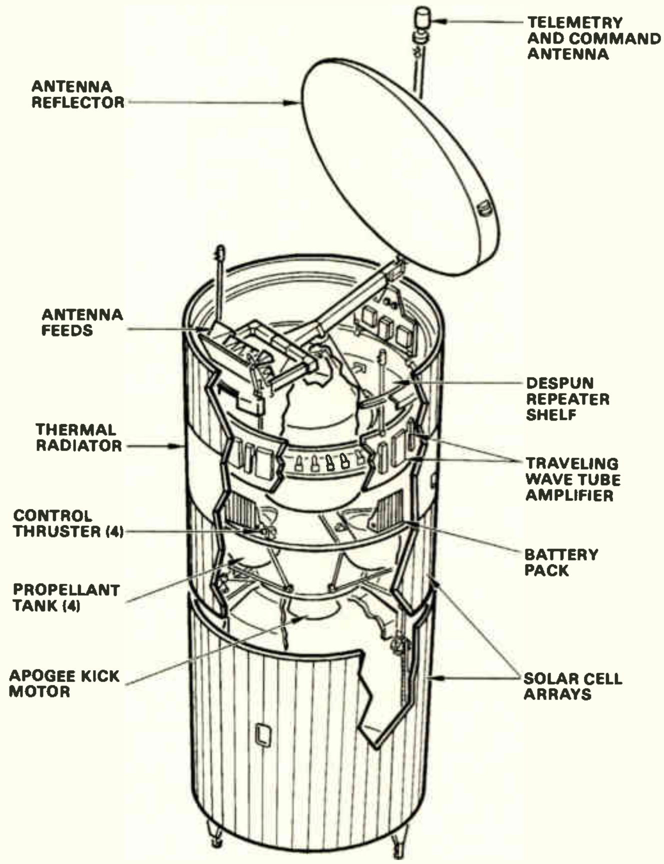


SBS 6 & Galaxy VI satellites built by Hughes Aircraft for Hughes Communications Inc., into preparation in the S1B building. (Photo courtesy: Arianespace)

Audio subcarriers forced to leave the air included DZMM/DWRR-Philippines Radio Stations, KBVA-FM (AR), IAM Radio Network, Ozarcana Satellite Radio, PBS/NPR radio, Radio France International (SCOLA feed), WCRP-FM (PR), WHME-FM (IN), WPHZ-FM (IN), World Harvest Shortwave Radio (WHRI/KWHR/WHRA), World Radio Network (SCOLA feed). FM2/3 Services: AP Network News, Muzak Music Services, numerous Grocery-Department-Speciality In-Store Audio Networks SCPC Digital Audio Services: Florida Radio Network, Florida Marlins, Tampa Ray Devil Rays, University of Florida Gators Baseball.

SCPC analog audio services were especially hard hit as this was the country's primary SCPC bird. Services affected included Agrinet, Georgia Network News (GNN), Illinois News Network, the In-Touch reading service for the blind, Kansas audio reader network for the blind, KBLA-AM (1580) Santa Monica, CA-Radio Korea, KEX-AM (1190) Portland, OR, KIRO-AM (710) Seattle, WA, and Seattle Mariners major league baseball (MLB) radio network, KJR-AM (950) Seattle, WA, KOA-AM (850)/KTLK-AM (760) Denver, Colo, and Colorado Rockies MLB radio network, KRLD-AM (1080) Dallas, TX, and Texas Rangers MLB radio network, Michigan News Network, Minnesota Talking Book radio network for the blind, Motor Racing Network, Radio America/American Entertainment Network, Soldiers Radio Satellite (SRS) network, Sports Byline USA, Sports Byline Weekend, On Computers radio show, Talk America radio network, Tennessee Radio Network, Tribune Radio Networks, United Broadcasting radio network, USA Radio Network, Voice of Free China (International Shortwave Broacaster) Taipei, Taiwan, WCNN-AM (680) Atlanta, GA, WCRP-FM (88.1) Guayama, PR, West Virginia Metro News, WGN-AM (720) Chicago, IL, and Chicago Cubs MLB radio network, WGST-AM/FM (640/105.7) Atlanta, GA, WHO-AM (1040) Des Moines, IA, Iowa News Network, Wisconsin Radio Network, WJR-AM (760) Detroit, MI, and Detroit Tigers MLB radio network, WJZK-FM (104.1) La Grange, GA, WLAC-AM (1510) Nashville, TN, Road Gang trucker program (overnight), WMVP-AM (1000) Chicago, IL, and Chicago White Sox MLB radio network, WSB-AM (750) Atlanta, GA, and Atlanta Braves MLB radio network, WTMJ-AM (620) Milwaukee, WI, and Milwaukee Brewers MLB radio network, WWRV-AM (1330) New York, NY-Radio Vision Christiana de Internacional, XEPRS-AM (1090) Tijuana, Mexico, and California Angels MLB Network (Spanish).

Some interesting miscellaneous services also suffered outages including the Los Angeles Fire Department, New Hampshire State Police, San Francisco Police and Fire Departments. Microspace (moving G4 services to G3R) out of Raleigh which serves six out of the top 11 national paging systems and 11 out of 13 financial and security information providers. Marshall Associates (provides government and commercial distant learning services).



HS 376 SPACECRAFT CONFIGURATION

Hundreds of digital dervices lost their space connection including Accuweather, AirTouch (80-90 percent of the country's 40-45 million pager owners lost service), Chevron (halted pay-at-the-pump service at 5,400 of 7,700 its gasoline stations), Digicom, DirectPC, MetroCall, MobileCom, MobileMedia, Planet Connect Computer Internet Services, PageMart, PageNet, PennSel, Reuters News Agencies, Skylink Internet Computer Services, SkyTel, United Press International, and Wal Mart. Also certain types of ATM systems suffered service loss.

Some Internet-based stock quote services such as quote.com, Yahoo, and Microsoft Investor (several of the companies rely on quotes from S&P Comstock).

Even the National Weather Service lost its ability to send certain products (including radar mosaic and satellite imagery) to their four major storm laboratories (National Hurricane Center-Miami, Florida; Severe Storm Lab-Norman, Oklahoma; aviation weather unit-Kansas City, Missouri; and the Hydro Center-Washington, DC). Also the center weather service units at all 21 Federal Aviation Administration air route traffic control centers throughout the United States lost weather information.

So What Happens Now?

Okay, so now what. PanAmSat is moving Galaxy VI over to replace Galaxy IV. That will work, but what about the users that were on Galaxy VI?

Fortunately there are some more birds going up later this year to help get some more capacity.

But what about the bigger picture....can this happen again? Galaxy IV uses a Hughes HS601 spacecraft that was launched June 1993 and had a expected end-of-life in 2005. Galaxy VI uses a Hughes HS 376 spacecraft that was launched October 1990 and had an expected end-of-life in 2002. Could there be a design flaw in the HS601 or was this simply a sad anomly?

Other Hughes HS601 spacecraft users include; American Mobile Satellites Corp and TCI Canada mobile communications satellites (MSAT-1/2), ApStar 2 communication satellite, DirecTV's DBS-1, 2 and 3 spacecraft (HS-601HP), ten Department of Defense UFO military communications satellites, the ICO medium earth orbit PCS constellation spacecraft (HS-601W), both of Indonesia's Palapa C communications satellites, Japan Satellite JCSAT-3 communications satellite, Mexico's Solidaridad 1 and 2 communications satellites, two Optus B/Aussat communcations satellites owned by Optus Communications of Australia, the european Astra 1C/1D/1E/1F direct to home broadcast satellites, and the PanAmSat Galaxy IIIR, Galaxy IV, Galaxy VII and PAS-2, 3, 4 and 5 communication satellites.

Also this fall's upcoming Leonid meteor storm (*ST* March/April 1997) could cause even bigger headaches for the satellite industry. The last major Leonids event was 30 years ago and there were no geostationary satellites in orbit at the time. Now fast forward to either November 1998 or 1999 and imagine 100,000 to 150,000 meteors per hour raining down on the Clarke Belt. Wow! Now a note from *ST* editor, Larry Van Horn tells us that the Echostar 4 is dead and that the NOAA-K APT downlink is degraded. Double wow!

While things will continue to change rapidly, at presstime I noticed the following services and their locations: Buena Vista/Disney syndication is on Telestar-5 tranponder 20. Galaxy IX transponder 02 had Kid's Warner Bros feeds. Galaxy IIIR transponder 11 is carrying World Harvest Television/Radio. Galaxy IX transponder 6 had Jerry Springer feeds. Galaxy VII had various CBS television and radio feeds. Japan's NHK TV network is on PAS 5 transponder 17 (C-band). Pastor Murray and Shepherd's Chapel Network is now on Anik E1 transponder 18. Galaxy IV's Ku-band traffic had shifted over to Galaxy IIIR/SBS-6 Ku-band and Dr. Gene Scott and the University Network moved from Galaxy VI transponder 19 to GE-3 (87 º west) transponder 20.

More changes as they become available in future *Domestic TVRO* columns. Now isn't it a great time to be a broadcaster!? ST

Doug Jessop has been in the broadcasting industry since 1979 and was the original creator of the North American Satellite Guide. Comments are always welcome at ***http://www.searcher.com/STcomments.html***

By George Wood
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Hot Bird Challenges Astra

Eutelsat's attempts to challenge Astra's second orbital position of 28/29º east continue, even after Eutelsat moved its Hot Bird 4 from the disputed slot to its proper spot at 13º east. Eutelsat has now actually placed an order for a satellite to be placed at the controversial orbital slot.

Called Europesat-1, the new satellite will carry 36 transponders and is to be in orbit by mid-2000. Eutelsat dismisses the confrontation with Astra's owner SES commenting, "The design of Europesat-1 at 29º east will allow co-existence with a system of satellites at 28.2º east belonging to SES, in accordance with principles for frequency sharing currently being finalized between the two satellite operators."

In response, an SES spokesman commented: "You can only share something with someone if you own it. Eutelsat doesn't. It hasn't had the rights to that orbital slot since the World Radiocommunications Conference last November."

With Hot Bird no longer interfering, Astra 1D has been more active at 28.2º east. British Sky Broadcasting, which will be launching its new digital service very soon, has been testing there in MPEG-2 on 11.758, 11.778, 11.836, 11.856, 11.914, and 11.934 GHz. All test transmissions have consisted of Sky News, color bars, or a Phillips test card. Sky's PAL test pattern remains on 11.993 GHz.

TCI's British subsidiary Flextech, which was planning to launch a rival digital service, is now optimistic its channels will be included in BSkyB's digital package. *What Satellite TV* reports that the shopping channel Wow TV has signed a deal with Sky that will see its 10 channels as part of the Sky digital package.

There will also be more sports in Sky's digital service. Sky Sports News will be a 24 hour sports-only news channel. Sky Sports Golf is also planned. Flextech is also starting The Sports Entertainment Network in the fall.

The digital offerings on Astra 1D will include 50 Music Choice Europe (MCE) channels on 11.778 GHz. This is to be increased to 60 in the future. On the other hand, MCE has reportedly postponed its plans to offer seven analog radio channels on the Astra satellites at 19 degrees east, which would have been free to Sky Multichannels subscribers. The company has decided it will "concentrate efforts on digital instead."

It's still uncertain if the BBC's digital channels will be part of the Sky digital offering, or will be offered as a rival package. But Sky continues to fight back against the BBC's threat to the BSkyB satellite monopoly.

Bye Bye Baseball?

With the CNBC/EBN merger, NBC Europe gained an extra transponder, and there's been speculation about potential, new and exciting NBC channels in Europe, such as MSNBC. Instead it looks like NBC is following the recent example of some other American broadcasters and is cutting back on its European service. NBC and *National Geographic* have announced a partnership where NBC programming in Europe (and Asia) will be eliminated in favor of *National Geographic*'s nature documentaries.

This comes after the Weather Channel, Country Music Television, and The Children's Channel dropped their European services. On July 1 NBC Europe will change its programming to the *National Geographic* Channel. However, NBC says it will keep much of its American programming on the air for its 25 million subscribers in German-speaking countries. (The question is, what does this mean? Will there be special programming for German cable, carried on encoded satellite transponders? Or uncoded transmissions that interested viewers can watch?) The two networks say the *National Geographic* Channel will still show a few hours a day of NBC news or CNBC programming. Is this the end of Jay Leno in Europe?

Another side-effect of the NBC-*National Geographic* deal may be the loss of just about the only broadcasts of Major League Baseball in Europe. Otherwise baseball on European TV has been largely killed off by the French, when they took over existing sports channels. Baseball remains twice a week on Britain's Channel 5, which is soft-scrambled in videocrypt.

I've long hoped that Ted Turner would put his Atlanta Braves on TNT, but that hasn't happened, even when the channel moved to 24 hour operation when it started digital services. Perhaps now with the expansion of Sky Sports, Rupert Murdoch will carry his newly-purchased Los Angeles Dodgers on a Sky channel.

There's been some other fall-out from the CNBC/EBN merger. Britain's *Financial Times* (FT) newspaper is planning to start a rival 24 hour business channel later this year. The FT had provided CNBC with programming before the merger.

The new hardcore porno channel Eros TV has started on Eutelsat II-F1, on 11.658 GHz, in D2-MAC/Eurocrypt S2, at 0100-0500 CET, in parallel with transmissions on Eutelsat II-F3. Eros is reportedly expanding its broadcast hours and adding respectability, with unscrambled general entertainment at 1700-2200 hours CET, followed by three hours of "adult entertainment" (presumably the kind of softcore that is legal in Britain) until the usual encrypted hardcore service starts at 0100 hrs CET.

