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Bracing for the Leonid FIRESTORM

Satellite Times

Cover Story

Cover Photo: *An artist's rendition of the Hughes Galaxy 5 satellite in geostationary orbit being bombarded by the Leonid meteor shower sometime in the next four years. For effect, the meteors have been exaggerated in size. (Digital photo composite by John Bailey)*

Bracing for the Leonid Firestorm

By Kirk A. Kleinschmidt, NT0Z

Will the November Leonid meteor shower wreak destruction throughout the Clarke belt, shattering $200,000,000 satellites with impunity? Sometime during the next four years—prompted by comet Tempel-Tuttle's return—the November shower could become a raging storm, the likes of which no orbiting structure has ever encountered. *Story begins on page 10.*

Vol. 3, No. 4

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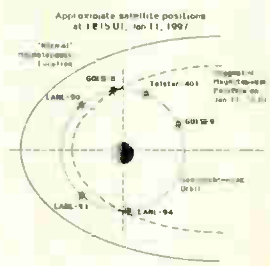
March/April 1997

Dearly Departed ...

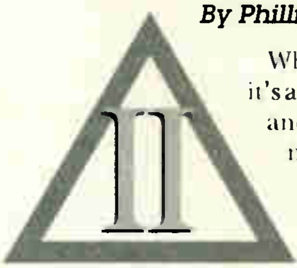
By Phillip Chien

On Saturday, January 11, at 6:15 a.m. Eastern time, the Telstar 401 satellite ceased to exist. Without any advance warning all the transponders suddenly went black—along with all of the telemetry signals. Millions of viewers who were watching ABC, PBS, UPN, FOX, and other 401 customers lost their signals. What happened? See the story starting on page. 19.

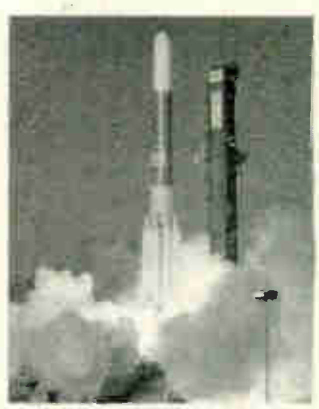


Ups and Downs of the Delta II Rocket

By Phillip Chien



When a rocket explodes above the launch pad, it's a spectacular event—visible for miles around, and audible for over 40 miles. It's also national news. See the complete story starting on page 22.



"Twister," the Intersteller Sequel ...

Twisters are no longer an exclusive phenomena of Earth. Hubble has discovered eerie funnels and twisted-rope structures in the heart of the Lagoon Nebula. See the amazing photos in *Space Watch* on page 86.

DEPARTMENTS

ST

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DOWNLINK

By Larry Van Horn
Managing Editor
steditor@grove.net

ST *Readers Speak Out*

NPR Article a Hit, and Now the Rest of the Story

Dear Larry,

Excellent article (*This is NPR from Space-Jan/Feb 97 ST*)! Really got my blood boiling! How dare outfits like NPR suck up our hard-earned tax dollars and then have the gall to scramble the signal! But there's more...

Turns out I was a big SCPC fan, primarily to pick up Penn State football and basketball broadcasts. These broadcasts were handled by Paxson Sports (see their website, www.paxson.com). Suddenly, at the start of this year's football season, there was silence where previously there was a broadcast. I called the broadcaster, who said these broadcasts were now digital...

Recently I got in touch with Paxson, who told me that I would need to spend almost $2,000 for a ComStream ABR200 receiver and $450 for a PLL LNB (I've got a LNB. Why do I need a PLL LNB?). I was told to contact a Mark Johnson at NPR.

I asked the Paxson rep if the NPR referred to National Public Radio. Sure does. Turns out Paxson's using the same technology as NPR... Based on this, it seems to me that SCPC is a dead duck. Of course, eventually the price for the digital receivers might decrease to the point that ordinary home listeners can afford them, but by that time the broadcasters (and I use that term with some reservation) will probably have found some newfangled technology that is incompatible with the existing digital receiver (or the broadcasts will be scrambled).

In the meantime, Paxson suggested I use the Internet RealAudio technology to receive the Penn State broadcasts. Unfortunately, the RealAudio technology is not (in my opinion) adequate for long-term listening. How many radios (or satellite receivers, for that matter) have ever bumped you off your server?

Please keep pursuing this issue! I am ticked off at Paxson, but really can do nothing about it:the signal is "theirs" (certainly not for me the listener to receive). But what NPR is doing should not be allowed. If my tax dollars pay for the signal, I ought to receive it. Larry Pressler must have had incredible wisdom to mandate PBS-X; too bad the NPR side of the house couldn't have been taken care of as well:then I might not be in the predicament I'm in!

Great magazine, great article.

—A. J. McKown,
84Lion@worldnet.att.net

Satellite Home Viewers Act

Dear Larry,

You hit it right on the head with your editorial about the Satellite Home Viewers Act! (*Satellite Times* Nov/Dec 1996) What is being overlooked about the thng is that a freedom of choice is being denied TV viewers. First of all I almost never watch the crummy network programs, but if I do it is usually on our local translators which come in fairly well relaying Honolulu over 200 miles away over 13,000 foot mountains. But, it's OK and we watch them mostly for local news and a *rare* work show. Since they are broacast locally at a convenient time for us it is better than watching PT-24 for network programming. but—and this is the biggie—we watch PT-24 stations for good reasons, as follows:

We have family in California and used to live there, we love to watch KPIX for Bay Area news and information. Heck, I have a card dated Februrary 17, 1949, which states I am a charter member of the KPIX Television Pioneer Club.

Our son lives in North Carolina and watches WRAL at home, so we like to see what's happening there. My wife's father lives in Seattle and so we use KOMO as a source of information for his area. *We do not watch network programs on any of those PT-24 stations!* Both KPIX and KNBC carried great infornation on the recent flooding in California which was *not* on the networks!

Now I am hearing that Hawaiian TV stations may be challenging our right to watch distant stations (network ones). Just who do those %$#@s think they are? Who does Congress think *they* are to pass such a stupid and restricting law which is probably unconstitutional?

Suppose I lived somewhere in Connecticut (or anywhere for that matter) and wanted to receive WNBC in New York. I might have a local NBC affiliate but I still want to see WNBC. So, I go down to my friendly Radio Shack and buy a super duper TV antenna. I put it up and, "voila," there is WNBC coming in quite well. So, does this mean that my local NBC affiliate will come marching to my door with police and guns and demand I take down the antenna? They had better bring *lots* of help!

This, in effect, is what the Satellite Home Viewers Act is doing! How did these people get this kind of power? Talk about a violation of rights!

Sincerely with Aloha,
—Charles (Chuck) Boehnke
cb@ilhawaii.net

Many thanks to those who called, e-mailed and faxed us about our new look. We appreciate your kind words! If you want to write the Downlink column (Letters to the Editor), send it to ST Downlink, P.O. Box 98, Brasstown, NC 28902, or via e-mail to: ***steditor@grove.net***

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

Space industry braces for fiery Leonid meteor storm of 1999

The movie "Asteroid" shows rocks from space crashing into the Earth with fiery explosions that reduce man-made structures to rubble. Of course it is fiction. But is it prophetic?

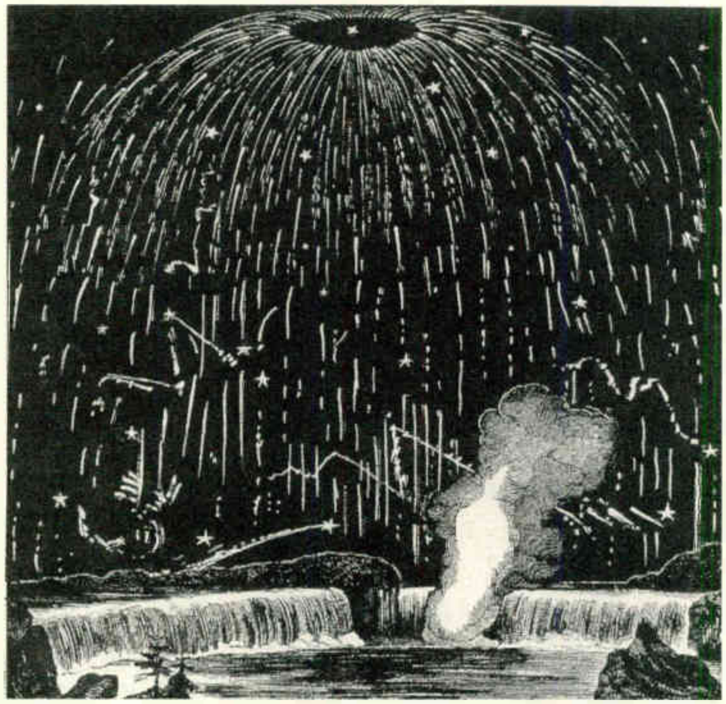
Right now, somewhere on the outskirts of our solar system, a cloud of Leonid meteoroids is streaking toward a point in space through which Earth will pass on or about Nov. 18, 1999 (see cover story in this issue). The cycle repeats every 33 years. On more than one occasion, the Earth has plowed through the cloud head-on. But this time, unlike in previous encounters, people and hundreds of spacecraft in orbit may be in danger.

On November 12, 1833, earthlings awakened to a firestorm of shooting stars and to the glare of fireballs shining through their bedroom windows. The barrage lasted for three hours. Historian R.M. Devens wrote that there were impromptu meetings for prayer and displays of religious devotion and abandonment of worldly affairs in preparation for judgment at dawn.

The last Leonid meteor storm struck on November 17, 1966. "We saw a rain of meteors turn into a hail of meteors and finally a storm of meteors too numerous to count," said witnesses in the American West and Southwest. At the New Mexico State University Observatory, scientists estimated a million meteors per hour.

And now sky watchers are cautiously predicting that we may get another intense storm in mid-November 1999, as published on Sky Online's Meteor Page: **http://www.skypub.com/meteors/**. It should be noted, however, that, while the Leonids can produce a storm every 33 or 34 years, they did not do so in 1899 and 1932. So a storm in 1999 is not a certainty. But at least one publication, *Space News*, reported in a copyrighted story that satellite owners and operators of the international space station are bracing for "the heaviest meteor storm since the dawn of the space age."

Previous storms were more of a light show than a threat. Few satellites were in orbit during the last Leonid storm in 1966. But in the 1999 storm, if it happens, hundreds of spacecraft and the people who inhabit them will literally fly through a cloud of rock shrapnel. The shuttle and its astronauts may be in orbit. Mir will be inhabited by cosmonauts. And the international space station will be under construction.



A woodcut illustrating the 1833 Leonid meteor storm. (Courtesy Sky & Telescope)

NASA is expecting a "10,000-fold increase" in the number of high-speed particles streaking toward its spacecraft, *Space News* reports. Satellite owners and insurance companies are worried about the risks. Although smaller particles will burn to ash in the Earth's atmosphere, larger meteors can reach orbital slots at speeds of 70 kilometers a second. At that speed even a pebble could devastate spacecraft and human flesh.

Scientists remind us that meteor forecasting, like weather forecasting, is not an exact science. But it is improving. And meteorologists will be gathering data over the next few years to say with increasing probability whether the storm will hit us head-on — illuminating the sky with fire— or slip quietly past us unseen. So far the signs point to a direct hit. *Sky & Telescope* writer Joe Rao warns: "We just might be in for the show of a lifetime."

Was Telstar 401 zapped by a magnetic cloud?

AT&T's Telstar 401 satellite, in the prime of its orbital life, while broadcasting television programs to the United States and Puerto Rico, unexpectedly and suddenly went silent at 6:15 a.m. Eastern Standard Time on January 11. Some of the satellite's services were switched to other satellites. Others remained out of service as ground crews worked to re-establish contact with the satellite orbiting at 97 degrees East.

Meanwhile, scientists in the International Solar Terrestrial Physics (ISTP) Program were tracking a magnetic disturbance in solar winds. Instruments aboard the science spacecraft SOHO recorded abrupt changes in solar wind parameters just hours before the failure of Telstar 401. Wind speed and density jumped suddenly at 0010 UTC, and again at 0430. Minutes later, instruments aboard another research vessel, WIND, located closer to Earth, recorded similar effects. The two spacecraft tracked the event through the magnetosphere, through the ionosphere, and to the Earth which responded with a vivid display of polar auroral activity.