But *What Satellite TV* reports that "TV watchdogs" (whatever those are) are calling on the British government to outlaw Eros TV, which would make it the sixth satellite sex channel to be banned in Britain.

When the Children's Channel (TCC) disappeared from most of Europe on April 1, the Nordic version of the channel continued, via Norway's Thor 1 satellite. Britain's largest cable operator, Cable and Wireless, has also continued to carry the channel, by relaying the Nordic version. But that came to an end on May 25. According to reports, Cable and Wireless has signed a special agreement with Flextech to allow it to carry TCC. The channel will be relayed to Cable and Wireless' cable headends via Intelsat 605 (27.5º west).

Having finished its claim-staking tests against Astra at 29º east, Hot Bird 4 is now in its permanent position along with Eutelsat II-F1 and Hot Birds 1 to 3 at 13º east. The new satellite was immediately pressed into service. The shopping channel Quantum, which has shared transponders with Eurosport on various satellites, now has its own 24 hour transponder on Hot Bird 4 on 10.930 GHz in clear PAL, with German sound on 6.60 MHz, English on 7.02, Dutch on 7.20, and French on 7.38.

Eutelsat has also used Hot Bird 4 to test Skyplex, which it describes in a press release as "a world first in onboard multiplexing of digital television, radio, and multimedia signals." The processor (on 10.719 GHz, SR 27500, FEC 3/4) can assemble six uplink carriers with a net bit rate of 6.3 Mbps into a downlink stream of 38 Mbps. This means signals from different locations can be uplinked to the satellite, and put together into a single digital transponder. Since a digital transponder can carry six to eight TV signals, plus audio and data streams, this is important. It has also been impossible with analog transponders. If a radio station wants to be included on an analog transponder, it has to get its signal to the uplink site to mix with the main TV signal, which might mean another satellite link, doubling the cost.

Another Skyplex unit will be included on Hot Bird 5, which will be launched this summer, and will be able to accommodate lower bit rates, down to 1 Mbps, and even down to 350 kbps, using advanced TDMA techniques.

Eutelsat has more satellites coming, and has made an interesting switch between two of its launches. Eutelsat W1 will launch with Ariane on June 30/July 1 instead of Atlas in August. Meanwhile, Hot Bird 5 will launch with Atlas on October 5, instead of with Ariane on September 11.

Italy's Telespazio has started a new package in clear MPEG-2 on Hot Bird 4 on 12.673 GHz. It includes the Thai TV5 Global Network. France's TPS has left Hot Bird 3 (12.149 GHz) and is now on Hot Bird 4 on 10.834 GHz. France 3 has joined the TPS transponder on 10.911 GHz.

An Arabic package has started on 12.654 GHz in clear MPEG-2 (SR 27500, FEC 3/4), including Sharjah TV, Bahrain TV, Saudi Channel 1, Kuwait TV, and Libya's Jamahirya Satellite Channel. The Arabic ANN has left Hot Bird 2 (11.766 GHz) and is on Hot Bird 4 on 10.949 GHz in clear PAL. A channel from Qatar is due to start on 11.863 in clear PAL, and the Turkish Kurdish separatist channel Med-TV is due on 10.872 GHz in clear PAL.

Med-TV has been given a formal warning by British TV regulators for breaking the programming rules on incitement to commit crime. The Independent Television Commission says further breaches could cause it to revoke the channel's licence. In its monthly report, the ITC says the warning was issued over a broadcast last October of a 55 minute interview with a commander of the military wing of the PKK Turkish-Kurd separatist organization.

The British Telecom (BT) package on Hot Bird 3 on 12.188 GHz has moved to 12.092 GHz, in clear MPEG-2 (SR 27500, FEC 2/3). CMT may be gone, but Country Music Radio has expanded, with digital transmissions in the BT multiplex.

Back on Astra's mostly analog position at 19º east, Granada Good Life, which was due to relaunch in April as Granada Home and Garden, instead became Granada Breeze on May 1. Originally aimed mostly at women, the channel includes new programs "aimed not just at home and garden, but body and mind as well." If you want to see what that means, the new Breeze has a website at: **http://www.gsb.co.uk/breeze**

While Granada Sky Television retrenches, British Sky Broadcast is closing one of its less successful efforts. Sky Scottish is closing, as it "has not reached the financial targets set at time of launch."

Flextech (TCI) is launching a music TV channel to compete with MTV. Carrying the misleading name UKFM (confusing, since it is supposed to be a TV station, and not an FM radio broadcaster), it will reportedly broadcast for 18 hours a day from Astra. It would produce half of its own programming, with the rest from the BBC.

Playboy TV has added a new PPV service on Astra transponder 58 at 2300-0300 hours. This is different from the regular Playboy Channel (on transponder 31), and gives viewers the opportunity to view programming for just one night, rather than pay for a monthly subscription.

Following the departure of CMT, SES's promo channel Astra Vision is now carried uncoded on Astra transponder 51. This channel has shown up before on unused transponders. With Astra real estate in high demand, it may not be there for long.

Tamil Oli Radio has begun on transponder 16 (Sky Movies Screen 1), audio subcarrier 7.56 GHz.

The arrival of digital broadcasting has meant the phase-out of more and more analog signals. Deutsche Welle says it plans to cease analog radio services on Astra in December. But the channel wants listener feedback, just in case there is still demand for an analog service. Listeners who would like the station to maintain its analog presence are encouraged to send e-mail to: **charles@dwelle.de.**

Also in Germany, the Kirch Group and Bertelsmann's CLT-Ufa say they have proposed changes to their planned digital TV venture in an effort to overcome opposition from the European Union (EU) anti-trust authorities. The EU's competition commissioner, Karel Van Miert, has repeatedly warned that the commission will block the venture if it isn't modified. When the two rivals finally announced a plan to work together, together with cable giant Deutsche Telekom, it seemed that Germany would finally have a single digital TV standard. Unless the new proposal finds favor, the EU anti-trust regulations intended to protect consumers may ironically deprive them of the many new channels available on digital cable and satellite, at least for the near future.

Merger fever has struck in Poland too, where local channel Wizja has gotten together with the Polish subsidiary of Canal Plus for a joint digital satellite service. The announcement came the day before the planned launch of Wizja's digital service, which was postponed because of the merger. Canal Plus Polska has 240,000 analog subscribers, and was going to launch its own digital service later this year. The combined service, called Wizja Plus, is to launch instead in September.

The Wizja digital package was to carry 15 international channels, including Hallmark Entertainment, Cartoon Network/Turner Classic Movies, Quest TV, Atomic TV, Knowledge TV, Travel Channel, and Home Box Office. It's estimated the new digital service will have up to 1.5 million viewers on satellite and cable by the end of this year.

Wizja planned to uplink from Britain, and concern among Poland's media establishment about the new alternatives to the national TV monopoly was reflected by comments in the Warsaw daily *Zycie Warszawy*: "This satellite raiding operation from near London can cause a real revolution on the Polish airwaves, including the collapse of our public television in its present form."

Intelsat 506 has moved from 31.4 to 29.5º west. Remarkably, NBC feeds reportedly remained on the air while the satellite was on the move. Muslim TV Ahmadiyya has started on Intelsat 605 on 3.766 GHz in clear MPEG-2. Estonia's TV1 is on Intelsat 707 on 11.462 GHz in clear MPEG-2 (SR 4340, FEC 7/8).

The Canal Digital package on Intelsat 707 and Thor 2 began scrambling in Conax on April 20. Norway's NRK International on Intelsat 707, 11.174 GHz, is also now coded in MPEG-2/Conax. Viewers outside the Nordic region can order subscriptions from NSB in Belgium.

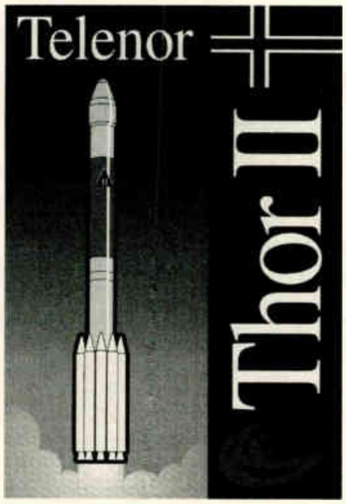
Over on Sweden's new Sirius 2 satellite, Denmark's DK 4 and Star TV have left 12.636 GHz, and are now only on 12.437 GHz. Cartoon Network Nordic has started on Sirius 2 on 12.437 GHz in clear MPEG-2. Cartoon Network Nordic is not in parallel with the ordinary Cartoon Network on Astra transponder 37 (where the Swedish sound track has been removed from 7.56 MHz).

Africa and Asia

Libya's People's Revolution TV has started on Arabsat 2B (30.5º east) on 4.167 GHz in clear PAL.

Two French stations aimed at Africa

have left Intelsat 605: CFI Afrique DTH (3.886 GHz in SECAM) and CFI Afrique Pro (3.935 GHz in MPEG-2). They are both now available instead on Intelsat 803 at 21.5º west.



On April 28 Egypt's Nilesat 101 and Japan's BSAT 1B were successfully launched with Ariane from French Guiana. Nilesat, which will be located at 7º west, has 12 Ku-band transponders. Nilesat will provide direct-to-home television, radio, and data broadcasting throughout the Middle East, Mediterranean region, and North Africa. One hopes that any European beams will be better than the extremely weak half-transponder used by Nile TV International to Europe on Eutelsat II-F3. This broadcasts in English and French, apparently in an effort to interest a foreign audience in Egyptian tourism. Ironically the Arabic language Egypt Satellite Channel on the same satellite is much stronger in Northern Europe, where there are presumably more potential tourists than homesick Egyptians.

BSAT 1B, with 4 Ku-band transponders, will be located at 110º east, and will mainly serve as a back-up for BSAT 1A.

As mentioned above, NBC and *National Geographic* have announced a partnership. To an even greater extent than in Europe, nearly all of NBC Asia programming will be replaced with the *National Geographic* Channel on July 1.

Following the merger between Japan Sky Broadcasting and PerfecTV, the joint service on JCSAT 3 (128º wast) is called Sky PerfecTV.

The American shopping channel QVC plans to begin operations in Japan, by linking up with a local partner. According to the "Nihon Keizai" business daily, QVC and Marubeni Corp will market everything from clothing to personal computers on cable and satellite television. To start the operation, the two companies have effectively bought out an existing Japanese homeshopping broadcaster.

Indian Broadcasting Minister Sushma Swaraj has called for a complete ban on "immoral" on-air advertisements for products such as alcohol and cigarettes. Swaraj's threatened ban of such "unacceptable" advertisements has caused concern among the Indian satellite community because liquor and tobacco ads tend to bring in the greatest revenues. According to estimates, Rupert Murdoch's Star-TV alone stands to lose nearly US$4 million a year if the ban is enforced.

On Apstar 1 at 138º east, CNN International on 3.980 GHz has switched from PAL to clear MPEG-2 (SR 26000, FEC 3/4).

On Apstar 2R (76.5º east) there are two new digital transponders in MPEG-2/Digistar: 12.538 GHz (Viva Cinema, Discovery, TNT, Cartoon Network, Channel V Int., Channel V Asia, and Star Sports) and 12.660 GHz (Star Plus Japan, Star World, Star Movies Asia, Star Movies North, and Phoenix Chinese).

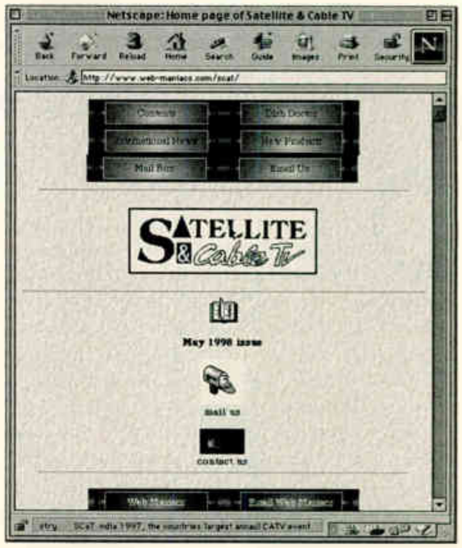
On Thaicom 3 at 78.5º east, Burma's MRTV has started on 3.688 GHz in clear NTSC. IBC has a package of encoded MPEG-2 TV channels on 12.475, 12.515, 12.555, and 12.600 GHz.

New Zealand's Sky Television renamed its two existing satellite television services on June 1. The move is in preparation for the arrival of digital TV. Following the pattern of Rupert Murdoch's BSkyB channels in Britain, "HBO: The Movie Channel" has become Sky Movies, while "Orange" becomes Sky One. However, Sky says it faces a slight delay in the launch of the digital service. Originally scheduled for September 1, the company now says it hopes to start installing digital decoders by October. This follows an agreement with Pace's Australian subsidiary to supply decoders for the digital satellite service.

Mark Long, founder of the *World Satellite Annual*, having relocated some time ago to Southeast Asia, has announced the launch of a new online *Satellite Directory Service* for Asia, the Pacific Rim, and the Middle East. The new service is for anyone who may be looking for contact information concerning businesses and organizations involved in the satellite communications business in the region. See: **http://www.mlesat.com.**

There are also details there about a *Satellites on Disk* CD-ROM covering present and future satellites between 26 and 183º east.

The Indian magazine *Satellite & Cable TV* has a Website with lots of news from South Asia at: **http://www.web-maniacs.com/scat.**



Beginning in August, many of you should be able to hear a number of international broadcasters over your local public radio stations. For some time now the World Radio Network (WRN), which relays some 20 international broadcasters on satellite, has been carried in the middle of the night on AM across Canada on *CBC Overnight*, and more recently there have been similar arrangements in South Africa and Israel. Now NPR is planning on launching a similar all-night service in co-operation with WRN.

I'll have more details next month, as I'm off to London and a visit to WRN. I'll also be attending this year's Cable and Satellite Show, one of the biggest events on the European satellite calender. With British Sky Broadcasting preparing to launch its digital service, along with the BBC and Flextech, you can be sure they'll all have a major presence, as will other programmers and hardware manufacturers involved in the new digital satellite TVRO industry. More next time!

Thanks to the usual contributors: James Robinson, Richard Karlsson, *SATCO DX*, and *TS-Asia*, along with the *Wall Street Journal* and *What Satellite TV*.

By Dan Veeneman

Introduction to Personal Communication Service Satellites

Over the past decade we've seen mobile telephones move from a bulky toy for the rich to an affordable, mass-market service. Nearly 60 million people now subscribe to cellular or Personal Communications Service (PCS) services, carrying their mobile and handheld phones wherever they go. As accepted as this technology has become, coverage and the ability to roam continue to be limiting factors. We are used to always being in touch, but with large areas of the United States not covered by a terrestrial service provider, let alone the rest of the planet, what do you do when you're out of range of the nearest tower?

One solution is to relay that signal by satellite, and this column is devoted to covering Personal Communications Satellites in all their forms and functions. Voice telephony, data, fax, paging, music, and other services are all carried by orbiting platforms of one kind or another, and we'll take a look at them in upcoming columns. This month we'll introduce the low earth orbit concept and review two systems that are already in space.

Low Earth Orbit

From 1945, when Arthur C. Clarke first envisioned communications stations orbiting the earth, until recently, geostationary platforms were the only option for commercial telephone service by satellite. Large, expensive, and designed to function for decades, these "birds" connect remote points on earth from their perch 22,300 miles overhead. At that altitude their orbital speed matches the rotational speed of the earth, and because they are directly above the Equator they appear to ground observers to be stationary in the sky.

As convenient as a geostationary satellite is, there are some drawbacks. After 30 years the "arc" above the equator is starting to get crowded, making it more and more difficult for a satellite operator to acquire a preferred "slot." In addition, radio waves take a quarter of a second to travel up to a satellite and come back down, leading to noticeable delays in telephone calls. Beaming signals that far also requires a significant amount of power and often necessitates bulky antennas and other equipment.

New systems poised to come on line in the next few years have avoided these problems by selecting a different type of orbit for their satellites. Rather than lofting a single, expensive satellite all the way up to geosynchronous altitude, these operators launch a number of less expensive satellites into what is called low earth orbit, or LEO. Communicating with satellites operating at these lower altitudes, some as low as 300 nautical miles, requires far less power and the round trip delay is no longer a factor.

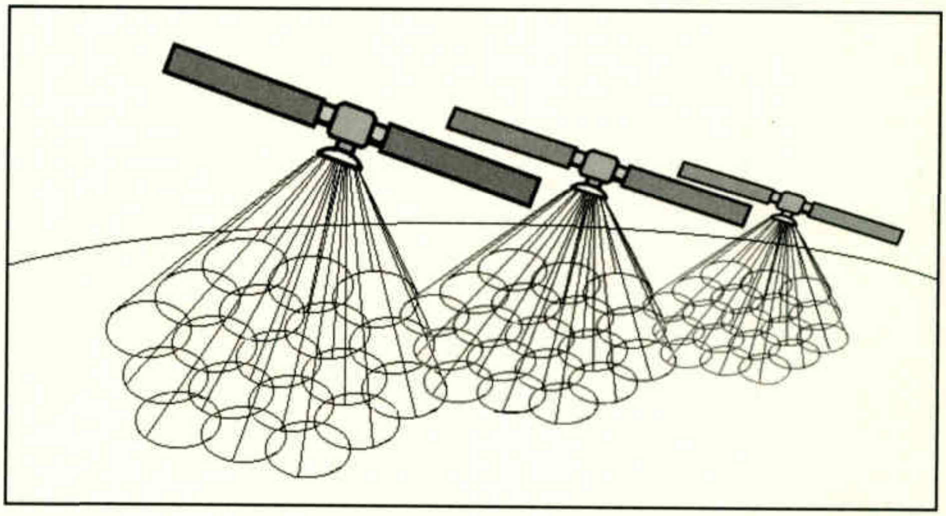
Big LEOs

The task of providing satellite telephone service using low earth orbiting satellites is quite a bit more complicated than using a geostationary satellite. The first and most obvious difference is that the satellites are moving with respect to the subscriber. A satellite will come up over the horizon, be in view for a brief period of time, then cross out of view again. Since at least one satellite has to be in view at all times in order to maintain a connection, a whole string of satellites has to be in orbit, one following the next in a continuous circle. This circle, or "plane," will be navigated by four or more satellites which provide continuous coverage as their overlapping "footprints" cross the Earth's surface. To cover most or all of the Earth requires more than one plane. The entire fleet of satellites is often referred to as a "constellation."

A good way to think about these satellites is to picture them as cellular base stations in the sky where the towers move and the user stands still. The area a single satellite can cover is known as a "footprint" and is made up of a number of "beams," each covering a portion of the total footprint. During a conversation the call will be handed off from beam to beam within a footprint as the satellite moves overhead. As the call reaches the edge of the departing satellite's footprint it will be handed off to the next arriving satellite. If everything works correctly the user will never notice these changes.

To connect a subscriber to a landline telephone, satellites must also communicate with ground stations, usually referred to as gateways. These gateways typically have four or more satellite dishes that track the satellites as they cross overhead as well as the associated radio gear and telephone interconnect equipment to link with the local telephone company.

There are a number of added complications that come with using LEO satellites, including frequency shifts due to Doppler, network management and user location issues, shorter equipment lifetimes, and ground control facilities for tracking, telemetry and control (TT&C) of the constellations. We'll



get to those in later columns, but for now we'll briefly review two of the major "Big LEO" systems designed to provide worldwide mobile voice service.

Iridium

With the backing of Motorola and an international consortium of investors, the Iridium system began life in 1987 as a concept to provide worldwide telephone service. The original design called for 77 satellites to circle the planet in low earth orbit and was termed "Iridium" after the element with atomic number 77. Technical reviews and design work further in the development cycle established a final configuration of 66 satellites; however, the moniker "Dysprosium" doesn't roll off the tongue in quite the same way as Iridium, so the name didn't change (also, dysprosium is derived from the Greek word *dysprositos*, meaning hard to obtain, which may have had negative marketing implications).

Edward Staiano, Iridium's vice president and CEO, has stated that "Iridium is not really a satellite company, it is a global wireless telephone company." It is certainly the most expensive, having cost more than $5 billion so far, and is arguably the most technically complicated of the Big LEOs. Eleven space vehicles (SVs) in each of six orbital planes will ensure that subscribers have at least one satellite in view at all times.

Unique to Iridium, these SVs use on-board processing to switch telephone calls. Traditional satellites operate as relatively simple transponders (termed "bent pipes"), blindly rebroadcasting to the ground whatever they receive. In contrast, Iridium birds receive and process calls on board the satellite, and can either downlink to the ground or connect the call to another SV using inter-satellite links. Each space vehicle is equipped with four crosslinks operating at 23 GHz, connecting it to satellites ahead and behind and to either side. These crosslinks allow a subscriber on one side of the world to make use of a gateway located anywhere on the earth, rather than one that is within range of the current satellite. These crosslinks also provide redundancy by allowing alternate paths from subscriber to gateway.

An incoming call will be routed from the phone network to one of several regional gateways around the world, with each gateway being capable of initially handling just over 1000 simultaneous calls. Each call is uplinked to an available satellite over the gateway, then passed off through intersatellite links to the satellite over the subscriber where it is downlinked to the phone.

Iridium satellites communicate directly with handheld user "terminals" using time division multiple access (TDMA) in L-band between 1610 MHz and 1625 MHz. These terminals will operate in dual-mode: when in range of an existing GSM system it will operate like a cellular telephone, but when out of range it will switch to satellite operation. Iridium will also offer a paging service, and farther down the road may offer low speed data connectivity.

Handset costs are expected to be in the range of $2000 to $3000, with airtime rates of anywhere from $2 to $9 a minute. Iridium will not deal directly with end users, but will contract with land-based GSM providers to offer their customers automatic roaming over Iridium.

The first five Iridium satellites were launched on May 5, 1997, from Vandenberg Air Force Base in California. Subsequent launches from the United States, China, and Russia occurred at the rate of about once per month and culminated in the final scheduled launch on May 17, 1998. A total of 72 satellites have been placed in orbit at an altitude of just over 400 nautical miles; however, at present at least five of these are not operational due to failures of one sort or another. Commercial service is slated to start on September 23, 1998.

Iridium satellites create another type of signal that doesn't require a handset, although you have to be in the right place at the right time to "receive" it. The three L-band phased array antennas on each SV form a pyramid shape that points down at the Earth. These flat aluminum panels have a surface area of more than 17 square feet and reflect sunlight very well. Depending on your location, an Iridium satellite may "flare" for upwards of twenty seconds, outshining all the stars and planets in the night sky.

Globalstar

Hot on the heels of Iridium, the $2.7 billion Globalstar program is funded and operated by a consortium of communications and electronics companies including Loral Space & Communications Ltd, Qualcomm, and AirTouch. Globalstar hopes to partner with local communications providers to extend telephone service to remote and underserved regions. Under their scheme, earth station gateways would be controlled by in-country service providers while Globalstar would manage the satellite portion of the network. All calls made from a country would enter that country's existing landline network from their local gateway, rather than bypassing them and depriving the local provider of lucrative telephone service charges. As many as 60 of these gateways are anticipated to be constructed worldwide.

Globalstar satellites will use Code Division Multiple Access (CDMA) to share the uplink and downlink frequency spectrum among subscribers. They will also use on-board GPS receivers for navigation and attitude control.

Globalstar will offer tri-mode handsets that will function on analog cellular (AMPS) networks, IS-95 (CDMA) cellular networks, and the Globalstar satellite network. Solar-powered phone booths are also planned for remote villages without reliable power. When a subscriber places a call, the terminal will search for a local cellular system. If one isn't found, it will request service from a local gateway via Globalstar. If the subscriber is validated and there is sufficient capacity available, the gateway will place the call and the connection will be carried via satellite. The local service provider will bill the subscriber, and Globalstar will bill the service provider (presumably at a discounted, bulk airtime rate). Airtime rates of $1.00 to $1.50 per minute are expected, with handsets costing anywhere from $750 on up.

Handsets will also have the capability of combining received signals from as many as four satellites, improving the likelihood of good reception and allowing each satellite to transmit at a reduced power level. Globalstar has been criticized in some quarters for having underpowered spacecraft, and it remains to be seen whether the power requirements on a fully-loaded satellite will exceed the total electrical storage capacity. Careful management of transmitter power and extended over-water recharge periods will be mandatory, and such combined handset diversity may be necessary in a mature system to meet customer quality and service demands.

Globalstar launched their first four satellites on February 14, 1998, and another four on April 24, 1998. Six remaining launches are planned, three using Ukrainian Zenit rockets and three using Russian Soyuz rockets.

	Globalstar	Iridium
Altitude (nautical miles)	763	421
Orbital period (minutes)	114	100
Operational Satellites	48	66
Orbital planes	8	6
Satellites per plane	6	11
Beams per satellite	16	48
Access Scheme	CDMA	TDMA
Life Expectancy (years)	7.5	5 to 8
Relay Type	bent pipe	on-board processing
Primary backer(s)	Loral	Qualcomm/ Motorola

More Information

The two systems we've looked at so far are designed primarily to provide voice service on a global basis. Other Big LEOs are in the planning stages, and there are additional personal communication services that can benefit from satellite relays. Future columns will cover these in detail, and there's always more information and links on my website at **http://www.decode.com**. I am reachable via electronic mail at **dan@decode.com**, and I look forward to reading your comments, suggestions, and opinions. Until next month, clear skies!

Some EENET broadcasts are aired from remote locations throughout the United States. Shown above is a studio location in a large auditorium.

vided the content. They identified the experts to do the training and then we were the vehicle to get the information out." However, EENET is changing. "Now we are now doing a lot of our own programing," says Downin. One of the first changes was the addition in 1997 of a new program series, called *National Alert*.

Tape and head-in room

The *National Alert* program airs the third Wednesday of each month from 2:00 to 3:30 p.m. Eastern Time. The first hour of these 90 minute programs is devoted to the latest training and information of interest to emergency management personnel and first responder professionals. Says Downin, "The shows are one-way video and two-way audio. We take live call ins. They can call in and ask questions while we are on the air." The last half hour includes public service announcements, and short 5 or 10 minute video segments that are used for training.

According to Downin, the National Alert series is unique, "because we not only produce the show in-house but we ask the viewers to send in video tapes from their communities so that we can share them with the rest of the country." Videos are sent in by local emergency management offices, fire departments and other agencies.

In addition to the regularly scheduled monthly edition of EENET's *National Alert* program, EENET airs special training courses, town hall meetings and video-conferences. The content of programs varies. Last August, *Managing Terrorism Events: The Oklahoma Experience* aired. This three hour live program from Oklahoma City used the bombing of the Murrah Federal Building as a backdrop to review processes and procedures for emergency workers facing a similar crisis.