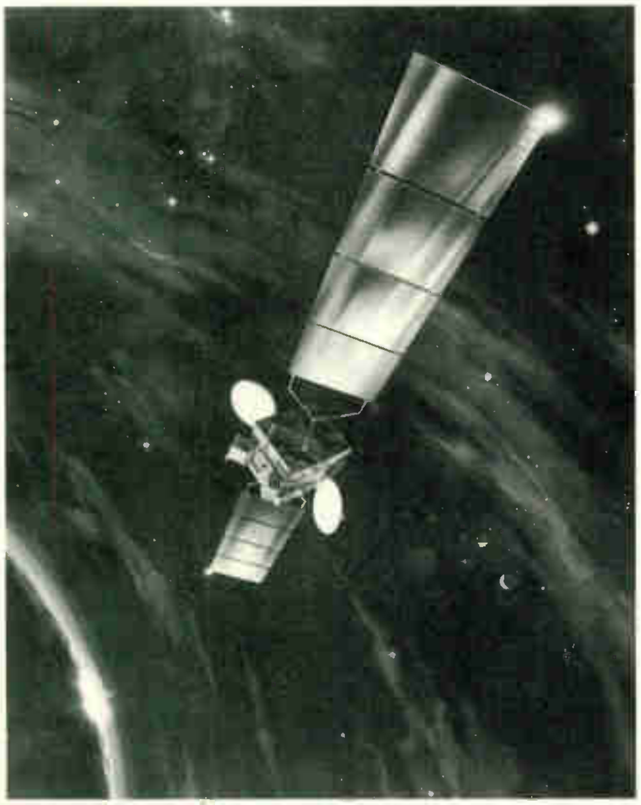
Scientists agreed the anomaly was probably a magnetic cloud — a transient in solar wind capable of generating strong fluctuations in magnetic fields. Such events are common in space. They are generated by the Sun, and can affect the Earth's magnetosphere, ionosphere, and thermosphere.

The magnetic disturbance coincided with Telstar's failure. "Preliminary evidence suggests increased levels in the radiation environment, possibly a connection to the malfunction of the satellite," the ISTP stated on its Internet site: http://www-istp.gsfc.nasa.gov/. One theory is that magnetic fluctuations shorted Telstar's electronic circuits.

The satellite's loss came just days before it was to be sold to Loral Space & Communications Ltd. Loral had agreed last September to buy AT&T's Skynet Satellite Services for $712.5 million. Telstar 401 was a part of that package. The sale was to be completed early this year. Both companies declined to speculate on what effect the loss will have on the transaction.

There are two other satellites in the Skynet fleet, Telstar 302 and Telstar 303. Both are aging. Telstar 302 was no longer in use. Telstar 303 was being used on a limited basis.

AT&T won't say to what extent Telstar 401 was insured. It would cost about $200 million to replace it. There are plans to launch Telstar 5 this summer.



The fate of Telstar 401 is considered in depth in this issue of ST. See feature story beginning on p. 19.

The eye of an eagle... and then some

Talk about keen vision. Just a few years ago we marveled over eagles being able to spot a rabbit a mile away. Then we squirmed at the idea of satellites photographing our back yards from orbit thousands of miles above the earth. And now we're told that the Hubble Space Telescope has found a star only 12 miles wide (about 20 kilometres) 3,000 light-years away in our southern sky. And not only that, but the star, scientists say, is 100 million times dimmer than the faintest star ever seen by the unaided human eye.

This tiny star turns out to be the most efficient generator of gamma-rays ever found in the Universe. Scientists hope to find out why. They call it Pulsar 1055-52.

Pulsar (we're on a first-name basis) is actually a neutron star. At one time it probably had a mass greater than our Sun — until it collapsed in a supernova explosion. Its great mass was squeezed into a ball no wider than a city. And its gravity and magnetic fields were condensed to become billions of times stronger than those of Earth.

A neutron star revolves rapidly, which causes it to wink like a cosmic lighthouse as it swivels its magnetic poles to and from the Earth. Pulsar spins at five revolutions per second. It is very hot—about a million degrees Celsius—but very little of its heat is radiated as light, which is one reason why the tiny star appears so dim to ordinary telescopes. It radiates mostly gamma rays, an extremely energetic form of radiation which scientists will study in an attempt to unlock Pulsar's secrets. It generates gamma rays by accelerating electrons through billions of volts of electricity. This makes Pulsar a gamma machine of unusually high power. One possible reason for the intensity of Pulsar's gamma rays as viewed from our perspective may be the orientation of the star's magnetic field with respect to that of the Earth.

Actually, the science community knew that Pulsar 1055-52 was out there all along, from the radio pulsations it transmitted. It's just that they had not visually located it. Roberto Mignani, Patrizia Caraveo, and Giovanni Bignami, all of the Instituto di Fisica Cosmica, in Milan, Italy, have been trying since 1988 to spot the star with two of the most powerful ground-based telescopes in the Southern Hemisphere. But another star kept blocking their view. This was an ordinary star 100,000 times brighter than Pulsar and about a thousandth of a degree off the line of sight. To get a better view, the astronomers needed an instrument in space. They found it in Hubble's Faint Object Camera, which located Pulsar radiating ultraviolet light at 3,400 angstroms, just outside the visible spectrum.

But the visible glare of the bigger star was still a problem. The solution? You photographers out there probably have guessed it: an ultraviolet filter. The filter passed Pulsar's emissions and blocked the visible emission of the problem star.

Now that they've found it, what's next? More work. More study. Pulsar is a relatively rare find. The radio transmissions of nearly 800 neutron stars have been detected; only eight have been found. Since the first pulsar was detected by radio astronomers 30 years ago in Cambridge, England, theorists have come to recognize neutron stars as veritable laboratories in which nature reveals the behavior of matter under extreme stress—just one step short of a black hole.

Supernova blast revealed by Hubble

On January 14, Goddard Space Flight Center confirmed the sighting of a supernova explosion that occurred a decade ago but just recently came within range of NASA's Hubble Space Telescope. Astronomers have been waiting for the ballooning fireball to become large enough to be resolved by Hubble, which has revealed a one-tenth light-year long dumbell-shaped structure consisting of two "blobs" of debris expanding apart at nearly 6 million miles per hour.

"This is a bit of a surprise," says Jason Pun of Goddard. "This is the first time we can see the geometry of the explosion and relate it to the geometry of the large glowing ring system around the supernova, which has an hourglass shape. The images may yield important clues to the dynamics of the supernova explosion and the structure of the progenitor star."

The dim area between the blobs may be related to the equatorial belt of material seen around the supernova that existed before the star exploded. The ring flared brightest at the beginning of the explosion and has slowly been fading since then.

The explosion was triggered when star's core collapsed and blasted out a wave of neutrinos which heated the star's inner layers to 10 billion degrees Fahrenheit. This triggered a shock wave that ripped the star apart and sent the debris hurtling into space. The fireball has since cooled (to a few hundred degrees Fahrenheit) and the debris is now heated by nuclear energy from the decay of radioactive nuclei produced in the explosion.

The debris is expected to collide with the inner ring as early as the year 2002. This should illuminate the nebulous matter surrounding the supernova, providing clues to the nature and evolution of the stellar explosion.

Another collectible for the Fed's UFO locker

National Weather Service employee Norma Jones thought she saw an aircraft in trouble while driving to work at New Braunfels, Tex., at 6:30 a.m., on January 15. "It looked like a ball of fire," she said. "Bright blue and yellow fire. It was at eye level. I didn't see it hit the ground, but I thought it landed in a corn field."

There were no reports of any aircraft in trouble in the area.

A few days later a local rancher, Ed Longcope, noticed a strange lump in his field while feeding his cattle. He walked over to examine it and saw a metal ball about two feet in diameter half buried in the earth. The top half was sticking out of the ground. The ball looked as if it had been in a fire. It was pitted on one side, like a large musket ball shot into rocky soil. He was mystified, so he called the Sheriff.

Deputies were confounded, too. They took the object to the National Weather Service office where Norma works. They did not know what it was, either.

"Take it to NASA," they said.

"We don't know what it is," said David Cox, commander of the U. S. Space Command, in Colorado Springs, Colo. His agency tracks objects in space.

The mystery deepened. Officials at Randolph Air Force Base in San Antonio caught wind of it. And in short order they confiscated the mysterious sphere.

And now comes the usual speculation to explain away the mystery. Government officials are saying it might have been a remnant of a Delta II rocket. Of course. But you'd think space experts would have known definitely and immediately if it was from one of their rockets.

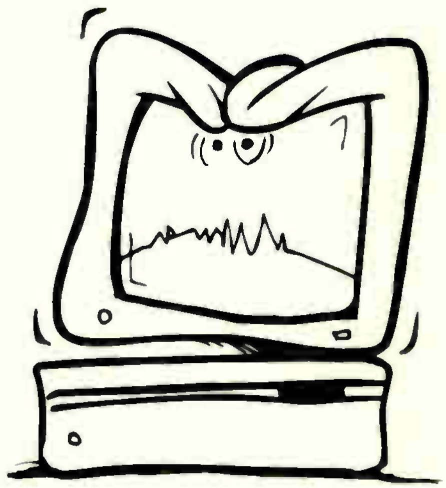
Meanwhile the sphere rests in an Air Force storage room, with other UFO mysteries.

And finally ...

Psst. Hey buddy. Yeah, you with the nerd glasses and the laptop computer in your briefcase. I'm over here, in the alley. Listen: Word on the street says some mighty important computers are going to crash when the year turns 2000. Okay, so you've heard. But here's something you ain't heard. I got an idea how we can make some real bucks off this. One man's crash is another's cash. Know what I mean?

Shhhh. C'mon. Step into the alley. People are staring. That's better. Let's lay a little groundwork here. At one tick past midnight of Dec. 31, 1999, when the last two digits of the year change from 99 to 00, computers will think the year has changed to 1900 instead of 2000. If they don't know how to handle the change, they'll crash. We're talking computers that run the world's business. Now, I've been doing some thinking, and the big question on my mind is: What's the real story here?

I'm told this fiasco began with programmers trying to save memory when computers didn't have much. Instead of using all four digits of the year, they used only the last two digits. Now, I'm supposed to believe these mathematical gurus didn't know that a two-digit, base-ten number stops progressing after 99? Yeah, right.



I started getting the picture when I saw the price tag for fixing the problem — $600 billion U.S. dollars. And who gets the bucks for the fix? Programmers. Am I the only one who smells a rat here?