Sue Downin proudly pointed out that anyone is free to watch EENET broadcasts and all programming is in the clear and in the public domain. Broadcasts take place both on C and Ku-band. Many cable television public access channels around the country also air these broadcasts. EENET also provides free copies of each show to every state emergency management office and all of the 10 FEMA regional offices to be included in a lending library for both emergency personnel for training use and viewing by the general public.

Because they purchase transponder time as an occasional user, says Downin, "We get moved around from time to time and the best place to get the updated schedule is the Internet."

Even though EENET maintains a mailing list of over 15,000 names, "It doesn't pay to mail the schedule because it changes often," says EENET's Sue Downin. Their solution was to resort to technology. Through their Internet site the latest schedule changes and satellite updates can be quickly posted and made available to their audience almost instantly. EENET's schedule is posted on their world wide web site **http://www.fema.gov/emi/sched.htm**. It includes information on their programming as well as the latest information on which satellites and transponders will carry their programs.

For those without Internet access, during normal business hours EENET operators answering their toll free numbers 1 (800) 500-5164 and 1 (800) 527-4893 will provide viewers with updated information about which satellite and transponders will be carrying EENET programming, so they can watch what's *On The Air*.

Current set at Emmitsburg

FINAL FRONTIER

By Philip Chien

Space Food

People need to eat everywhere, even in space. But what do the astronauts eat, and how good is the food? On early spacecraft the biggest complaint was the food, typically baby food in squeezeable tubes. One cosmonaut commented, "I couldn't shake the feeling I was squeezing a tube of toothpaste into my mouth."

Contrary to the Madison Avenue myth Tang was not the drink of the astronauts. It was one of many beverage choices. NASA dietitian Vickie Kloeris explained, "We used Tang because it was one of the first powdered drinks available. Now we also use Country Time Lemonade, Kool-Aid, and other instant drinks." The Apollo fuel cells generate drinking water along with power and the water was used to mix drinks and rehydrate freeze-dried food products.

A vacuum oven simultaneously heats the meal-sized portions while decreasing pressure to keep the food's texture. The astronaut squirts hot or cold water into the package and shakes it up. When freeze-dried food is mixed with water it is restored to its original texture instead of just mush. It's opened with scissors and eaten with a normal spoon.

I tried the spaghetti and meat sauce which was about as good as canned spaghetti. The ingredients were similar: spaghetti, tomato paste, beef, salt, textured soy flour (caramel colored), sugar, dehydrated cheese, hydrolyzed vegetable protein, spices, onion powder, monosodium glutamate, and garlic powder.

Irradiation is the only controversial preservation technique. Ionizing radiation destroys microorganisms and insects. Irradiated foods keep their texture and flavor much better than other preservation techniques. Irradiation is certainly a safe method of food preservation and, with recent scares about contaminated mad cow beef, will hopefully become more acceptable to the general public. Nevertheless, opponents claim that foods may lose nutrition or change chemically, potentially becoming carcinogenic. Astronauts choose their own menus and most prefer the irradiated products.

The public's fascination with astronauts has created a market for pseudo-space foods. High tech attractions sell "Astronaut Space Food"–basically relabeled camping food. The fine print states "representative of foods used on earlier space missions." So it isn't astronaut food–unless they're at a tourist attraction!

Space food has improved over time. Today's space shuttle menus include a wide variety of different menu choices and several preservation methods. Much of the food is off-the-shelf supermarket items repackaged for spaceflight. Astronauts select their own menus, with advice from nutritionists.


Rhea Seddon "sits" down to a meal in the mid deck. Sleep restraints for two crewmembers are in the background. Photo credit: NASA.

Some fresh food is available on each mission. The trays, packed the day before launch, include carrot sticks, bananas, breads, and anything the astronauts want out of the ordinary. Japanese scientist Mamoru Mohri wanted to carry traditional Japanese soups, so the food laboratory purchased instant mushroom, onion, and seaweed soups from a local supermarket. Other special requests have included Girl Scout cookies, Swiss chocolates and plain spaghetti (for educational demonstrations–not eating).

A few astronauts are vegetarian, either for health or religious reasons. There's a wide variety of different non-meat foods from which they've been able to fill their menu cards quite adequately.

Holidays in orbit are important to the astronauts. They're away from their families, but get to share a special meal with their crew. It may come as a surprise to learn that the Thanksgiving turkey dinner served aboard the shuttle is just a plain old $1.99 Dinty Moore off-the-shelf supermarket product.

In 1997 Thanksgiving was a

special challenge. Dave Wolf, aboard the *Mir* space station had a rehydratable turkey meal with mashed potatoes and peas in cream sauce. Thanksgiving is primarily an American holiday but his Russian companions were happy to share it with him. On the shuttle the situation was similar–three Americans, a Japanese, a Ukrainian, and an Indian-born vegetarian. Six turkey dinners were packed, but each crewmember had the choice of eating whatever they preferred.

For the 1975 Apollo-Soyuz mission food gained new levels of importance as part of the political ceremonies. The Soviet cosmonauts and their American counterparts would treat each other to their meals. There were taste tests, and both groups had an interesting time trying unusual foreign foods. The relatively benign Slavic foods chosen by the astronauts included: borscht, jellied turkey, cheeses, and black bread. The cosmonauts surprised the astronauts by offering them a tube labeled with a popular brand of Russian Vodka. It turned out that it was borscht with a vodka label!

With the joint shuttle-*Mir* project and Russian involvement in the International Space Station, food has taken on additional importance. The shuttle usually brings up fresh vegetables and fruits for the *Mir* crews. Late night comedian Jay Leno kidded that one advantage to flying a Russian cosmonaut aboard the shuttle would be finally finding somebody who would actually enjoy Tang! Well, Sergei Krikalev's first meal aboard a U.S. spacecraft consisted of cauliflower with cheese, tortillas, pears, shortbread cookies, almonds, and peach-apricot drink–no Tang.

Astronaut Loren J. Shriver, mission commander, pursues several floating chocolate candies on the flight deck of the Space Shuttle Atlantis. Photo credit: NASA.

For the most part the Russian and U.S. space foods have similar packaging techniques, although there are a couple of differences. On *Mir* water is in extremely limited supply while on the shuttle there's so much water generated that much of it is dumped overboard as waste. But on shuttle missions space is at a premium. So *Mir* has a higher amount of canned food which doesn't require water to rehydrate, while the shuttle has a higher amount of rehydratable food which doesn't require as much space to store.

It's traditional for shuttle and *Mir* crews to invite each other over for a special dinner. These are special opportunities for the crews to share some quality time together during the hectic five days while the shuttle is docked. It turns out that several cosmonauts enjoy Cajun Barbecue! U.S. astronauts, used to prepackaged prepared food, have commented about how surprised they are at the casual approach on *Mir*–a cosmonaut can just reach into the refrigerator and cut off a hunk of salami as a snack or a present to his American visitor.

On a couple of flights there is extra space in the freezers which will carry biological samples back from *Mir*. Normally the freezer is empty at launch but astronaut Ken Cameron was able to convince his managers to permit him to carry some high quality ice cream as a present for the *Mir* crew. The joint dinner included Peach Ambrosia a la mode for desert.

There have been a variety of myths about the quality of Russian space food. Most of them are based on cultural differences–in Slavic countries raw onions and garlic are considered delicacies. On the other hand Russians have had to get acquainted with the concept of sandwiches, especially at working lunches.

U.S. astronaut Norm Thagard's personal dislike for any canned fish products was misinterpreted as his hatred of Russian canned perch. There were many Russian foods which he did enjoy, including rehydrated mashed potatoes with onion, and canned beef with kasha. I tried the beef with kasha and found it to be very tasty and filling, although it had more fat than what most Americans would consider healthy.

One key operational limitation on *Mir* will also apply to any long term space station. You always want to have a month's meals available, just in case there's a problem with a supply ship either getting delayed or unable to dock. And you always want to eat your oldest food first to prevent food from reaching their expiration dates.

Cosmonauts get to select their personal food choices, but much of the food they eat when they first arrive is food which was originally selected by the previous crews. So while each astronaut makes food selections, much of the food he actually eats in space are the choices made by the previous astronaut on the *Mir.* There are a couple of loopholes, though. Each resident on *Mir* gets a couple of trays of bonus food which are exempt from the food inventory system. In addition there's enough variety between different cosmonauts choice for each person to have a fairly wide selection.

When U.S. astronaut Dave Wolf was to replace Wendy Lawrence in mid-1997 he was forced into a bigger challenge. Wendy's menu choices included less meat and diet soft drinks than what Dave wanted. So Dave filled his bonus trays with irradiated steaks and drinks with sugar. Nevertheless, for his first month on orbit Dave's primary menu choices were those selected by the previous *Mir* resident, Mike Foale, followed by Wendy's menu.

The long term U.S. astronauts on *Mir* have had unusual stories evolve about their foods, caused primarily by the media. In one of her many interviews Shannon Lucid was asked if there was anything she missed or had run out of, and she commented that she had run out of M&M candies. No big deal. And several packages of M&Ms were included on the next unmanned Progress cargo ship to *Mir.* But it was something which was easy for the public to understand–the brave American woman in space with two Russian cosmonauts has run out of M&Ms. And in later interviews she was asked about whether or not she had enough M&Ms.

Shannon was incredibly surprised when she got back to Earth and NASA Administrator Dan Goldin handed her several large boxes of red, white, and blue M&Ms with the presidential seal. (Yes, white M&Ms do exist.) President Clinton had heard about Shannon missing M&Ms and thought that some special Presidential seal M&Ms would be an appropriate present for her! Along with the M&Ms came the realization that the American public found a new hero. Shannon quickly became one of the most famous U.S. astronauts, something which she had previously experienced as one of the first female astronauts to be selected by NASA. The M&M company offered Shannon 188 cases of M&Ms–one case for each day she spent in space, but as a government employee she couldn't accept any gifts over $25.

Astronaut Thomas P. Stafford (left) and Donald K. Slayton hold containers of Soviet space food in the Soyuz Orbital Module during the joint U.S. - USSR Apollo-Soyuz Test Project docking in Earth orbit mission. The containers hold borsch (beet soup) over which vodka labels have been pasted. This was the crews' way of toasting each other.

Jerry Linenger realized how Shannon's M&M comments were overblown, but he still commented about how he had missed pretzels while he was training in Russia. And he made similar comments while he was on *Mir.* So, naturally, his first present when the shuttle arrived to take him home was pretzels. After he returned to Earth all of his friends and acquaintances sent him pretzels–enough so he commented "I'm so sick of pretzels that I don't want to see another pretzel ever again!"

There are concerns about the astronauts' nutritional intakes. If they ate all of the food they selected they'd have balanced diets but a large percentage of food gets returned uneaten; on some missions up to 50 percent of the food isn't consumed. For the relatively short space shuttle missions this isn't a concern, but long duration space station crews and future lunar and Mars projects require healthy–and well fed crews. The logic goes, if the quality of the food is better then the astronauts will eat more of it. And a happy, well nourished crew will perform their tasks better.

The next significant improvement in space food will occur when the U.S. Hab module arrives at space station around 2003. It will include a refrigerator/freezer and most of the foods will be similar to frozen dinners, although portioned as separate *a la carte* items. It's possible that NASA will give a commercial contract for the space station food to a consortium of food industry companies.

So what are the favorite astronaut foods? It varies from person-to-person, but shrimp cocktails, applesauce, Russian meat with kasha, and beefsteak are some of the more popular choices.

What type of food do the astronauts miss the most while they're in space? Pizza. The food technician who comes up with a recipe for a tasty pizza which can be taken into space is going to make a lot of astronauts extremely happy.

WHAT'S NEW

by Wayne Mishler, KG5BI

DIRECTV offers new 24-hour cartoon channel

Toon Disney, a new 24-hour, all-animation channel from Disney Channel, became available on DIRECTV in mid-April. The programming will draw from more than 2,000 episodes of animated television programming in the Walt Disney Company library. It will offer Disney-branded animation, as well as titles shared with Disney Channel. The channel features a variety of Disney's favorite characters with series, shorts and movies including such highlights as *Little Mermaid, Gummi Bears, New Adventures of Winnie the Pooh,* and *Darkwing Duck.* Preschool blocks are available for children. Animated movies are offered every Friday night featuring such favorites as *Alice in Wonderland, Dumbo, The Rescuers* and *A Goofy Movie.* Toon Disney showcases the Disney Company's vast animation library, representing seven decades of magic, from series and specials to shorts and movies.

K-band antennas meet needs of European broadcasters

Andrew Corporation's Earth Station Antennas now support K-band reception worldwide. Unique two or four-port corrugated feed system increases antenna efficiency and lowers noise. The 3.7-, 4.6-, 5.6-, and 7.6 meter antennas can be operated for both fixed and mobile satellite services.

The antennas feature spacious equipment enclosures and optional motorized drive systems to enable precision antenna positioning. Their aluminum and steel construction are rated to withstand 125 mph (200 km/h) winds, and engineers say the main reflector and Gregorian optics are designed to provide excellent pattern characteristics and high gain.

For information, telephone the Andrew Corporation at 1-800-255-1479 extension 366 and request bulletin number 10222.

Phone company offers high speed Internet connections

GTE is offering consumers, businesses, universities and Internet service providers continuous high-speed Internet access and remote office connectivity 50 times faster than conventional modems. Service has already begun in 16 states.