Seems to me the fix could be as simple as a patch to automatically rewrite code to make it use the system date in a computer. You know, like those patches that automatically update programs to newer versions. But then, what do I know? Not being a programmer, I'm not in line for the big bucks. Unless...heh heh ... you and I could work a deal. Tell you what. You put that laptop of yours to work and write the patch and I'll help you sell it for...say...$500 billion. That'll save the world a cool hundred billion. We'll be heroes. They'll throw the money at us. We, of course, will accept. And for your work I'll let you keep two-thirds (the last two of the three digits) and I'll keep what's left. Whatayasay? ST

Sources:
Associated Press, AT&T, European Space Agency, Lockheed Martin Missiles & Space, NASA, *Sky & Telescope*, *Space News*, *Washington Times*-courtesy of Mr. Art Audley

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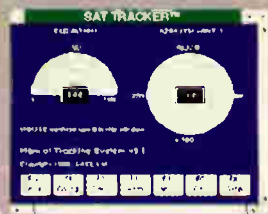
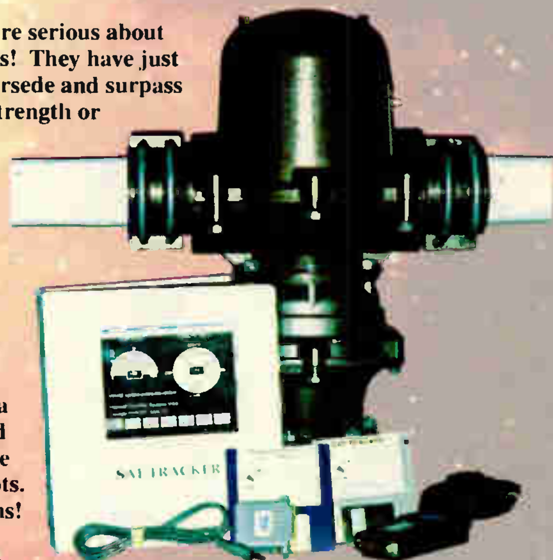
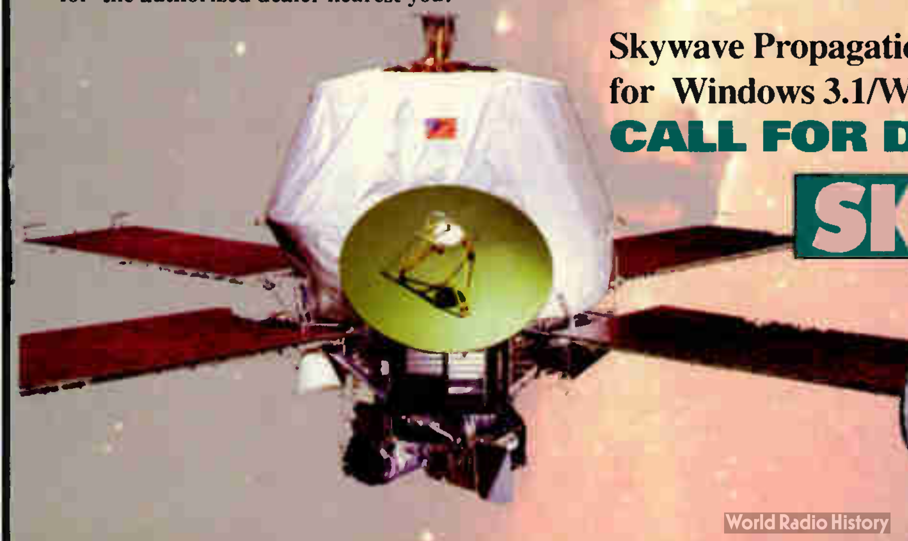


The SAT TRACKER© is a combination of hardware and software which allows you to accurately track all types of satellites or celestial objects from Horizon to Horizon. The system will even assist in accurately tracking rapidly moving low orbit satellites such as the military "LEO" Satellites or Amateur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

EMOTO - EV800X & EV800DX



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



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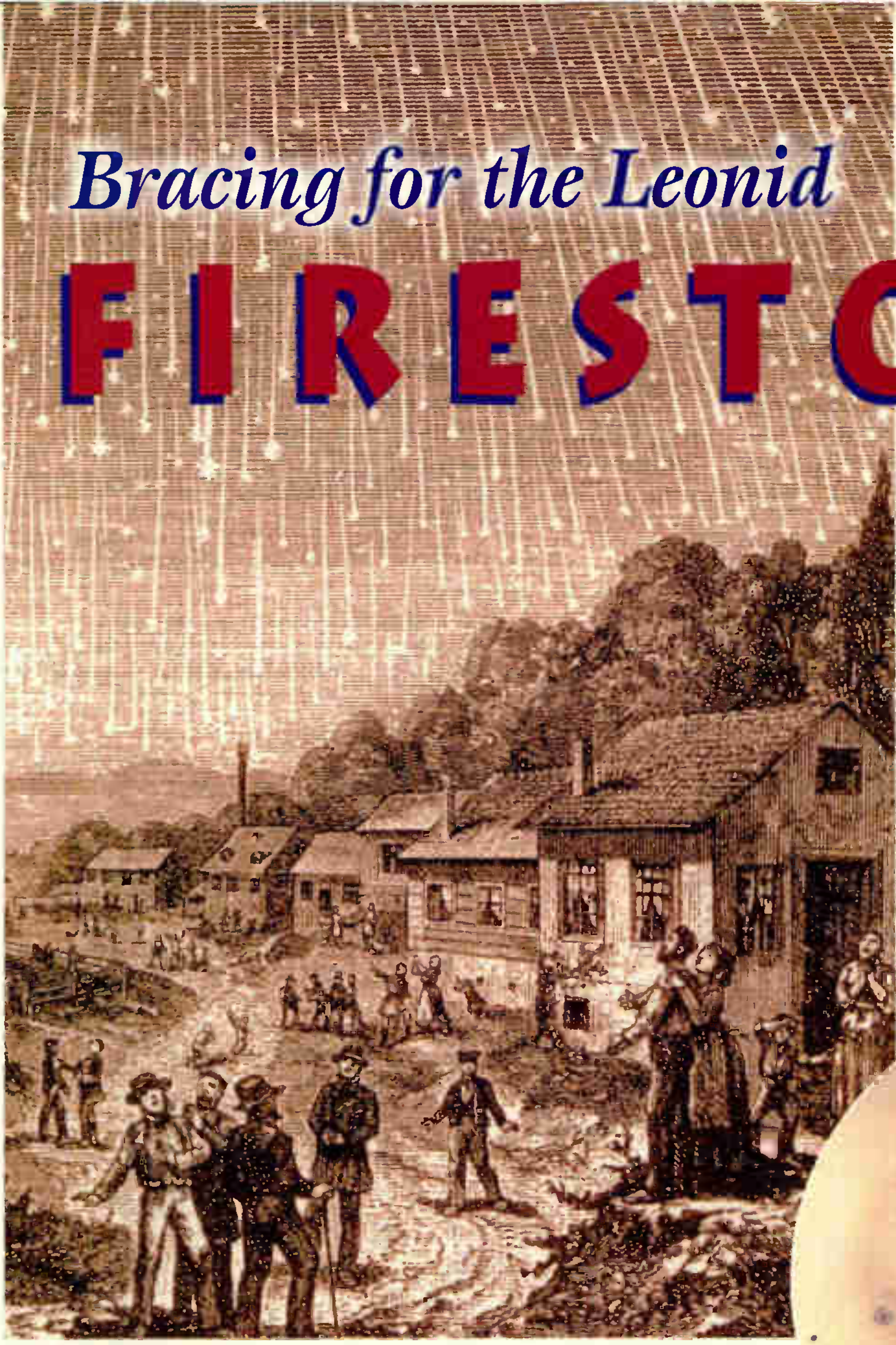

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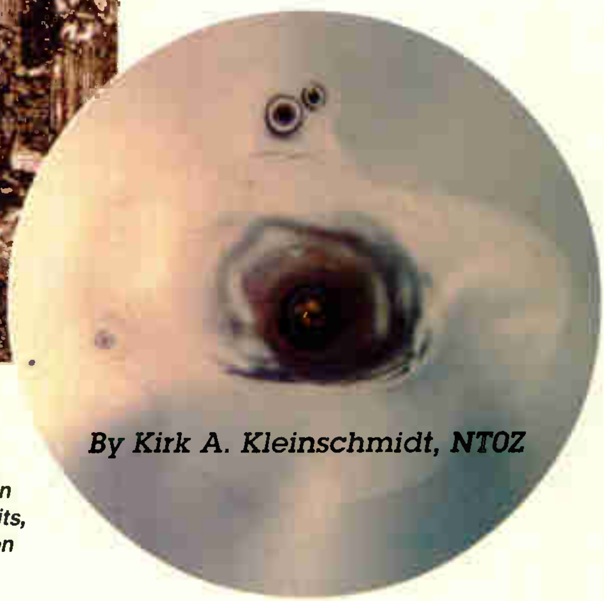


The 1833 Leonid meteor storm, depicted in the illustration above, left a lasting impression on observers, many of whom thought it was a sign of the apocalypse. The Leonids of 1997-2000 may leave impressions of another sort, as sand-grain-sized meteorites threaten the destruction of satellites. At right is a close-up of meteorite damage to NASA's Long-Duration Exposure Facility (LDEF), launched in 1984 and recovered in 1990. Many of LDEF's exposed surfaces were acned with pits, craters and gashes left by colliding micrometeroids or other debris. See sidebar on page 16 for more information on LDEF.

By Kirk A. Kleinschmidt, NT0Z

Like a stone slung in battle by an ancient god, the cold, unyielding mass of the comet held purposefully to its cosmic trajectory. Forged by titanic forces in the unknowable time before man rose to prominence on the third planet of its present-day captor, the icy ball had rocketed past Earth countless times, silently witnessing the waxing and waning of civilizations as it held unswervingly to its assigned orbit.

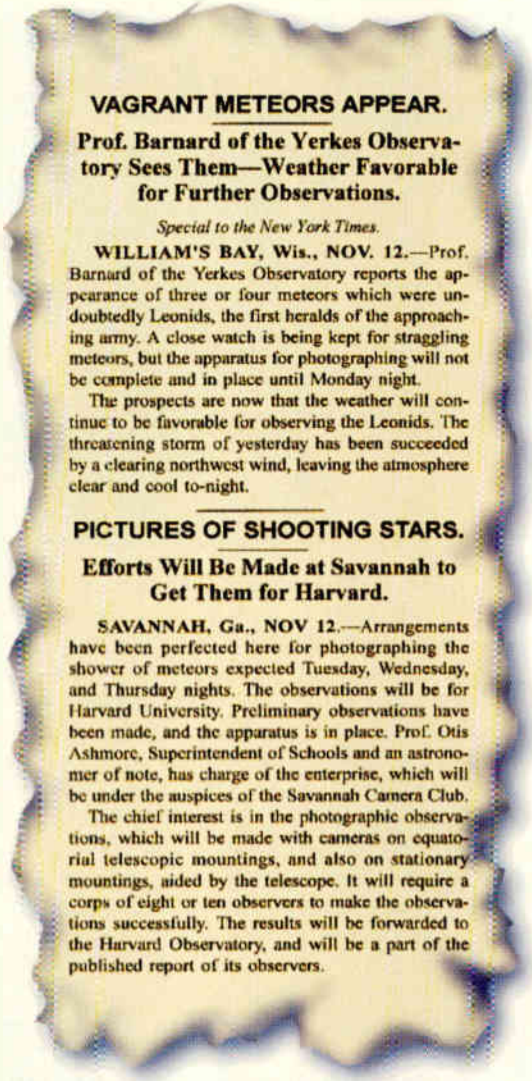
Exactly how the comet came to be and why it was loosed upon the solar system have been long forgotten, as has its intended foe. But by some twist of fate, or perhaps by ancient or divine intention, the comet would soon rain destruction upon an unknowing enemy.

The comet's many orbits around the sun had taken their toll, however, ever so slowly diminishing its ultimate destructive power. In the farthest reaches of its elliptical path, having been flung there after the last encounter with the sun, the comet plied the heavens largely unassailed. But each time the unstable amalgam of rock and ice was pulled toward the star's searing heat and unrelenting gravity, bits and pieces were ejected from the main mass, littering the region with billions of micrometeoroids. These fragments, then, and not the gloriously powerful comet itself, would taste battle at last.

At 3:37 a.m. Eastern Time on November 17, 1997, *Galaxy 5*, the venerable cable TV "super satellite," orbiting Earth itself some 23,500 miles above the equator, was instantly and utterly destroyed when a cometary fragment no bigger than a grain of sand ripped through its innards with seemingly relativistic swiftness. Colliding with a combined velocity of more than 150,000 miles an hour, the grain itself was consumed in the plasma-hot furnace created by the kinetic encounter.

A torrent of other nearby fragments, having missed the target, would soon slash brilliant streaks across Earth's nighttime sky as they burned their way into the atmosphere. By the end of this unlikely battle, six of Earth's precious geosynchronous satellites would be destroyed or damaged, reduced to lifeless junkpiles that, if left unmolested, would remain in orbit for a million years before burning their own paths across Earth's darkened sky.

On that night, television programs, telephone conversations, computer networks, radio stations and even encrypted images secretly sent from military spy satellites disappeared, as if switched off by some cosmic hand. If the comet, called Tempel/Tuttle in this modern era, had any intelligence as it rounded the sun yet again, perhaps it noticed that Earthlings were now venturing into space—and that they and their constructs seemed quite vulnerable in their new environment....



VAGRANT METEORS APPEAR.

Prof. Barnard of the Yerkes Observatory Sees Them—Weather Favorable for Further Observations.

Special to the New York Times.

WILLIAM'S BAY, Wis., NOV. 12.—Prof. Barnard of the Yerkes Observatory reports the appearance of three or four meteors which were undoubtedly Leonids, the first heralds of the approaching army. A close watch is being kept for straggling meteors, but the apparatus for photographing will not be complete and in place until Monday night.

The prospects are now that the weather will continue to be favorable for observing the Leonids. The threatening storm of yesterday has been succeeded by a clearing northwest wind, leaving the atmosphere clear and cool to-night.

PICTURES OF SHOOTING STARS.

Efforts Will Be Made at Savannah to Get Them for Harvard.

SAVANNAH, Ga., NOV 12.—Arrangements have been perfected here for photographing the shower of meteors expected Tuesday, Wednesday, and Thursday nights. The observations will be for Harvard University. Preliminary observations have been made, and the apparatus is in place. Prof. Otis Ashmore, Superintendent of Schools and an astronomer of note, has charge of the enterprise, which will be under the auspices of the Savannah Camera Club.

The chief interest is in the photographic observations, which will be made with cameras on equatorial telescopic mountings, and also on stationary mountings, aided by the telescope. It will require a corps of eight or ten observers to make the observations successfully. The results will be forwarded to the Harvard Observatory, and will be a part of the published report of its observers.

These clips appeared in the November 12, 1899, New York Times. Although astronomers were excited about the potential for a November 17 Leonid storm, the much-forecasted event was a disappointment. The storm's failure to materialize "on schedule" caused many observers to miss the rather intense Leonid showers in 1900 and 1901.

TABLE 1: Strongest Observed Leonid Returns Since 1799

Year	Activity > 10 times background	Peak Hourly Rate
1799	Nov 12, 0712 -1200 UTC	> 10,000
1832	Nov 12, 2136 - Nov 13, 0712 UTC	> 20,000
1833	Nov 13, 0712 - 1200 UTC	50,000
1866	Nov 14, 0000 - 0448 UTC	10,000
1867	Nov 15, 0712 - 1200 UTC	>1,500
1965	Nov 17, 0224 - 1912 UTC	> 5,000
1966	Nov 17, 0936 - 1424 UTC	150,000

Note: This information was derived after examining the original sources. In this table, the Peak Hourly Rate is the number of meteors from the shower a standard observer would see under unobstructed skies with the radiant point overhead and the faintest star visible to the unaided eye. *Table courtesy of Peter Brown, UWO.*

The Danger is Real

If you think this scenario is overly dramatic, you may be right. But as space scientists around the globe are confirming by their research and concern, the potential for destruction or damage to satellites (or other orbiting objects) from meteoroid collisions during upcoming Leonids meteor showers is *very real*.

Satellites have recently been killed by micrometeoroids encountered during meteor showers far less active than those predicted for the 1997-2000 Leonids. And *Mir*, the Hubble Space Telescope and US space shuttles have been visibly damaged by debris and micrometeoroid collisions.

What might happen to the more than 500 manmade satellites now in orbit during a meteor storm 10,000 times more intense than normal—with particle impact speeds exceeding 150,000 miles an hour?

What indeed! Those conditions were measured during the 1966 Leonid storm, and scientists are worried that we'll see a repeat performance (or one or *more* showers of lesser, yet potentially destructive intensity) during the November Leonids showers of the next four years.

Physical collisions alone are cause for concern, but a second threat may be even more ominous. Because of the tremendous impact velocities involved (closing with the Earth at 71 km per second, the Leonids are the fastest-colliding cometary fragments known), the highly charged plasma clouds generated by the impacts of even extremely small Leonids particles may be powerful enough to kill satellites that would have been minimally affected by the physical collisions.

Considering the doubled danger of collisions *and* plasma threats (and the potential for one or more strong Leonid peaks from 1997 to 2000) the satellite community is entering a stressful period—a period that can repeat every 33 years.

Before we explore the darker side of meteoroids in our spacefaring era, however, let's brush up on comets, astronomy, and the Leonids themselves.

Early Leonids History

Thanks mostly to comets, we here on Earth have had the pleasure (and the terror) of watching falling stars for a long time—longer than civilized man can even remember. Even in modern times, the incredible heavenly displays during meteor storms seemed to herald inauspicious, apocalyptic events.

Records of Leonid showers and storms reach back more than a thousand years and, interestingly enough, almost half of all the meteor storms chronicled since those first records were made have been seeded by comet 55P/Tempel-Tuttle, which has transited close to the Earth every 33 years for a very long time.

Although we now know that meteor showers are caused by the Earth moving through the orbiting debris fields left in the wakes of passing comets, scientists and astronomers as recently as the early 1800s still thought falling stars were purely terrestrial events.

The Leonids shower of 1833 changed all that. When thousands of falling stars poured from a radiant point in the constellation Leo—a point that "moved" with the constellation as the nine-hour event unfolded—astronomers got the message (and instituted the convention by which future showers would be named).

That night, November 12-13, 1833, skies were clear across most of North America, and anyone gazing skyward during the episode was treated to quite a sight. According to Long Island meteorologist/astronomer Joe Rao, the Leonids storm left a terrifying, long-lasting impact on America.

> "Newspapers reported that many sleepers were awakened by the moving glare of Leonids fireballs or commotion in the streets. And at the height of the storm, in which some observers reported seeing 10,000 bright meteors an hour, one watcher thought the stars were literally falling from the sky, and that there would be none left in the sky the following night."

In the late 1800s, historian R.M. Devens listed the 1833 storm as one of the 100 most memorable events in US history. According to Rao, the 1833 event has even been credited with spurring the profound religious revivals that swept the country during that era.

Comets and 55P/Tempel-Tuttle

A typical comet (if there is such a thing) is an irregularly shaped ball of ice, dust and debris anywhere from a half-mile to 10 miles in diameter. Two popular comets illustrate the size difference. Halley's comet—a bruiser—is 6 to 8 miles across; Hyakutake, much smaller, is only a half-mile in diameter.

And while there are undoubtedly comets and other large fragments moving through interstellar space, the comets Earth encounters have relatively stable (although highly elliptical) orbits around the sun. Tempel-Tuttle's orbit traces a very narrow ellipse that rounds the sun and stretches out as far as the orbit of Uranus. The debris left behind by these periodic comets ends up as shooting stars and meteor showers each time the Earth intersects the comet's orbital path.

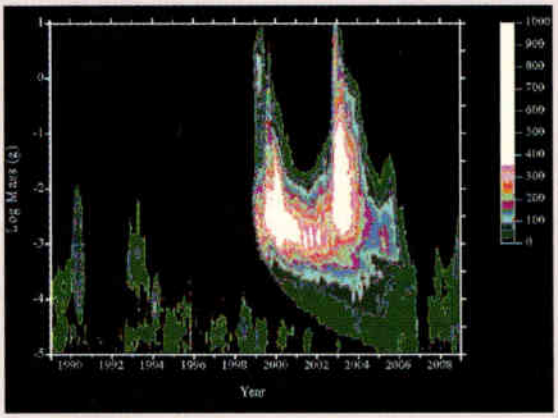
As the comets move closer to the sun, increased radiation heating causes surface ices (mostly water) to sublimate and move away from the main mass, "dragging" small solid particles off the comet's surface in the process. The gas and dust make up the visible "tail" we associate with observable comets. The larger particles become orbiting meteoroids.

The size and activity of a comet; its orbital path and direction; the density and width of its particle stream; and the comet's distance form the sun all determine how the Earth "experiences" these fast-moving debris fields and, ultimately, the quality and quantity of observable falling stars during meteor showers.

A combination of factors stacked in Tempel-Tuttle's favor allow it to produce periodic spectacles. The comet orbits the sun in nearly the same plane as Earth (inclined only 13 degrees) *in the opposite orbital direction.* By cometary standards its particle stream is very narrow (the main stream is estimated to be only 22,000 miles across) and quite dense—especially when the comet is close to the sun, as it was in 1833 and 1966, and as it will be again in 1998-2000.

Under these conditions, when the Earth moves through Tempel-Tuttle's debris stream, the meteors and the planet

Modeling the Leonid Stream



This figure, colorized for impact, summarizes the early computer modeling results of the Leonid stream as performed by Peter Brown and the UWO Meteor Group. The Y axis shows the logarithm of meteoroid mass (10 g at top and 10 micrograms at the bottom) and the X-axis shows the time in years. The diagram in total shows which mass of Leonid meteoroids is predicted to be encountered by the Earth, and in what relative numbers according to computer simulations.

This diagram should be interpreted as the relative probability of encountering particles of a given mass in a given year by the Earth—it cannot make absolute predictions of the size or scope of any Leonid storms. The meteoroids shown were ejected from parent comet 55P/Tempel-Tuttle between 1666 and 1965 and are shown at the time they reach the descending node of their orbits (the time when they could encounter the Earth).

The Earth actually passes through the stream each Nov 17-18, so a vertical line drawn from near the end of any one year shows which particles might be encountered in that year.

In total, just over 6 million test particles are represented in this simulation, of which less than 1% are found to move along orbits which might intersect the Earth (and hence be shown on this diagram). *Figure courtesy of Peter Brown and the University of Western Ontario.*

are moving towards each other with a combined velocity of 71 km per second (42.6 miles an hour).

Imagine rear-ending another car on the highway. You're going 70 miles an hour and the car ahead of you is going 50 miles an hour. The difference is a manageable 20 miles an hour. You'll crash, but you'll probably survive. This is somewhat like what happens when we encounter debris orbiting the sun in the same direction as Earth. With Tempel-Tuttle, it's like crashing your car head on into the supersonic *Concorde*. The collision is much more violent.

Because of the comet's concentrated debris field, most of the meteors appear in the span of a few hours—the time it takes for the Earth to move through the stream. During a Leonids storm, earthbound observers see an intense display.

No matter how spectacular the Leonids are today, however, at some point in the future—anywhere from 30 to 30,000 years (only a guess)—we may lose the November Leonids to decay.

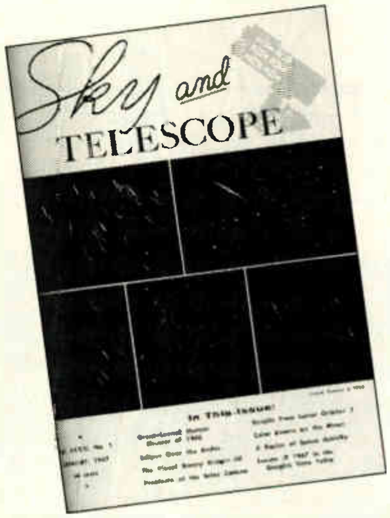
"Tempel-Tuttle was barely visible in 1965," says Rao, "and some astronomers are wondering if it's dying. After about 10 revolutions around the sun, the particle stream spreads and scatters. And new fragments are usually only formed when the comet is near the sun."

When the sublimated gases and ejectable material material are exhausted, no new particles are ejected, the "tail" fizzles and disappears and the comet becomes a lifeless, orbiting mass.

Before that fateful day, however, we'll certainly see more fireworks from Tempel-Tuttle, or from one or more of the dozen-or-so recurring meteor showers that are monitored by scientists and watched by thousands of skywatchers around the globe.

The 1966 Storm and What it Could Mean in the 1990s

Although the much-heralded Leonids storm of 1833 was spectacular, the November 17, 1966, storm was probably as much as three times as intense, with rates that approached 150,000 meteors per hour. In the years prior to 1966, however, the shower was anemic compared to previous storms and had lost its hold over many enthusiasts. But to the delight of viewers in central and western North America, that night in November saw falling stars once again pouring from the sky in a display rivaling any before it.



Published on the heels of the great 1966 Leonids storm, the January 1967 issue of Sky & Telescope was plastered with photos and stories describing the event.

According to Rao, "In 1965, the year before the big display, Tempel-Tuttle, which had been 'lost' by astronomers for nearly a hundred years, was rediscovered. That year the Earth passed very close to the comet's orbit—little more than the moon's distance away." With Tempel-Tuttle returning to perihelion in late February 1998, the cycle may be starting again.

According to a landmark 1981 study of past Leonid activity by Donald Yeomans, a space scientist and Leonids expert at NASA's California Jet Propulsion Laboratory, it's in the years just before and just after the comet passes by that the Earth tends to pass through Tempel-Tuttle's full onslaught.