In the first of two phases, GTE is converting its current ADSL trials into broad-market deployment, enabling customers in portions of Beaverton, Ore., Durham, N.C., West Lafayette, Ind., and Redmond and Kirkland, Wash., to access the World Wide Web at speeds up to 1.5 megabits per second (Mbps).

During the second half of this year, GTE plans to offer ADSL service in no less than 30 additional market clusters in California, Florida, Hawaii, Illinois, Indiana, Kentucky, Michigan, Missouri, North Carolina, Ohio, Oregon, Pennsylvania, Texas, Virginia, Washington and Wisconsin.

By the end of the year, GTE's central offices in parts of 16 states will be equipped to offer high-speed digital connections to the Internet over existing telephone lines.

ADSL works by connecting a pair of modems to each end of a telephone line, with one modem located in the telephone company's central office and the other at the customer's premises, providing a continuous Internet access rather than traditional dial-up modem connections.

With ADSL, consumers can simultaneously surf the World Wide Web and place telephone calls over the same line. Compared to cable modems, ADSL offers greater flexibility in choosing Internet service providers and deciding between network connectivity alternatives. ADSL also delivers dedicated bandwidth from the central office to individual users at homes or offices, unlike cable modems that provide shared bandwidth among a group of users over the same path.

"Our trial participants have told us loud and clear that their increased need for information requires greater bandwidth and speed. With ADSL, their information highway will be lined with green lights, and they can confidently put their interactive pedal all the way down to the floorboard," said John Appel, president-GTE Network Services.

"Our world is becoming more and more digital, and voice, video and data services are converging into a single ubiquitous network. ADSL becomes the 'last mile' or local loop enabler that helps deliver a new realm of multimedia content and enhanced Internet protocol services to customers."

Pending regulatory approval, GTE plans to offer several ADSL service packages featuring various transmission speeds ranging from 256 kilobits per second (kbps) to 1.5 megabits per second (Mbps). For comparison, a 2 1/2-minute movie clip of Superman (8.8 megabytes) would take 35 minutes to download using a 33.6 kbps modem, yet less than 47 seconds using a 1.5 Mbps ADSL modem. Likewise, an initial downloading of a 50 megabyte interactive game would painstakingly take three hours and 18 minutes with a 33.6 kbps modem, but just 4 1/2 minutes with a 1.5 Mbps connection.

GTE will offer customers month-to-month, multi-year term and volume discount plans with a target monthly price range of $30 to $250, excluding one-time installation, Internet service charges and modem lease. A modem lease rate of about $12 per month is expected, plus a one-time installation fee of $60 or $140, dependent upon whether or not a modem and inside wire are installed at the customer's premises.

The company also plans to offer customers high-speed ADSL with Internet access service, for approximately $60 a month through a relationship with GTE Internetworking, the Internet unit of GTE Corp. The company also intends to develop high-speed ADSL and Internet access service packages with other Internet service providers.

Current ADSL market trials in Redmond and Kirkland, Wash., West Lafayette, Ind., Durham, N. C. and Beaverton, Ore. involve more than 1,300 users, including some 1,000-plus Microsoft employees, a small number of Intel employees in Oregon, plus students, faculty and scientists at Duke University Medical Center and Purdue University.

Internet access added to cable TV

Internet cable TV service is now being offered to customers in St. Louis, following a successful six-month trial test.

Charter Communications and WorldGate Communications are offering the service through a CFT 2000 set-top terminal, which offers expanded tuning for additional analog channels, interactive program guides, virtual channels, CD quality digital audio services and the ability to support emerging interactive applications.

These applications include high-speed Internet access, Near-Video-On-Demand (NVOD), Enhanced Broadcasting, Caller-ID and Visual Voice Mail. The company says cable Internet connections are from four to ten times faster than those attainable over standard telephone modems (28.8 kbs.) Digital technology allows real time interactivity at 27 Mbps, all delivered with crisp MPEG-2 video and Dolby AC-3 digital audio.

With broadband Internet access, web surfers will no longer tie up a telephone line, require additional local phone access charges, or have problems with busy signals.

Subscribers can link a program they are watching directly to a related web site. For the operator, the ability to have subscribers access advertisers' web sites can provide a significant new source of revenue.

Airborne TV comes to corporate jets

For the first time, corporate jet passengers will be able to tune into live broadcasts of CNN, Bloomberg Television, ESPN, Classic Sports Network by ESPN, and many of their other favorite channels while in flight.

The programming, provided by DIRECTV, now appears on the Airshow TV system, resulting from an agreement between DIRECTV and Airshow Inc.

Airshow TV, which received FAA certification in December 1997, is the newest innovation designed by Airshow Inc., the world's leading provider of passenger flight information systems. The new programming service will enable passengers to watch many of the same television channels they watch at home in digital quality picture and sound via DIRECTV. Passengers will also be able to view popular networks such as CNN, The Discovery Channel, and The Weather Channel.

"The ability to view live television programming via a tiny satellite dish on an aircraft means thousands of corporate jet passengers won't miss a beat in keeping up with the latest news, weather, and information that affects their business," says Terry Ferguson, vice president, Business Development and Strategic Planning for DIRECTV.

Airshow TV operates across the continental United States. Plans to expand service to Latin America, Europe, and Asia are currently underway, although programming may differ.

New line of converters simplifies receiver design

The work of circuit designers became easier with the introduction of MTS4000 converters. With the addition of a few external components, these converters receive and convert 70 or 140 MHz Intermediate Frequency to either C or Ku-band frequencies. They also work the other way, by receiving C or Ku-band frequencies and converting them to 70 or 140 MHz. All of the IF, RF, digital, and analog circuitry are contained in a streamlined 11 by 5 by 1.44-inch module.

The entire family of products, including the Ku-band modules, is guaranteed to have a minimum of 5 dB of margin over the IESS 308/309 phase noise requirement. Each module has frequency-agile tuning across a typical 900 MHz of bandwidth. The entire product family shares a common interface protocol and outline configuration.

The advantages of the MTS4000 family of converters are in their cost-effectiveness and ease of use. Because the converters are highly integrated and share a common interface and outline, they greatly speed reception circuit design. Just add a fan, power supply, reference, controller card. By using these new converters, system designers of C and Ku-band converters would have significantly fewer components to integrate, test, document, and store. Re-designing an existing converter for a different frequency band requires only a change in the control software and a new MTS4000 module. The hard part, the RF portion, with all of its associated hardware is already completed for you. All of the time and expense associated with making the individual components of a typical converter function has been engineered into a working product that exceeds the IESS 308/309 requirements.

These modules were designed especially for the Satellite Communications Industry. For information telephone (707) 570-3315.

Company offers satellite television to rural customers

Rural households in 11 southeastern states will soon be able to subscribe to DIRECTV as a result of an agreement between DIRECTV and Wireless One, Inc.

Wireless One will also target C-band subscribers for conversion to the digitally-delivered DIRECTV programming service and the 18-inch dish.

DIRECTV will initially be offered to customers either not served by cable or unable to receive wireless service. DSS® systems will be available for rent to customers.

Wireless One reported that initial market tests have demonstrated a strong demand for DIRECTV programming among residents who are unable to receive cable or wireless signals.

Twenty-four percent of residents in the market area expressed intent to subscribe. Subscribers will pay a monthly DSS equipment rental fee to Wireless One, and will be billed separately by DIRECTV for subscription packages, sports subscription services and pay per view selections. The rental fee will include service of DSS equipment.

Wireless One primarily serves suburban and rural households, businesses, and apartments that are generally unable to receive hardwire services Texas, Louisiana, Alabama, Tennessee, Florida and Georgia.

DIRECTV provides more than 3.5 million subscribers with access to more than 185 channels of programming, such as popular cable networks and commercial-free audio channels in digital-quality picture and sound, as well as more sports than any other direct broadcast satellite (DBS) service or cable provider.

New 24-hour sports network announced

DIRECTV and ESPN will launch ESPN West, a new Southern California regional cable network, in October.

The new network will feature games of the National Hockey League's Mighty Ducks of Anaheim and Major League Baseball's Anaheim Angels.

A customized Southern California version of ESPNEWS will air every evening on ESPN West with local scores and highlights.

Also featured will be broad-appeal events such as college football, baseball and basketball from top conferences all over the country.

Special interest and alternative sports programming will include skateboarding, snowboarding, surfing and mountain biking. A broad range of prestigious international soccer matches has been scheduled as well.

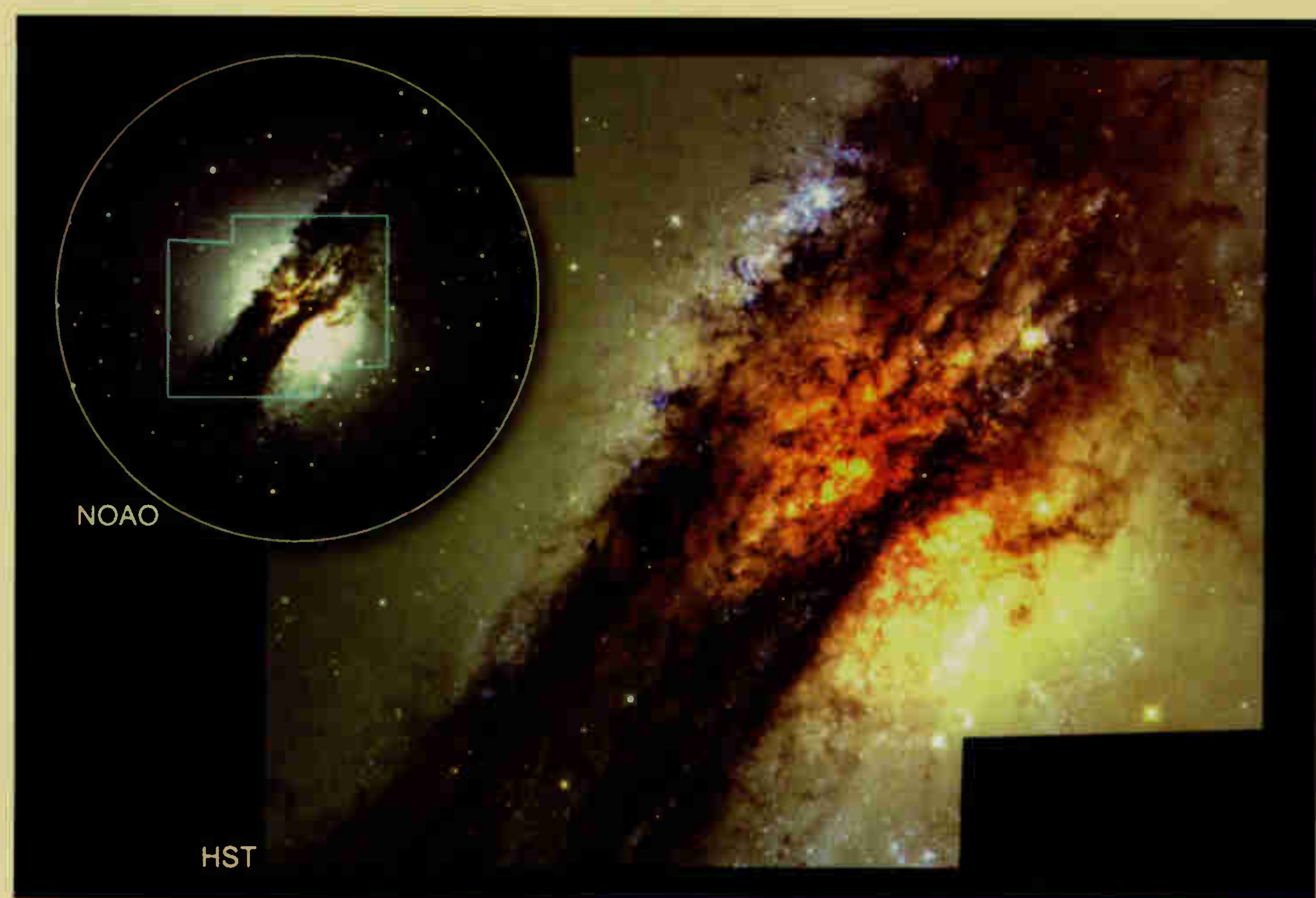
SPACE WATCH

By Larry Van Horn

Turbulent Cauldron of Starbirth in Nearby Active Galaxy

NASA's Hubble Space Telescope offers a stunning unprecedented close-up view of a turbulent firestorm of starbirth along a nearly edge-on dust disk girdling Centaurus A, the nearest active galaxy to Earth.

A ground-based telescopic view (upper left insert) shows that the dust lane girdles the entire elliptical galaxy. This lane has long been considered the dust remnant of a smaller spiral galaxy that merged with the large elliptical galaxy. The spiral galaxy deposited its gas and dust into the elliptical galaxy, and the shock of the collision compressed interstellar gas, precipitating a flurry of star formation. Resembling looming storm clouds, dark filaments of dust mixed with cold hydrogen gas are silhouetted against the incandescent yellow-orange glow from hot gas and stars behind it.