Peter Brown, a doctoral candidate at the University of Western Ontario, specializes in the numerical modeling and analysis of meteor showers (and the Leonids in particular). He says that earlier meteor rate estimates of the 1966 storm ranged from a low of 15,000 meteors per hour, to more than a million meteors per hour.

"The very high and the very low estimates are almost certainly inaccurate," says Brown. "In addition to the rates reported by observers on the ground [the limiting factor in observations made in during earlier storms], scientists used radar and cameras to count the incoming meteors with much greater precision. We're very comfortable with estimating peak rates of between 100,000 and 150,000 meteors per hour."

At that elevated rate, satellites are exposed in 30 minutes to the number of particles and micrometeoroids normally encountered in a full year.

After the dawn of our satellite age, the highest hourly meteor rates observed since the 1966 storm were produced by the 1985 Draconids, which peaked at 600 meteors per hour. With a much slower closing rate of 23 km per second, the Draconids don't pack nearly the power of the much faster Leonids.

So, will the killer meteor storm emerge to cripple our precious fleet of satellites, take down the Hubble Space Telescope or cause a tragedy aboard the newly orbited space station *Freedom*? Or, like some years in the past when conditions should have been "perfect," will the storms fizzle and disappoint?

"The beauty of predicting meteor storms," says Rao, "is that, despite our best efforts, nobody can really predict what's going to happen exactly when."

While agreeing, Brown is quick to point out that "there is a very high probability that, no matter what happens, at least one November period between now and 2000 will produce the most intense meteor activity since 1966."

Nicholas Johnson, head of NASA's Orbital Debris Program, still characterizes meteor storm prediction as a "Black Art. We just don't know exactly what's going to happen and when."

While he and his colleagues strive to uncover the secrets, we have four or more years to watch and wait.

TABLE 2

Estimated Equivalent Impact Probabilities for a Satellite of Standard Area (10 m²) for Peak Hourly Rates and Durations for the Strongest Leonid Returns Since 1799

Year	Impact Probability % (Standard Area)
1799	0.02
1832	0.04
1833	0.1
1866	0.01
1867	0.001
1965	0.06
1966	0.07

Note: The hourly rate curves are very uncertain for all returns except 1965 and 1966; the estimated impact probabilities should be taken with caution. *Table courtesy of Peter Brown, UWO.*

The impact crater in the Space Shuttle Challenger's window caused by tiny orbital debris. Note the 1mm scale in the close-up view at top for an idea of the size.

Death of a Satellite

Objects in orbit are constantly bombarded by very small particles. Spacecraft designers know this and do their best to accommodate the harsh environment. Particles, temperature extremes, solar emissions and the vacuum of space make their job quite difficult.

Space shuttle windows get "sandblasted" and pitted during missions and are routinely replaced before the craft is relaunched. Long-duration orbiters such as *Mir* have protective window covers to reduce cumulative micrometeoroid damage. The space station *Freedom* will even be "armored" to withstand the impact of a 1 cm aluminum sphere traveling at 10 km per second.

(That may not be enough to protect against Leonid micrometeors, however. Brown calculates that a Leonid particle weighing only 1/100 of a gram would produce impact energy equivalent to that generated by the larger, slower-moving aluminum sphere.)

And there's more. Solar flares and geomagnetic storms "stun" and even kill satellites. Solar panels and rocket motors weaken and fail. Command and control links go dead. These are the usual mortality vectors for things in orbit.

And while micrometeoroids don't usually kill satellites on the spot, a large satellite was killed in such an encounter in 1993. The incident spurred Brown and other scientists to study micrometeoroid streams more closely. The race for improved predictive tools began in earnest.

The casualty was *Olympus*, a large communications platform operated by the European Space Agency. During the 1993 Perseids meteor shower, which produces peak meteor rates of only 30 times normal background levels (the 1966 Leonids peaked at 10,000 times greater than background levels), an outboard solar panel was hit by a meteoroid.

According to Brown, who has reviewed the official studies of the incident, scientists think that the kinetic energy transferred during the hit "torqued" the satellite off axis.

Had this been the extent of the damage, *Olympus* probably would have recovered. But as a result of the impact, a highly charged plasma cloud "bathed" the satellite and entered its internal structure, causing gyro errors.

Brown says, "Ground-control operators eventually got the satellite stabilized and under control, but all of the satellite's station-keeping fuel had been burned during the recovery. The satellite as effectively dead."

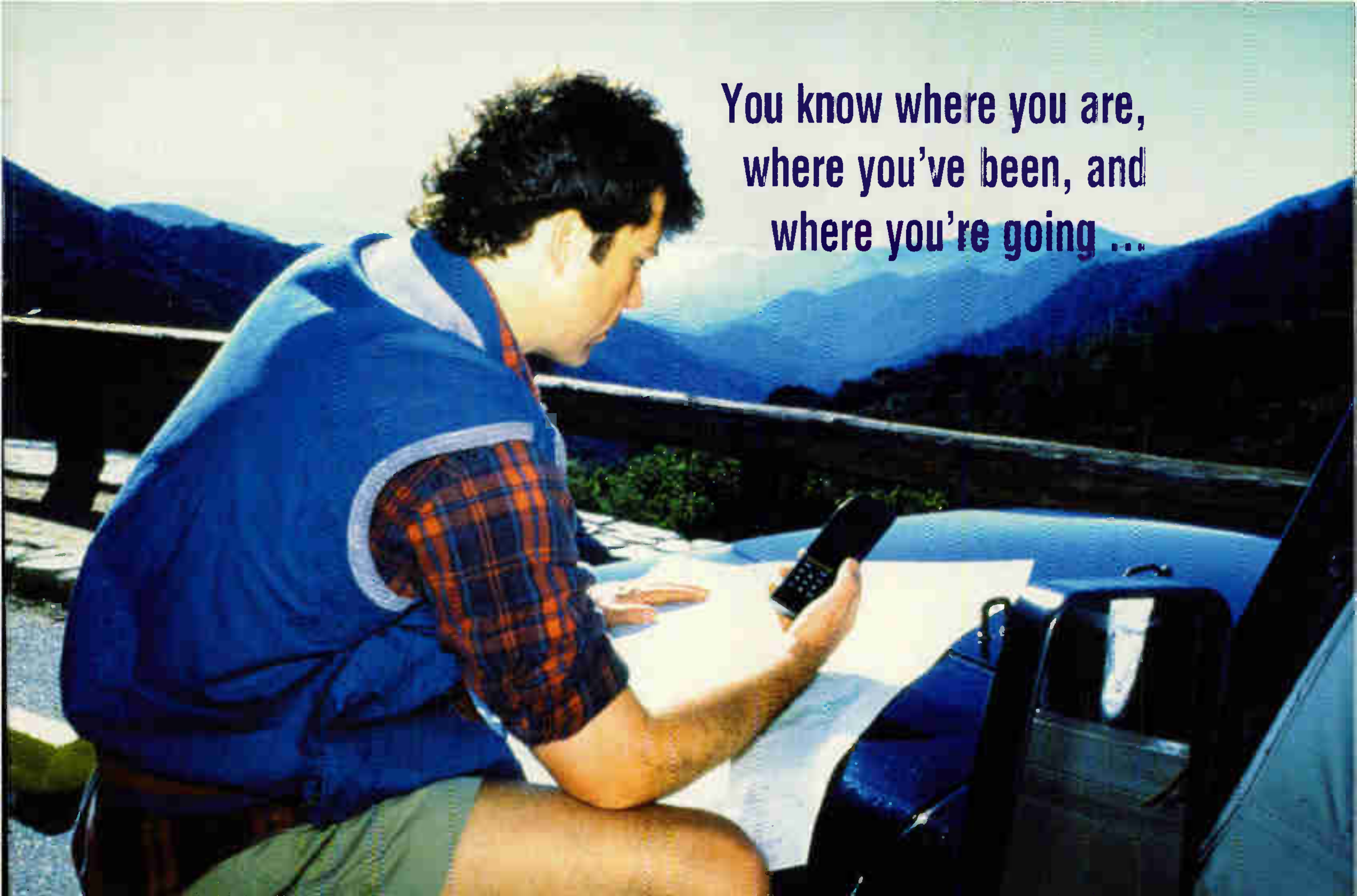
During the same 1993 shower a shuttle mission was delayed and the Hubble Space Telescope was positioned so that its powerful optics were aimed directly away from any incoming meteors. Later shuttle missions would reveal that the Hubble's high-gain dish antenna was cleanly punctured by a meteoroid (or orbiting debris), as were several *Mir* solar modules. Whether the hits took place during the Perseids shower isn't known.

Kinetic Encounters or Plasma Attack?

When most of us think about particles hitting satellites we tend to imagine *ballistic* damage. Much like shooting a bullet at a target, we visualize meteoroids punching into satellites at tremendous speeds. We might even picture the satellite breaking up or even exploding—like a scene from a Clint Eastwood movie.

Ballistic damage is a pressing concern, especially when even a tiny, speck-like particle moving at incredible velocity can pack as much punch as a tank round or a stick of dynamite. A particle's kinetic energy increases with the square of its velocity, and Leonids particles, with closing velocities much greater than those of typical meteoroids, can pack a tremendous punch.

In the realm of everyday physics this simple model makes sense, especially when a particle hits a thick, solid object such as



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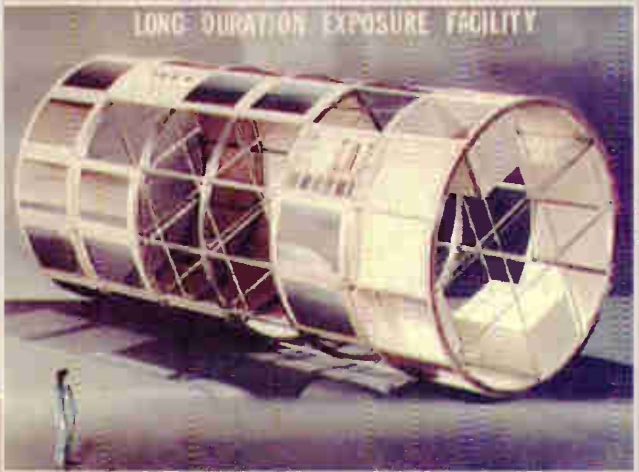
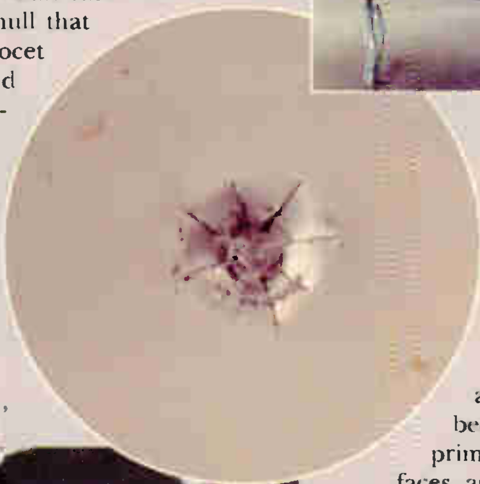
LDEF—A Spacecraft Designer's Best Friend



When you decide to paint your house or add vinyl siding to cover the old exterior, your choices are pretty straightforward. Do you go with the best paint you can get at Sears, or do you opt for the Sherwin Williams brand? And vinyl siding is vinyl siding. You simply choose the color and a siding contractor and you're set.

When building a spacecraft, however, the materials available are limited by weight, strength, and environmental considerations. Spacecraft exteriors—unlike most houses—have to withstand temperature extremes, harsh solar effects, a hard vacuum *and* stand up to constant bombardment by micrometeoroids and orbiting debris.

If NASA could orbit an old Iowa-class battleship, with an 18-inch-thick steel hull that can shrug off a direct hit by an excocet missile with little or no damage, we'd likely see some truly impressive orbiting fortresses.