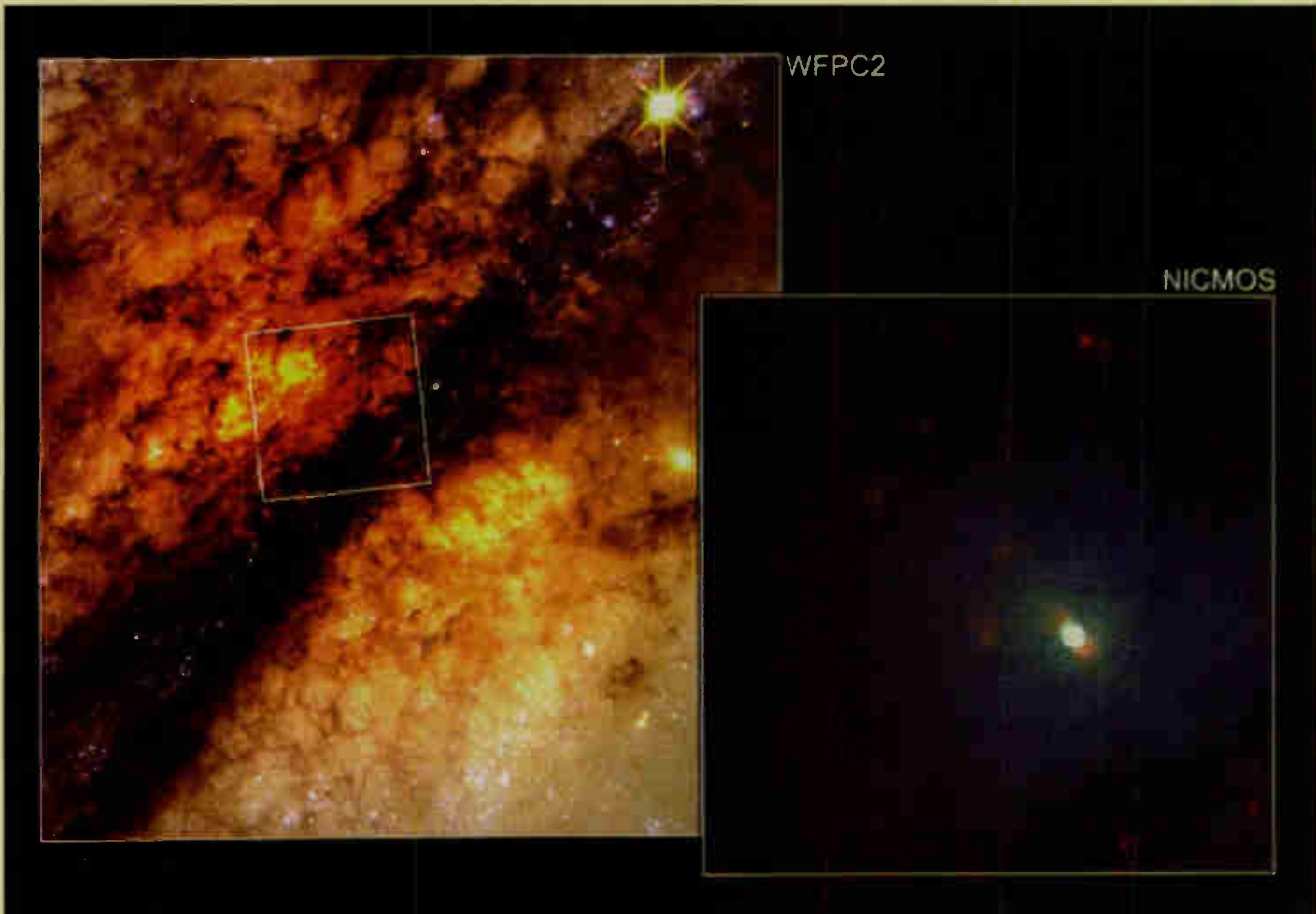


Ground-based image, upper left: NOAO HST image, lower right: E.J. Schreier, (STScI), and NASA STScI-PRC98-14 May 14, 1998

Brilliant clusters of young blue stars lie along the edge of the dark dust rift. Outside the rift the sky is filled with the soft hazy glow of the galaxy's much older resident population of red giant and red dwarf stars.

The dusty disk is tilted nearly edge-on, its inclination estimated to be only 10 or 20 degrees from our line-of-sight. The dust lane has not yet had enough time since the recent merger to settle down into a flat disk. At this oblique angle, bends and warps in the dust lane cause us to see a rippled "washboard" structure.

The picture is a mosaic of two Hubble Space Telescope images taken with the Wide Field Planetary Camera 2, on Aug. 1, 1997 and Jan. 10, 1998. The approximately natural color is assembled from images taken in blue, green and red light. Details as small as seven light-years across can be resolved. The blue color is due to the light from extremely hot, newborn stars. The reddish-yellow color is due in part to hot gas, in part to older stars in the elliptical galaxy and in part to scattering of blue light by dust–the same effect that produces brilliant orange sunsets on Earth.



Centaurus A: The Inside Story

A close-up high resolution Wide Field Planetary Camera 2 image **(shown upper left)** of the dramatic dust disk which is thought to be the remnant of a smaller spiral galaxy that merged with the large elliptical galaxy. The shock of the collision compressed interstellar gas, precipitating a flurry of star formation and giving the material a fleecy pattern. Dark filaments of dust mixed with cold hydrogen gas are silhouetted against the incandescent yellow-orange glow from stars behind it.

(Lower Right) Hubble's Near Infrared Camera and Multi-Object Spectrometer was used to peer past the dust to discover a tilted disk of hot gas at the galaxy's center (white bar running diagonally across image center). This 130 light-year diameter disk encircles a suspected black hole which may be one billion times the mass of our Sun. The disk feeds material to presumably an inner, unresolved accretion disk that is made up of gas entrapped by the black hole. The red blobs near the disk are glowing gas clouds which have been heated up and ionized by the powerful radiation from the active nucleus.

The false-color NICMOS image was taken on Aug. 11, 1997 at a wavelength of 1.87 microns ("Paschen alpha"), characteristic of ionized Hydrogen. ST

By Larry Van Horn

Safsaf Oasis, Egypt

These images show two views of a region of south-central Egypt, each taken by a different type of spaceborne sensor.

On the left is an optical image from the Landsat Thematic Mapper , and on the right is a radar image from the Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR).

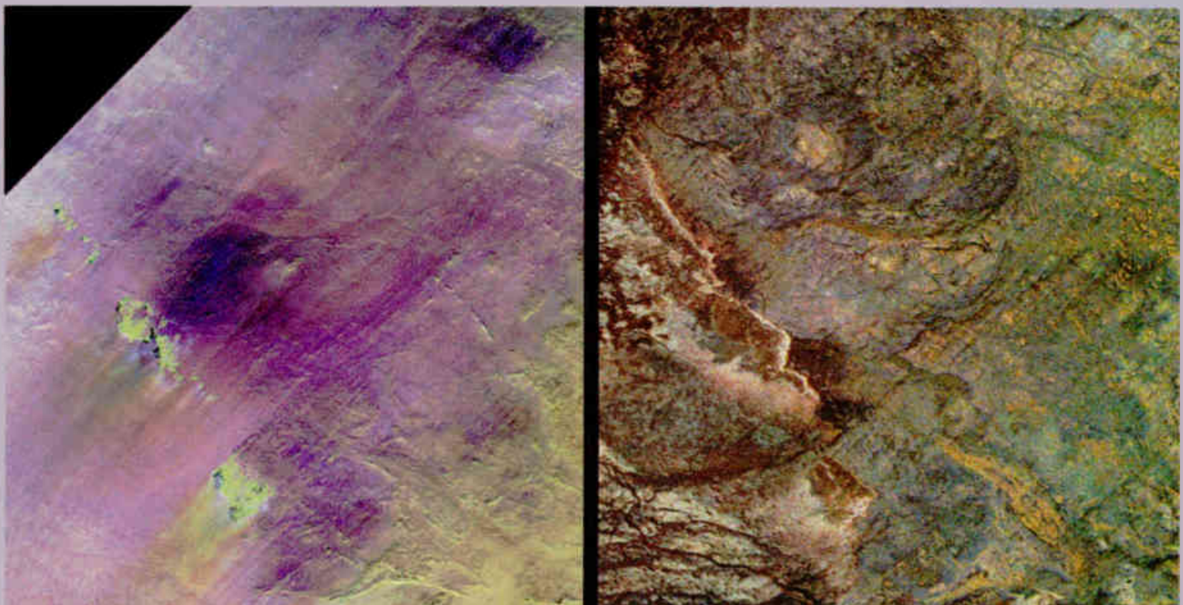
This comparison shows that the visible and infrared wavelengths of Landsat are only sensitive to the materials on the surface, while the radar wavelengths of SIR-C/X-SAR can penetrate the thin sand cover in this arid region to reveal details hidden below the surface. Field studies in this area indicate that the L-band radar can penetrate as much as 2 meters (6.5 feet) of very dry sand to image buried rock structures.

Ancient drainage channels, shown at the bottom of this image, are filled with sand more than 2 meters (6.5 feet) thick and therefore appear dark because the radar waves cannot penetrate them. Only the most recently active channels are visible in the Landsat scene. Some geologic structures at the surface are visible in both images. However, many buried features, such as rock fractures and the blue circular granite bodies in the upper center of the image on the right, are visible only to the radar.

The Safsaf Oasis is located near the bright yellow feature in the lower left center of the Landsat image. Scientists are using the penetrating capabilities of radar imaging in desert areas to study structural geology, mineral exploration, ancient climates, water resources and archaeology. Each image is 30.8 kilometers by 25.6 kilometers (19.1 miles by 15.9 miles) and is centered at 22.7 degrees north latitude, 29.3 degrees east longitude north is toward the upper right.

In the Landsat image, the colors are assigned as follows: red is Band 7 (mid-infrared); green is Band 4 (near infrared); and blue is Band 1 (visible blue light). The colors assigned to the radar frequencies and polarizations are as follows: red is L-band, horizontally transmitted and received; green is C-band, horizontally transmitted and received; and blue is X-band, vertically transmitted and received.

The radar image was acquired by the Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR) on April 16, 1994, on board the space shuttle *Endeavour*. SIR-C/X-SAR, a joint mission of the German, Italian and United States space agencies, is part of NASA's Earth Science Enterprise. The Landsat Program is managed jointly by NASA, the National Oceanic and Atmospheric Administration and the United States Geological Survey. ST



By Larry Van Horn

Monitoring the Russian Navsats

Perhaps the easiest Russian satellites for the newcomer to monitor are the VHF navigation spacecraft in the 150/400 MHz range.

These satellites are receivable on even the simplest of receivers. In my early days of monitoring satellites I had an old Bearcat Electra BC-210 programmable scanner using a plug-in whip antenna indoors on the dining room table and got fair results monitoring these interesting satellites.

Launched from the Russian cosmodrone in Plesetsk on a Tsyklon rocket these 800-kg satellites are placed into a 1020 by 965 km orbit inclined 82.9 degrees. Orbital periods average 104 minutes. Each spacecraft has a diameter of 2-meters, a height of approximately 2.1-meters.

Users of the system derive their navigation information from the Doppler-shifted VHF transmission on 150 MHz of satellite position and orbital data. By acquiring fixes from several satellites, a user's location can be calculated with an accuracy of 100-meters. The time needed to ascertain one's position is dependent upon the user's latitude and the number of operational satellites in orbit.

The 150 MHz downlink signal is sent at 50 bits/sec and sounds just like a frequency shift keyed or radioteletype transmission. There are three sidebands at 3, 5, and 7 kHz either side of the carrier. A "1" data bit is transmitted by a frequency shift from 3 to 5 kHz. The 7 kHz sideband produces timing.

There are currently two different VHF navigation satellite systems using ten spacecraft in use by the Russians. The older constellation (first launch in 1974 with Cosmos 700) consists of six satellites in orbital planes spaced 30 degrees apart. This system has never been publicly discussed and is dedicated to the support of Russian military forces. A virtually identical civilian navigation system, called Tsikada, began deployment in 1976 (Cosmos 883) and uses four orbital planes separated by 45 degrees. The Tsikada orbital planes are carefully offset from the military satellites to maximize the two systems' effectiveness. Only one satellite is active in each plane.

Nadezhda civilian navigation satellites carry COSPAS-SARSAT transponders with a 1544.50 MHz downlink. This system is used to discover and locate distress beacons from ships and aircraft. The 1544.5 MHz downlink should only be active when the satellite is receiving a distress beacon on 121.5, 243.0, or 406.0 MHz.

There are five frequency pairs used by these satellites: 149.910/399.760, 149.940/399.840, 149.970/399.920, 150.000/400.000, and 150.030/400.080. Two frequency sets have been used for plane 1 (149.97/399.92 MHz and 150.03/400.08 MHz). All other planes have fixed frequency assignments as indicated in Table One. Table one is the current status report of the Russian VHF navigation satellite network at presstime courtesy of John Corby and the internet Hearsat-L newsgroup.

So the next time you tune around 150 MHz on your scanner and you hear what sounds like a radioteletype signal, you can tell your radio friends that you have bagged your first Russian spacecraft from the cosmos. Until next month, good hunting.

ST

Table One: The Russian Navigation Satellite Constellation Status Report–compiled and verified by John David Corby

Cat No.	Satellite	Operating Frequencies	Status
Military Navigation Satellites			
Plane 1			
24953	Cosmos 2346	150.030, 400.080 MHz	Active
24304	Cosmos 2334	150.030, 400.080 MHz	Working standby
23773	Cosmos 2327	149.970, 399.920 MHz	Failed
22888	Cosmos 2266	149.970, 399.920 MHz	Working standby
22006	Cosmos 2195	149.970, 399.920 MHz	Off (status unknown)
Plane 2			
24772	Cosmos 2341	149.910, 399.760 MHz	Active
23526	Cosmos 2310	149.910, 399.760 MHz	Working standby
21937	Cosmos 2184	149.910, 399.760 MHz	Working standby
20577	Cosmos 2074	149.910, 399.760 MHz	Failed
Plane 3			
22207	Cosmos 2218	149.940, 399.840 MHz	Off
21666	Cosmos 2154	149.940, 399.840 MHz	Active
Plane 4			
24677	Cosmos 2336	149.970, 399.920 MHz	Active
22590	Cosmos 2239	149.970, 399.920 MHz	Off (status unknown)
21796	Cosmos 2173	149.970, 399.920 MHz	Off (status unknown)
Plane 5			
21230	Cosmos 2142	150.030, 400.080 MHz	Off
22487	Cosmos 2233	150.030, 400.080 MHz	Off (status unknown)
Plane 6			
23092	Cosmos 2279	149.940, 399.840 MHz	Off
21875	Cosmos 2180	149.940, 399.840 MHz	Off (status unknown)
19826	Cosmos 2004	149.940, 399.840 MHz	Off (status unknown)
Civilian Navigation Satellites			
Plane 11			
23603	Cosmos 2315	150.000, 400.000 MHz	Active
22307	Cosmos 2230	150.000, 400.000 MHz	Off (status unknown)
21902	Cosmos 2181	150.000, 400.000 MHz	Off (status unknown)
17066	Cosmos 1791	150.000, 400.000 MHz	Off (status unknown)
Plane 12			
21152	Nadezhda 3	150.00, 400.00, 1544.5 MHz	Active
Plane 13			
23463	Tsikada	150.000, 400.000 MHz	Active
21089	Cosmos 2123	150.000, 400.000 MHz	Failed
Plane 14			
23179	Nadezhda 4	150.000, 400.000, 1544.5 MHz	Active
20508	Nadezhda 2	150.000, 400.000, 1544.5 MHz	Failed

Note: Cosmos 2142 (plane 5) and Cosmos 2279 (plane 6) are not operating, which leaves these two orbital planes without an active satellite. Both these satellites have been non-operational before, and returned to operation without warning.

By Steve Dye, gpsyes@aol.com

GPS Applications in Aviation

This month's column looks at GPS applications in aviation. As mentioned in previous articles, GPS is emerging as aviation's benchmark navigation technology, and will one day find itself as an integral part of a space-borne primary navigation system. The benefits of GPS navigation over traditional methods are seen plainly even by the novice aviator–and I can include myself among them as I am a student pilot. I am of course learning navigation the traditional way, but it is quite apparent that even a handheld non-aviation GPS receiver serves nicely as an emergency back-up if nothing else, and also proves itself as a valuable aid to navigation.

The two main applications of GPS in civil aviation are essentially enroute and terminal navigation. GPS' first large scale aviation application was by a couple who flew their Cessna 310 around the globe using GPS as their primary navigation means. Of course, nothing like GPS and aviation ever work together unless regulations, advisories and red tape come into it, so the next few paragraphs discuss this in brief.

The responsibility for establishing the regulations and certifying GPS usage in civil airspace is shared by the International Civilian Aviation Organization (ICAO) and, naturally, the FAA: the former having the responsibility of regulating international air traffic, the latter regulating the US national air space system (NAS).

One more item of bureaucracy before we get to the real stuff: we all need standards, and aviation GPS certainly should be included. There are two advisory groups who deal with developing and recommending standards. These are the Radio Technical Commission of Aeronautics (RTCA). This agency develops minimum operational performance standards, which will in turn guide the FAA in adopting regulations. Secondly, Europe has its equivalent which performs the same function for the EEC (Let's hope we don't fall into the VHS/Betamax trap here! The beauty of standards is that there are so many to choose from.)

The major concerns with GPS being used in civil aviation are factors such as availability, accuracy and integrity. Imagine the nightmarish scenario wherein tens of en-route airliners are using GPS to navigate and a major space or ground segment outage occurs. Never, ever, take air traffic control (ATC) for granted–they would have their nightmare as well.

System availability and accuracy are not an issue for civilian users, but what about integrity? In terms of navigation, integrity is defined as the system's ability to provide users with a timely warning when the system should not be used. Internal problems within a space vehicle (GPS satellite) are monitored and a notification message is sent to users. Additionally, there are five ground-based monitoring stations worldwide whose function is to interpret the GPS navigation signal and determine errors, which are then corrected by an uplinked signal in the super high frequency (SHF) band.

Getting to the point: any fault that threatens integrity has to be detected and isolated. There are two main approaches to integrity monitoring–Receiver Autonomous Integrity Monitoring (RAIM) and GPS Integrity Broadcast (GIB).

RAIM, as the name suggests, allows the receiver to perform an unaided analysis of the signal's integrity. How? A common RAIM method is to isolate a defective satellite by using an over-determined position calculation. An over determined position is one that uses more than (the necessary) four satellites to arrive at the solution. So, if, for example, six satellites were used, a host of four satellite combinations are available, and the process of elimination will allow the receiver to determine the defective satellite(s).

GIB consists of ground based monitoring systems that utilize another satellite system to broadcast warnings. GIB is based upon continuous monitoring of the navigation signal from a precisely surveyed location, and notifying users of the range errors. The receiver then selects a different satellite combination which will promote the user with integral service.

Designed for Aviation

FIGURE 1

Let's dive right into some practical GPS receivers for aviation, and look at the displays. Figure 1 shows a portable GPS reviver manufactured by Apollo. The display in this case shows the airplane in the center and a number of airports surrounding it. The airports are identified by their standard 3-character identifier.

The display also indicates the ground speed seen as 168 knots, the distance to the selected airport or waypoint is 29 miles, and the bearing of 186 deg. This GPS receiver, like so many others, will draw information from an internal database that requires constant updating. The database carries a wealth of information such as airport locations, their location facilities, airspace classifications and more.

I like the idea of moving map displays, myself, and more complex receivers include sectional information on the display, so you know where you are, what class of airspace you are in, and where the nearest runway is, just in case you need to get down quickly. How many cases have there been of pilots being blown out to sea, or flying into terrain or the occasional weather balloon due to poor visibility or not knowing where they are? A moving map helps in positioning and alerts the pilot to all kinds of hazards..

Figure 2 shows a palmtop computer loaded with software that interacts with a GPS receiver connected externally. I really like this. I know most cockpits are cramped, and the designers had this in mind. The GPS receiver can be placed elsewhere; with a cable running from the GPS to the palmtop, you could put it on top of your instrument panel, then flip the lid closed when you need to.

Notice the circles on the display. These

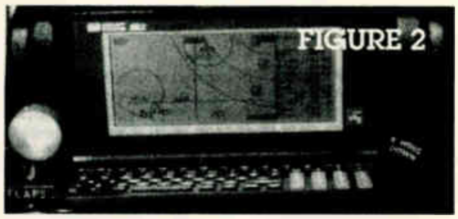


FIGURE 2

represent controlled airspace. In aviation, there are a number of airspace classifications that are used to separate air traffic–controlled and uncontrolled, visual or instrument flight, and so on. Military airbases are also controlled airspace, and like other airspace classifications, require ATC permission.

Air spaces are also used to separate inbound traffic from other traffic crossing the area. The traffic crossing the area needs to ask ATC if it may come through (possibly to avoid a large route deviation). One way of knowing where you are is to use what we refer to as a sectional. The sectional is like a road map for the airways, and indicates all airspaces' boundaries. A GPS receiver makes it so much easier–the display shows you exactly where you are, are you in the air space, are you approaching it? Call the ATC and let them know exactly where you are.

One very good example of GPS usage was back in March when I flew cross-country from Fort Lauderdale to Key West. In the Keys, there's a big observational balloon, held in place by a steel cable. This cable also acts as an extremely effective "airplane wing removing device" should you happen to meet it–which is definitely not advised. The GPS receiver (we were using a Garmin 95) indicated this hazard on the display, and we were able to fly our route, happy that were well away from danger.

Take a look at figure 3. This is the display from a moving map portable. The airplane is flying towards San Angelo airport (SJT), it still has 62 miles to go and is on a course of 359 degrees. Notice the other airports on the display–useful to know if you need to land for whatever reason, or they act as good landmarks to satisfy yourself you are on course for your destination.

Figure 4 shows the display as we get closer to the airport. We are still on a heading of 359, but are 10.4 miles away. Figure 5 takes us closer; we are now five miles out, and are beginning to see the runway configuration. Finally, figure 6 shows us half a mile from the airport, and a full view of the runway configuration. Happy landings.

Figure 7 shows the display from another GPS receiver that uses a database of airport information.

Of great importance to pilots is all pertinent information regarding an airport. How long is the runway? Do you do left or right turns in the traffic pattern? What runways are there? Are they lit, hard surfaced? All this information is available from an Airport Facility Directory printed by the Department of Commerce; it is by no means a pleasure to read while you are planning a flight or while you are in it. Figure 7 gives us some very good information here: this airport has two runways, 15 and 33 (meaning they face 150 and 330 degrees); they are hard surfaced, lit, and are 5300 feet in length. This is perfect for an inbound pilot; another page will show ATC or common traffic contact frequencies for that airport.

In the near future, I hope to write more on GPS and its aviation applications. For those interested in reading more, I would like to recommend the excellent book *GPS Aviation Applications* by Bill Clarke (McGraw-Hill).

That's all for this month; have to fly

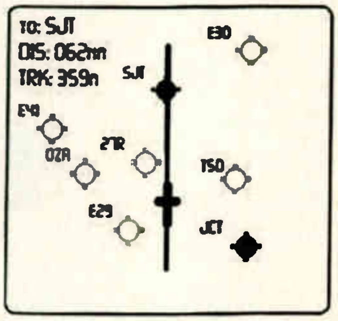


FIGURE 3

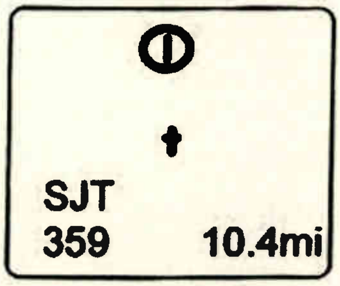


FIGURE 4

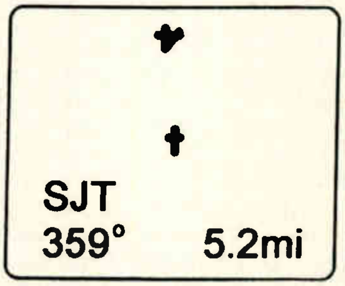


FIGURE 5

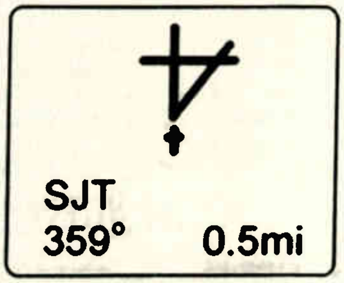


FIGURE 6

FIGURE 7

ST COMPUTERS & SATELLITES

Dr. T.S. Kelso

More on Geostationary Orbits

In our last column, we discussed the basics of the geostationary orbit, describing the unique characteristics which make this particular orbit so valuable. In this issue, I would like to cover some operational considerations which can be important when working with satellites in these orbits. In particular, I would like to discuss how to determine the location of a geostationary satellite—relative to the earth's surface and any observer on its surface—and how the sun's position can affect onboard power management and communications.

Locating Geostationary Satellites

Ease of tracking—or, rather the lack of tracking—is one of the primary characteristics of the geostationary orbit which make it so valuable. An observer on the ground can simply point an antenna toward a fixed point in space and then forget it—no tracking is required. However, before the antenna can be pointed, the observer must first determine where the satellite is located.

As we saw in our series on orbital coordinate systems (in the September/October 1995, November/December 1995, and January/February 1996 issues of *Satellite Times*), the first step to determining the location of a satellite relative to an observer is to determine both the satellite and observer's position in the same coordinate system. For this development, we are going to use the *Earth-Centered Fixed (ECF)* coordinate system—latitude, longitude, and radius (or altitude)—as our common coordinate system.

As it turns out, one of the common ways of expressing a geostationary satellite's position is to specify its longitude—that is, the longitude on the equator over which the satellite appears to hover. This information can be obtained from various sources including the *Geostationary Satellite Locator Guide* found in every issue of *Satellite Times*. This guide is generated using the latest two-line element sets and determines each satellite's longitude at its ascending node.

For the satellite to be geostationary, of course, its latitude must be zero and its altitude must be 35,786 kilometers (for this development, we will assume a true geostationary orbit and a spherical earth). Knowing the longitude of the satellite and the latitude and longitude of the observer, we can now determine where to look.

If R is the radius of the earth, r is the geostationary altitude, λ is the satellite's longitude, θ is the observer's longitude, and ϕ is the observer's latitude, then the satellite and observer's ECF positions are:

Satellite	*Observer*
$S_x = (R+r)\cos\lambda$	$O_x = r\cos\phi\cos\theta$
$S_y = (R+r)\sin\lambda$	$O_y = r\cos\phi\sin\theta$
$S_z = 0$	$O_z = r\sin\phi$

and the range vector is the satellite's position minus the observer's position:

Range

$$_x = (R+r)\cos\lambda\_ - r\cos\phi\cos\theta$$
$$_y = (R+r)\sin\lambda\_ - r\cos\phi\sin\theta$$
$$_z = -r\sin\phi$$

To calculate azimuth and elevation, we use the same coordinate transformation described in *Orbital Coordinate Systems, Part II* in the November/December 1995 issue of *Satellite Times.* As an example, let's calculate the position of Galaxy 4 from Pasadena, California.