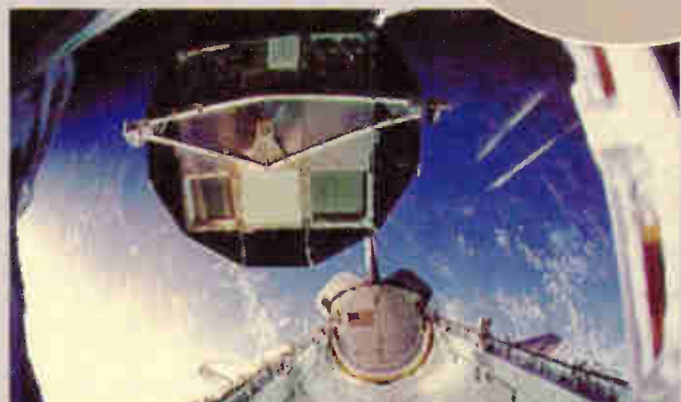
But the physics of launching and orbiting Earthly payloads is too restrictive. To build strong, lightweight orbiters, NASA needed data on how a variety of materials would hold up under the "weather" of low-orbit space.

Launched in 1984 and recovered by a 1990 shuttle mission, NASA's Long-Duration Exposure Facility (LDEF) gave scientists a lot of answers.

Among other things, LDEF exposed a wide variety of structural materials to the space environment—aluminum, fiberglass, composites, glass laminates, ceramic, paints, polymers, thermal insulation, etc.

Since LDEF was recovered, scientists and NASA's Langley Research Center have been analyzing the results of the craft's 87 primary experiments. Many of the exposed surfaces, as shown in the accompanying figures, are acned with pits, craters and gashes left by micrometeoroids or other debris.

LDEF was intended to be spaceborne for only a year or so, but the 1984 *Challenger* disaster curtailed shuttle missions for several years, forcing LDEF to live up to the "L" in its name! With no means of relaying sensor data, scientists had to wait patiently to recover the experiments. *Photos courtesy of William Kinard of NASA's Langley Research Center.*



There's no substitute for experience, and from its inception the Long-Duration Exposure Facility (LDEF) was employed as the ultimate orbital guinea pig, performing 87 experiments to gauge the long-term effects of space travel—not the least of which were tests on the space-worthiness of various structural materials.

the main body of a spacecraft or satellite. This allows the tremendous kinetic energy stored in the fast-moving particle to be transferred to the "target."

As noted earlier, when a micrometeoroid hits a thinner, less substantial object (solar panels or dish antennas, as we've seen earlier), it punches through like a cookie cutter and keeps on going. Only a fraction of the kinetic energy can be transferred during the very brief encounter.

If the main mass of a satellite gets hit by a large particle, however, it will likely be destroyed, perhaps spectacularly. The particle may indeed rip right through the craft's innards, emerging as a flaming, white-hot projectile. And even if no Hollywood effects are produced, the satellite will at least "wink out," deader than the proverbial door nail.

Kinetic damage is bad enough, but Brown and his colleagues are more concerned about the plasma clouds produced when superfast particles hit just about anything (such as those that may have been produced in the *Olympus* incident).

Understanding this mechanism is more difficult and not altogether intuitive. As scientists are discovering, slower, bigger micrometeoroids cause more kinetic damage and produce less "plasma effect" than faster, smaller particles.

When particles collide at Leonids velocities, the physical matter simply "falls apart" and disintegrates into a charged plasma cloud before the bulk of its kinetic energy can be transferred to the target.

Imagine an Iowa Farm-League pitcher who could throw a baseball so fast that when the hitter smacked it dead to rights with his bat, instead of the cover being knocked off the ball, as in the old movies, the ball literally "poofed" into nothing (a plasma cloud) while the batter corkscrewed around as if he missed the ball entirely!

The intensity of the plasma field generated on impact varies with the particle's velocity *to the fourth power.* According to Brown, "*Olympus* was struck by particles moving at 60 km per second. At 71 km per second, a Leonid strike is much more intense." Most debris collisions in low-orbit (space shuttle and space station altitudes) are at 7 or 8 km per second, making the plasma cloud produced by a Leonid hit some 10,000 times more powerful).

It's amazing to think that a Leonids particle weighing a thousandth of a gram might strike the main structure of a satellite at 155,000 miles an hour and leave only a microscopic pit in the paint—microseconds before consuming the satellite's electronic systems in a powerful plasma cloud, shocking it as though it had been struck by lightning!

TABLE 3: Predicted Leonid Shower Peak Times

Year	Center of Predicted Peak Periods
1997	Nov 17, 1100 UTC
1998	Nov 17, 1702 UTC
1999	Nov 17, 2302 UTC
2000	Nov 17, 0517 UTC
2001	Nov 17, 1117 UTC
2002	Nov 17, 1731 UTC
2003	Nov 17, 2359 UTC

Note: These times assume that storms in the late 1990s will occur near the same solar longitude as the 1966 storm. The years 1998-2000 are most likely to show storm activity at some level, while 1997 and 2001-2003 are likely to show enhanced activity. *Table courtesy of Peter Brown, UWO.*

Brown notes a second effect of plasma clouds that may be just as deadly. If the affected satellite survives the direct plasma pulse, it may still be destroyed or damaged by electrostatic discharges between its own insulated components.

In orbit, the vacuum of space is an excellent electrical insulator. Insulated portions of the satellite system (antennas, solar panels, batteries, etc) gradually accumulate static charges picked up by "brushing against" the continuous stream of solar emissions, much like an airplane that becomes charged by flying ("frictioning") through the air.

Under normal conditions these charges can safely accumulate. After all, they're well insulated by space itself. But when a satellite is enveloped by a highly conductive plasma cloud, the charged components can "flash over," potentially damaging or knocking out electronic circuits.

"From 1989-2000," notes Brown, "the Earth is closest to sun, increasing the static charges built up by satellite parts exposed to solar effects. At Leonid speeds, hits don't have to cause *any* mechanical damage to kill or damage a satellite. In fact, at 71 km per second, plasma damage may be much more of a problem than mechanical damage."

Brown and others are working to improve their understanding of plasma-damage mechanisms. His group is under contract with NASA and other space agencies to model meteor streams and to help develop risk-assessment methods. The group's final predictions concerning the Leonids threats are six months to a year away.

What's NASA Doing?

Johnson, Brown, and others are sifting through Leonids information on several fronts, and NASA is examining common-sense preventive measures.

Says Johnson, "Certainly there will be no scheduled shuttle missions or critical launches during the potential storm periods. And if astronauts are aboard the yet-to-be-launched space station, they may be moved into the station's most-protected internal areas during potential storm periods, or they may even be moved into the emergency crew-recovery modules for the relatively short-duration peak periods."

NASA is also carefully analyzing all existing Leonids data (primarily through Brown and his UWO group) to improve its prediction methods and models. A new meteor radar system is also being used to improve the agency's meteor-rate predictions versus actual post-event observations. Optical observations of "side-stream" meteors are also planned (meteors passing by the Earth on either "side").

According to Johnson, in June the

Learning About the Leonids

There's a lot of material available to those who want to learn about the Leonids and other comet/meteor shower topics. Those with internet access can pore through reams of interesting information. To get started, try Gary Kronk's Meteor Links page at **http://medecine.wustl.edu/~kronkg/metlink.html**, the home page for the International Meteor Organization at **http://www.imo.net/**, or the home of the North American Meteor Network at **http://www.medecine.wustl.edu/~kronkg/namn.html**.

Joe Rao's excellent article, "*Leonids: King of the Meteor Showers,*" appeared in the November 1995 issue of *Sky & Telescope*. For many readers, Joe's article and "*Planning Your Leonid Watch,*" in the same issue, will amount to "one-stop Leonid shopping."

If you want to participate in international meteor-watching/counting activities, the North American contact person for the International Meteor Organization is Robert Lunsford, 161 Vance Street, Chula Vista, CA 91910. On-line IMO registration forms can be found on the group's web page, listed above. Meteor shower research relies heavily on the observations of hundreds of amateur skywatchers, so if you're interested, your contributions will be appreciated.

agency will conduct a meeting/presentation for commercial satellite operators to inform them of NASA's latest findings and predictions, and to help them assess potential threats for various satellite types.

Industry and Insurance

According to Brown and Johnson, industry reaction to the Leonids threat is mixed. Some operators are concerned, some are almost casual. This may be expected, however, in an industry that keeps mostly to itself and keeps secrets "close to the chest."

Rick Hauck, CEO of INTEC, a space insurance specialty company, says industry leaders are aware of potential Leonids problems, but most aren't overly concerned. As for his company, based on present information, INTEC plans no changes in the way it rates satellites for on-orbit insurance.

"We hope to be able to accurately predict and alert commercial satellite operators at the right moment so they can configure their satellites for maximum protection," says Hauck, "but we see the Leonids as a relatively small risk compared to the multiple existing risks that all satellites are exposed to on a daily basis."

A typical communications satellite costs $100-$200 million to build and launch. Some companies have contingency plans, some don't.

Says Brown, "I'm not surprised that many satellite operators aren't overly concerned right now. They're used to dealing with hard numbers, and right now there are no hard numbers to provide."

Minimizing Threats

When deadly particle streams threaten, what's a satellite operator to do? There aren't a lot of options, and some satellites are more "agile" and responsive than others.

Turning a satellite's solar arrays parallel to the incoming meteor stream is probably the best action. Measuring 60 feet across or more, solar arrays usually have much more surface area than the satellite's core. This protective measure may not be practical, however, if the satellite's batteries can't tolerate potentially reduced charging power while the array is pointed elsewhere.

Other protective measures include stowing retractable extremities; shutting protective covers, hatches and doors; rotating sensitive instruments and sensors away from the particle stream, and so on. Considering the velocities involved, most satellites are sitting ducks.

The Bottom Line

What are the *real* odds of a spacecraft colliding with a Leonids meteoroid? Even Las Vegas' best odds-makers would have a tough time with that one. Hard data is scarce. Orbiting structures vary in size, and satellites over different parts of the globe see widely varying particle rates. Objects in low orbit on the "back" side of the Earth wouldn't see any Leonids meteors at all as long as Earth's protective mass plowed into the stream ahead of the satellite!

We know that if the Leonids storm at their 1966 level or better, satellites exposed to the stream will encounter meteoroid and impact probability levels some 10,000 times greater than normal. We also know that there is at least a reasonable chance that this may occur during the Leonids showers over the next few years.

Brown, using 1966 rate data, calculates an impact probability of approximately 0.1% per hour for a satellite of "standard area" exposed to peak-rate particle streams. For his calculations, a standard area is 10 square meters. Some satellites are much larger, especially when their solar arrays are exposed to the stream.

An impact probability of 0.1% per hour doesn't sound all that risky, but when you consider that, according to Brown, a satellite of standard area normally has a 0.07% impact probability *per year*, the meteor storm figure stands out.

What about bigger orbiting objects? Brown's analysis of the space station *Freedom*, with an exposed area of almost 500 square meters, suggests a Leonids-storm hit probability of about 0.5%, with a maximum risk of 1%.

This figure assumes the station's heavy shielding, however, and the figure estimates the risk associated with a *critical* impact. It's chances of being hit by smaller particles may be greater. And how the station may be affected by potential plasma discharges is unknown.

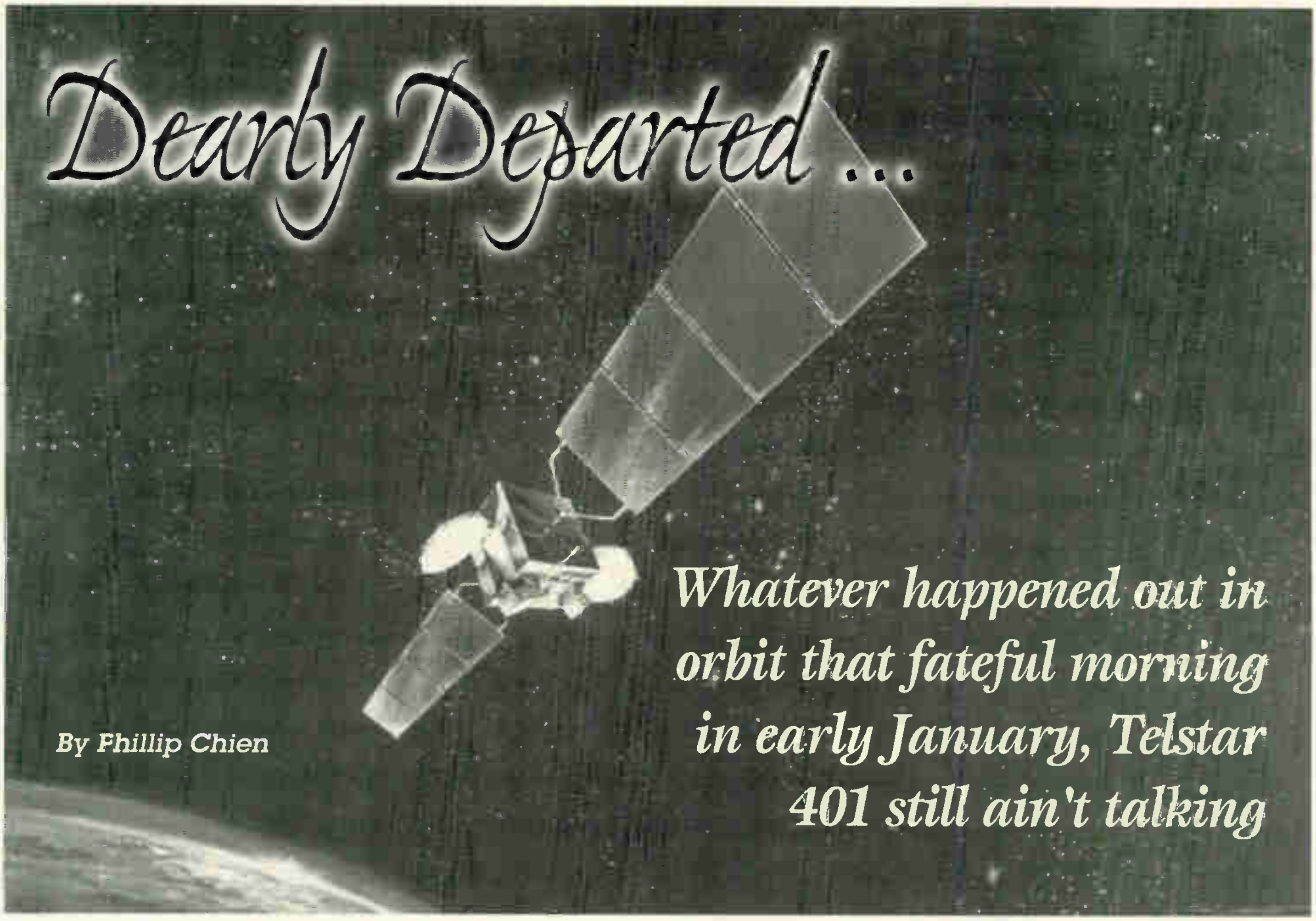
Even with impact probabilities that seem mathematically insignificant, there are hundreds of objects in orbit, each one a potential target for the fast-moving Leonids. Much like our primitive ancestors, we'll just have to watch the heavens and see what happens!

Thanks

Without the help and patient tutoring of a pile of experts, this article would never have been written—at least not by me!

Thanks go to meteorologist Joe Rao, whose awesome November 1995 *Sky & Telescope* article provides a "must-have" Leonids education; to Canada's Peter Brown, meteor storm researcher and odds-maker rolled into one, whose batch of research papers and tables helped out immensely; to NASA's Nicholas Johnson, who coincidentally works at NASA's Johnson Space Flight Center; to the photo archivists at NASA; and to everyone quoted herein. Thanks!

Rao, Brown, and Johnson also reviewed this piece for technical accuracy, for which I'm especially thankful. ST



Dearly Departed ...

Whatever happened out in orbit that fateful morning in early January, Telstar 401 still ain't talking

By Phillip Chien

On Saturday, January 11, at 6:15 a.m. Eastern time, the Telstar 401 satellite ceased to exist. Without any advance warning all of the transponders suddenly went black—along with all of the telemetry which is normally transmitted continuously. Millions of viewers who were watching ABC, PBS, UPN, FOX, and the other Telstar 401 customers lost their signals. What happened? Here's an educated guess.

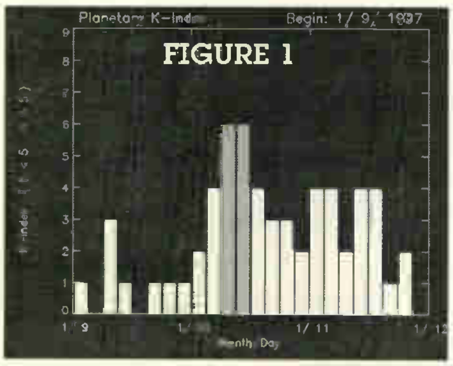
Satellite dish owners who were viewing the direct feeds from Telstar 401 reported that it was an immediate loss of signal, without any fading, noise, or other degradation of signal ahead of time. One instant the signal was there—the next second it was gone.

Within hours all of the primary feeds had been transferred over to backup satellites, in some cases preempting lower priority channels. And they in turn moved over to their backup transponders.

So what happened to 401?

Evidence points towards a geomagnetic storm—literally the Sun burping. On January 6 a geomagnetic storm was detected on the Sun's surface. It took five days for that storm to travel 149 million kilometers (93 million miles) to the Earth. When it arrived it temporarily disabled the GOES-8 weather satellite, and apparently "fried" Telstar 401's electronics. Figure 1 is a graphic showing the storm's Planetary K-index—a measure of the electrical potential. An international armada of solar and near-Earth space environment satellites were able to monitor this unprecedented event—a high potential storm in a time when the sun's normally very quiet.

A similar storm in January 1994 disabled the Canadian Anik E2 satellite. In that case ground controllers were able to successfully recover control. but could not get the spacecraft's momentum wheels (gyroscopes) back in operation. Consequently that spacecraft needed to use its thrusters to keep it pointed towards the Earth, which has reduced its anticipated lifetime.

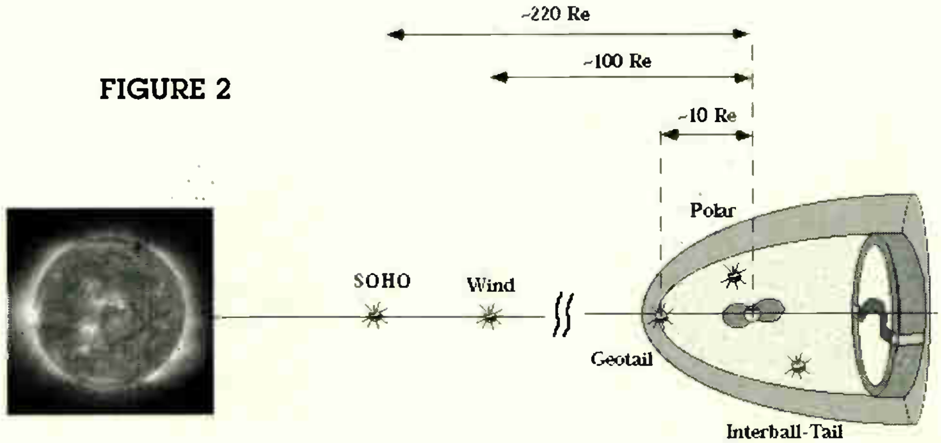


Telesat Canada was lucky to get back partial control of Anik E2. But AT&T Skynet wasn't so lucky. Within a week AT&T declared 401 a total loss, and ceased attempts to contact the satellite. It had only been in service for three years out of a planned twelve. The loss of the remaining anticipated service on the satellite was estimated at $150 million.

AT&T Skynet spokesperson David Thompson stated, "The thrusters were not firing when failure occurred." However, there are outside indications that the thrusters may have accidentally been

Relative Location of ISTP Constellation during Sun-Earth Connections Event: January 6-11, 1997

FIGURE 2



commanded to fire, possibly because of the storm's electrical interference.

An important clue to what happened lies in the two line elements, generated by the U.S. Space Command (USSPACECOM). USSPACECOM is responsible for tracking every single object in orbit, whether it's an active satellite, spent rocket stage, or piece of debris. At geosynchronous altitude anything larger than a soccer ball can be tracked. Figure 2 shows the plot of the satellite's period (how long it takes to complete one orbit) and eccentricity (how close it is to a perfect circle) over time. On January 10 at 2354 Universal time there was a sharp increase in eccentricity with a decrease in the period.

Normally a single "spike" can be discounted as an anomalous piece of tracking data; however, the unexpected changes continued, with the period and eccentricity leveling out. This data would seem to indicate that there was a firing of the spacecraft's thrusters to stabilize the spacecraft's orbit, and something went wrong which caused the spacecraft to tumble out of control.

Amateur satellite observer Mike McCants used the Austin Astronomical Society's 30 centimeter (12.5-inch) telescope to observe Telstar 401 a couple of days after its loss. Typically a 3-axis stabilized GE-7000 satellite like Telstar 401 appears as a steady 9th or 10th magnitude "star." Mike reported that Telstar 401's brightness was changing between 9th and 13.5th magnitude, with a period of 12 or 13 minutes. This matches the assumption that the satellite had tumbled out of control. Figure 3 is a graph of Mike's observations.

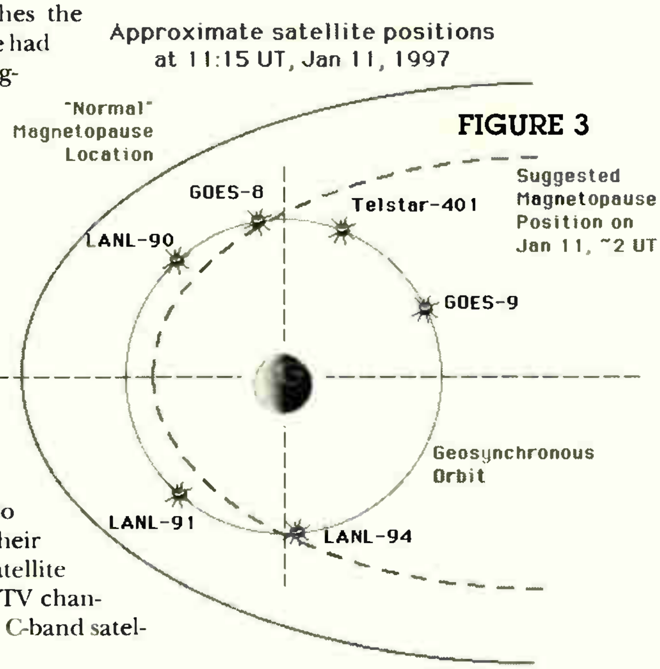


FIGURE 3

Telstar 401 was one of the most important distribution satellites for network television and syndicated feeds. ABC, FOX, UPN, and PBS all used Telstar 401 to distribute their network programming to their affiliates. In addition, major television distributors like Buena Vista (Disney), Keystone (Paramount), and others used the satellite to distribute programming to their clients. In addition the satellite hosted two full-time adult TV channels for private homes with C-band satellite dishes.

The loss of Telstar 401 occurred during the middle of negotiations for AT&T to sell off its Skynet division. On September 25, 1996 Loral Space and Communications agreed to purchase the Telstar satellites, the Hawley command center in New Jersey, and the Skynet services and customers for a total of $712.5 million. Loral and AT&T have indicated that they are still committed to the sale, but it remains to be determined how the 401 failure will affect the terms.

AT&T has asked the FCC for permission to move Telstar 302 from 85 West to 97 West as a bridge until Telstar 5 enters service. Telstar 302 had been "semi-retired" but has an anticipated remaining lifetime of six months, enough to permit an orderly transition to Telstar 5.

Telstar 302 was launched in 1983 on a Delta launch vehicle with a planned lifetime of nine years. It was removed from active service after 401's launch, remaining available as a backup satellite and for occasional use.

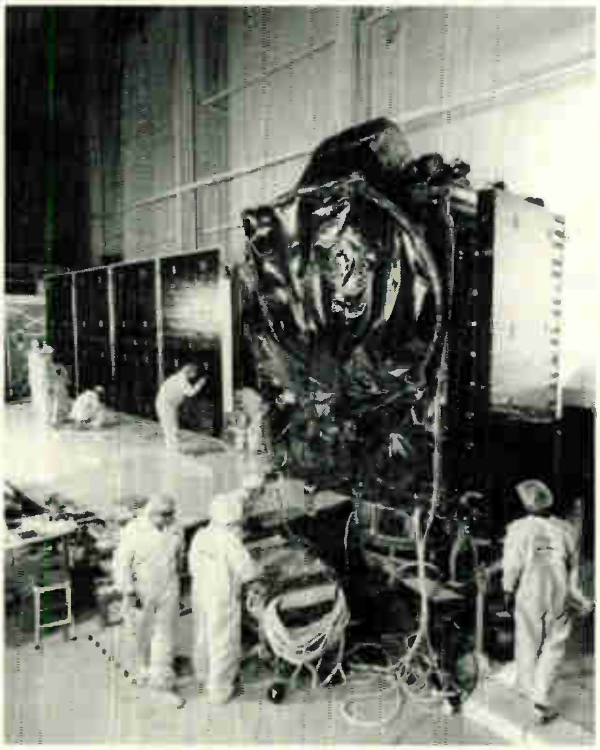
Telstar 5 is undergoing final construction in Palo Alto California by Space Systems Loral. It's scheduled for launch in May on a Russia-built Proton launch vehicle. Its original planned orbital location was 93 degrees West, but AT&T has requested permission to reassign it to the 97 degrees West slot which was occupied by Telstar 401.