Constants	*Satellite*	*Observer*
$R = 6{,}378$ km	$\lambda = 99.0°$ W	$\phi = 34.15°$ N
$r = 35{,}786$ km		$\theta = 118.15°$ W

Using these values yields an azimuth to the satellite of 148.25°, an elevation of 45.32°, and a range of 37,390 km—values pretty close to the true values.

While this approach can be used to produce good estimates, these are probably not calculations you would want to do by hand (although they can be done fairly easily using a spreadsheet). Plus, if you do not know the satellite's longitude, you will need to start from the satellite's orbital elements, further complicating the process. Of course, you can use a program like *TrakStar* to calculate the latitude, longitude, and altitude or the look angles (azimuth, elevation, and range) of any satellite (geostationary or otherwise) for any time interval desired using two-line element sets found on the *CelesTrak* WWW site.

Power Management Issues

Geostationary orbits present some interesting challenges for power management. To understand these challenges, we must first understand a little about the attitude (orientation in space) of geostationary satellites and the position of the geostationary orbit relative to the sun.

All modern geostationary spacecraft use one of two forms of stabilization to maintain their attitude: dual-spin or three-axis stabilization (see Figure 1). With dual-spin stabilization, the satellite takes the shape of a cylinder which rotates about its long axis. This type of satellite has two sections: a spinning section upon which the solar arrays are mounted and a despun section where the communications antennas are mounted. The spinning section provides basic stabilization and can rotate as fast as 100 RPM (in the case of the early GOES satellites). The despun section rotates, too, albeit at a much slower rate of one rotation per orbit (day)—keeping the antennas pointed at the earth and preventing the satellite from going into a flat spin (which is the natural tendency).

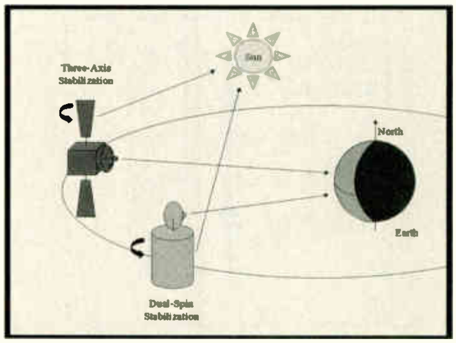


FIGURE 1. ***Geostationary Spacecraft Attitude Types***

With three-axis stabilization, the spacecraft attitude is maintained through the use of momentum wheels or control moment gyros. The body of the spacecraft does rotate once per orbit (day) to keep the antennas pointed at the earth. The solar arrays are mounted on paddles which also rotate once per day to keep them pointed toward the sun.

In both cases, it should be noted that the rotation axis of the satellite is perpendicular to the satellite's orbital plane—which for geostationary orbits is the equatorial plane. We will see why this is important shortly.

As with all satellites, the solar arrays on geostationary satellites are subject to a number factors which can result in significant fluctuations in the amount of power available to onboard systems. To begin with, the position of the satellite relative to the sun varies throughout the year. As the earth goes around its orbit, its distance from the sun changes from a minimum of 0.983 astronomical units (AU's—the mean distance from the earth to the sun is approximately 1 AU or 149,597,870 km) to a maximum of 1.067 AU—a difference of 12,518,000 km. If we consider the energy received from the sun at 1 AU to be 100%, then the energy received varies from 97% to 103%, as shown in Figure 2.

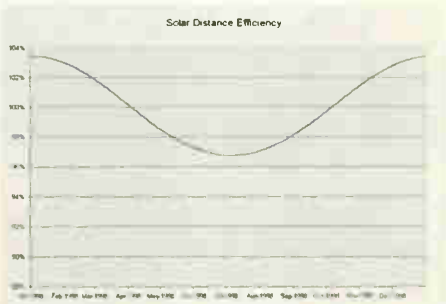


FIGURE 2. ***Solar Distance Efficiency***

Not only isn't the earth's orbit truly circular, but the plane of the earth's equator does not lie in the plane of the earth's orbit (the ecliptic). Earth's seasons are a direct result of this circumstance. From our vantage on earth, it appears that the sun slowly moves from 23° below the equatorial plane (at the winter solstice) to 23° above the equatorial plane (at the summer solstice) and back again over the course of a year. As seen in Figure 3, our geostationary satellite sees the same thing.

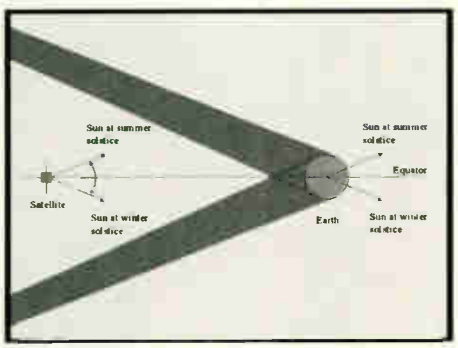


FIGURE 3. ***Sun-Earth-Satellite Geometry***

The apparent motion of the sun above and below the equatorial plane has two effects. First, it changes the angle of incidence of solar energy received on the solar arrays since they must rotate about an axis perpendicular to the equatorial plane. As a result, the amount of solar energy absorbed by the solar arrays drops off as a factor of cos(∂), where ∂ is the sun's declination (angle relative to the equatorial plane). If we consider the amount of energy received when the sun's rays are perpendicular

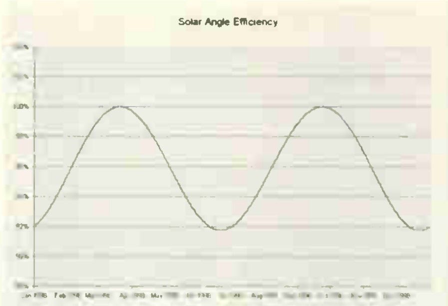


FIGURE 4. ***Solar Angle Efficiency***

to the solar arrays to be 100%, then the energy received drops to less than 92% at the solstices, as shown in Figure 4.

From Figure 3 we can also see that because of this sun-earth geometry, the geostationary orbit is usually outside the cone of the earth's shadow. That is, until around the times of the vernal and autumnal equinoxes (the beginning of spring and fall). At these times, geostationary satellites enter their eclipse season, when they can spend as much as 70 minutes of every day in shadow. These seasons run from the end of February through the middle of March and the beginning of September through the middle of October. The percentage of sunlight received for geostationary satellites is shown in Figure 5. To prepare for eclipse seasons, the satellite operators must ensure that the spacecraft batteries are properly conditioned to pick up the load during each day's eclipse.

FIGURE 5. ***Eclipse Efficiency***

If we combine the effects of variations in solar distance, solar angle, and eclipses over the course of a year, we get the result in Figure 6. As can be seen in this figure, total solar energy available varies 12%–from a low of 89% to a high of 101%.

If we also factor in the effects of degradation on the solar cells and their optical coverings due to the space environment and look at a nominal seven-year satellite lifetime, we get the graph in Figure 7. Typical results show the optical covering degrades about 7% the first year before stabilizing, while the solar cells degrade about 3% their first year and 2% each subsequent year. As can be seen from the graph, the power levels drop from a high of 99% overall efficiency to a low of 72%. When designing the spacecraft power subsystem, that

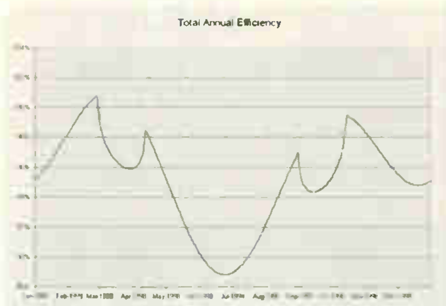


FIGURE 6. ***Total Annual Efficiency***

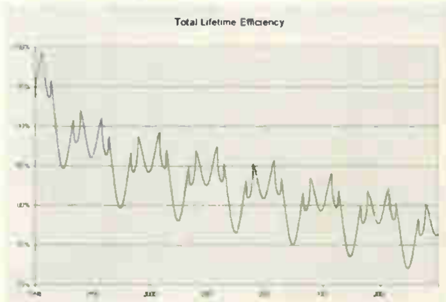


FIGURE 7.

means if 7.5 kW of power are required for normal operations, the power subsystem must be designed to provide almost 10kW initially so that available power doesn't drop below the threshold before the end of the planned satellite lifetime.

Solar Interference

In addition to planning for variations in spacecraft power, satellite operators and users also need to plan for communications outages (or degradation) around the eclipse seasons. As the sun sweeps across the sky each day and gradually moves north or south with the seasons, there will come a time twice each year when the sun is directly behind a geostationary satellite as seen from a ground-based antenna. When this happens, the flood of solar radio energy into the antenna's main lobe can severely disrupt communications. Fortunately, such disruptions only last a couple of minutes. You may have actually seen one of these outages while watching your favorite cable channel (most of which are transmitted via geostationary satellites). For observers in the Northern Hemisphere, this happens prior to vernal equinox and after the autumnal equinox.

We covered a lot of ground in this article—orbital mechanics, spacecraft attitude, power management, and even materials—all factors important in the design and operation of any satellite, but particularly important for geostationary satellites. I hope I've shown how these various areas interact and overlap and, in the process, shed some light on the topic of spacecraft design. As always, if you have any questions, please feel free to write me at **tskelso@celestrak.com**. Until next time, keep looking up!

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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.

OIRECT BROAOCAST SATELLITE (OBS): 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.

OOWNLINK: 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.

GROUNO 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.

OSCAR: Orbiting Satellite Carrying Amateur Radio.

PERIOO OECAY 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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All Our Eggs in One Basket

When my local public broadcasting station announced the loss of their satellite feed May 19, it seemed rather benign–they starting playing more classical music instead of the perfunctory sound bites that I had learned to tolerantly ignore ("And now noted harpist Jeff Ingraham will tell us why zithers have anywhere from 29 to 42 strings...").

But as the hours–and days–progressed, it became obvious that more than a few sound bites had been lost. Commercial TV and radio sports, news, and entertainment networks like CBS and CNN Airport network lost their feeds. Disney, World Harvest, NASCAR racing, international and ethnic broadcasters, Paramount, NPR, PBS, AP went dark. In-store audio like Muzak and dozens more fell strangely silent. And it didn't stop there.

Major paging companies and digital service providers across the continent abruptly stopped service, with outages affecting PageNet, Wal-Mart, Accuweather, Reuters, Skylink, SkyTel, UPI, ATM machines, and even fast-pay gas station pumps. It was estimated that upwards of 90 percent of the nation's pager owners–some 40 million Americans–lost touch with their worlds; including doctors, law enforcement officers, emergency personnel, and other professionals whose calls save lives, or whose businesses depend upon instant contact.

But the list goes on. Airline safety may have been compromised by the loss of the Federal Aviation Administration (FAA) National Weather Service flight weather information, and several major metropolitan public safety agencies lost their extended communications links.

Was this just a fluke? The satellite's owner-operator, Hughes Space and Communications Company, has dozens of HS601 payloads in orbit; are those other platforms vulnerable to the same catastrophic failure that crashed the heavily-utilized and ill-fated Galaxy IV at 99 degrees west? After all, these Hughes platforms carry everything from DirectTV to Department of Defense communications satellites (10 of these alone).

Over a year ago, we pointed out in our March-April issue the exposure the communications industry had in space (Ironically, a Hughes Galaxy satellite was the model we used in our story!). In that feature, we pointed out the hazards posed by the upcoming Leonid meteor swarm, and many observers say the November 1998 event may be the bombardment of the century!

So what does this portend to the communications industry? Have we succumbed to the siren song of the high-tech aerospace industry, investing with blind faith in a new technology with a fatal flaw? Are we depending too much on the thrill of the ride and the willingness of investors? Have the windfall profits of the Gateses, Turners, and McCaws blinded us to the realities of speculation?

Perhaps we are too critical; there are hazards associated with virtually all investments, especially those with such sophisticated interdependencies. After all, there has been only one *Challenger* disaster (along with quite a few near misses, plus ground casualties), and only one satellite failure of the magnitude of the Galaxy loss (acknowledging the demise of Telstar 401 and both the Anik-E satellite rollovers). Such imperfections must be expected–if only we knew when and where.

The lesson to be learned here is the importance of redundancy, fall-back systems which continue the viability of the system when the primary carrier fails. Let's not abandon tried-and-true terrestrial communications. Remember the dependability and maturity of high frequency (HF) links as demonstrated by Desert Storm and NASA's space program; the daily regimen of VHF/UHF backbone links as well as multiplexed microwave; the millions of miles of wired systems in place and working satisfactorily worldwide. And don't pull your telephone out of the wall just yet.

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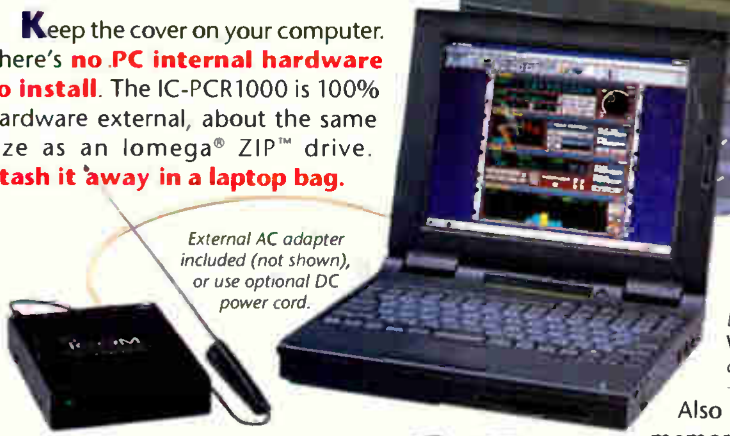

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