Space Systems Loral is also in the initial stages of construction of the Telstar 6 and Telstar 7 spacecraft. They're expected to be launched in the 1998-1999 timeframe; however, launch vehicle plans have not been finalized. The current contract also calls for a Telstar 8 spacecraft as a ground spare, and it's likely with Telstar 401's failure that its production will be accelerated.

The total value of the Telstar 401, 402, and 403 spacecraft, including launches and insurance, was reported to be $600 million. Telstar 402 was lost shortly after its launch in September 1994, leaving Telstar 402R (*nee* 403) the only working satellite in the Telstar 400 series. Currently Skynet's orbital assets include the fully functional Telstar 402R satellite, and the Telstar 302 and 303 satellites, which are reaching the end of their propellant supplies. The ground assets include the partially completed Telstar 5, 6, and 7 satellites under construction at Space Systems/Loral.

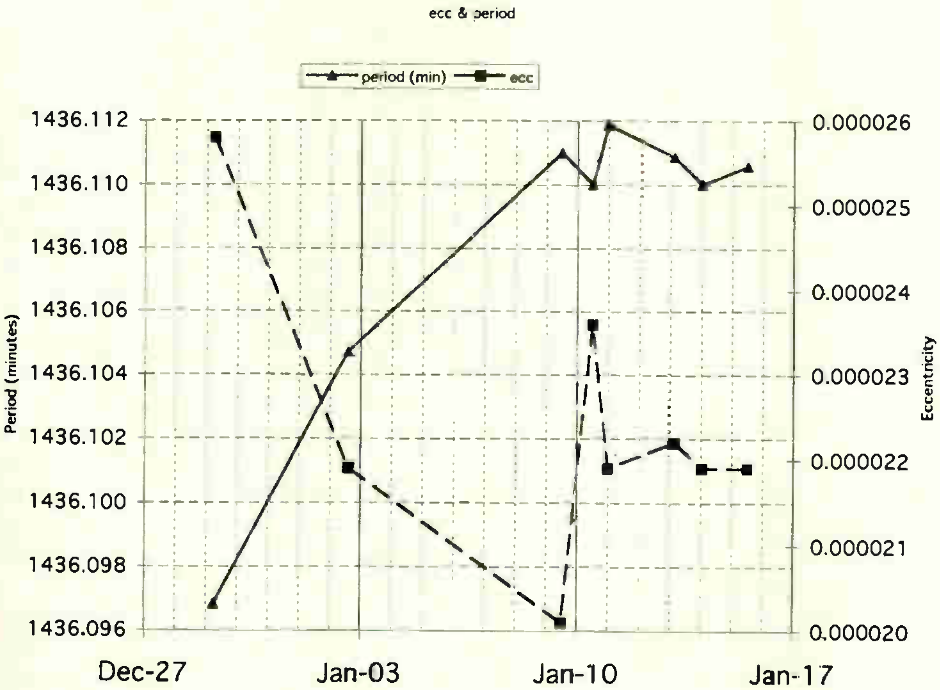
The Telstar 4 program was started in 1988 when AT&T examined replacements for its aging Telstar 301, 302, and 303 spacecraft. AT&T wanted to add Ku-band capabilities and more sophisticated spacecraft, which would fulfill the company's requirements into the next century. The company examined the Hughes HS-601, Loral FS-1300, and General Electric GE-7000 busses, and selected GE Astrospace in 1988. Three satellites were procured, two flight units plus a ground spare. Commercial launch services proposals were received from Arianespace and General Dynamics.

Telstar 401 was the heaviest domestic communications satellite ever built. At launch the 401 satellite weighed 3477 kilograms (7666 lbs.), almost three times the weight of the Telstar 300 series satellite it replaced. Each of the two solar wings measured 9.1 meters (30 feet) wide and generated 3.6 kilowatts of power. The satellite's communications payload consisted of 24 C-band transponders and 24 Ku-band transponders.



Telstar 410 was the heaviest domestic communications satellite ever built, weighing 7,666 lbs.

Each C-band transponder had the flexibility to operate from 12 to 23 watts, as specified by the service provider, and the Ku-band operated nominally at 60 watts but could be boosted to 120 watts. Depending on the spacecraft's power budget, up to 12 Ku transponders could be operated at the 120 watt level. The C-band SSPAs were configured as 28:24 redundancy, and Ku TWTAs were configured as 36:24, to ensure full transponder redundancies for the spacecraft's entire planned life. C-band bandwidth was 36 MHz and the Ku side was configurable for either 27 MHz or 54 MHz. Total RF power was 1680 watts. In addition, the spacecraft had cross strapping capabilities by which a signal can be received on one band and retransmitted on the other.



The C-band capabilities of the Telstar 400 satellites alone were a significant improvement over the existing 300 series. The transponders produced more power and the satellite had a longer planned lifetime. The Ku-band payload opened up new AT&T's markets, especially for VSAT applications.

Telstar 401 was launched on December 15, 1993, on an Atlas IIAS launch vehicle. The launch marked the inauguration of the highest performance version of the Atlas II family and the first launch of a GE-7000 satellite. Due to better than anticipated launch vehicle performance, less spacecraft propellant was required than budgeted for the transfer orbit, and Telstar 401 arrived on station with additional propellant. Had the spacecraft lasted its normal duration, the—additional propellant could have been used to extend its useful life in orbit. AT&T had anticipated operating Telstar 401 though the year 2006 before the failure.

While Telstar 401 is now a dead satellite and an expensive piece of space junk, it should not be a hazard for other spacecraft. There are no indications of a physical explosion, like a battery or propellant tank failure, which would have resulted in major pieces separating from the satellite. Without active control from the ground it's clear that the satellite is dead. Eventually the satellite will drift out of geosynchronous orbit toward a "graveyard" where dead objects in geosynchronous orbit tend to collect.

There is enough room at geosynchronous altitude to permit many satellites to occupy a given orbital location without any fear of collision, so it's quite safe to park another satellite in Telstar 401's slot. If ground-based radar tracking seems to indicate that an non-functional satellite is heading towards a satellite in use, the active satellite can make an appropriate engine burn to move out of the way.

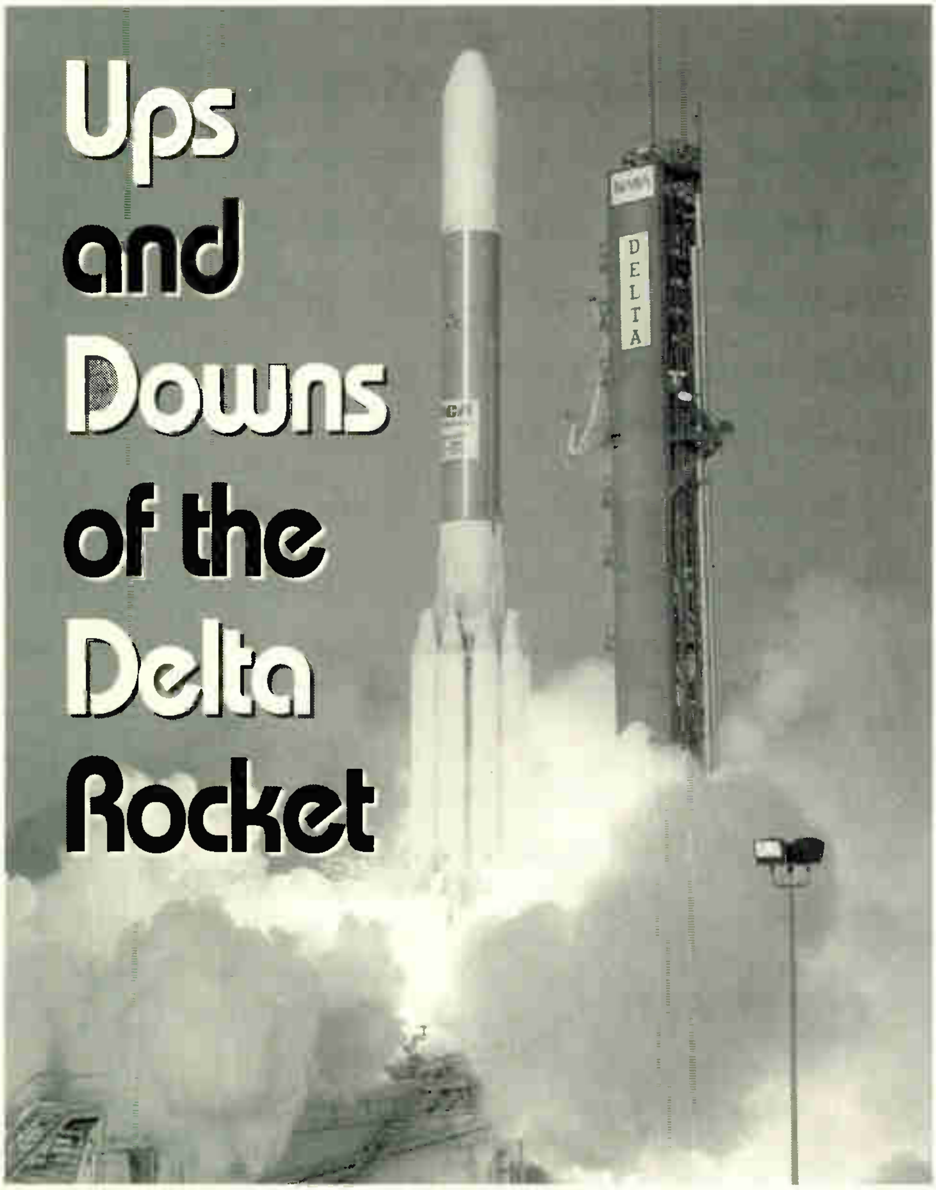
In any case, the loss of Telstar 401 was a significant set back to the communications satellite industry, major satellite distribution networks, and the home satellite dish community.

ST readers can keep up with the latest developments by monitoring the AT&T's Skynet worldwide web site at:

http://www.att.com/skynet/

To keep track of space weather, readers should point their web browsers at the space environment home page at: **http://www-istp.gsfc.nasa.gov/istp/cloud_jan97/event.html** ST

Ups and Downs of the Delta Rocket



When a rocket explodes above the launch pad, it's a spectacular event—visible from miles around, and audible for over 40 miles. It's also national news. And it was a particular shock in the case of the extremely reliable McDonald Douglas Delta II launch vehicle.

By Phillip Chien

On January 17, 1997, Delta 241, carrying the first GPS Block IIR satellite, was launched at 11:28 a.m. Eastern Time. Two seconds after launch a sharp bang was heard, and at 13 seconds after launch the rocket exploded—in a cloud of heat, noise, and falling debris. Personnel within the flight hazard zone quickly ran for cover. As a precautionary measure the public in nearby Cape Canaveral was asked to stay inside in case any poisonous byproducts from the rocket's propellants drifted in their direction.

It was the worst Delta disaster—and the worst accident for an unmanned launch vehicle in two decades. But even then the Delta's reliability record still stands out. Out of 241 launches the Delta has been successful on 227 tries. Out of the 14 failures, two were only partial failures, with the payloads still able to perform part of there missions. The last complete failure of a Delta launch vehicle prior to Delta 241 was Delta 178—eleven years—and 63 launches ago.

Delta 241 was a 7925 model. The "7" indicates that it has the improved Rocketdyne RS-27A engine in its first stage. This engine burns RP-1 (highly refined kerosene) and liquid oxygen. The RS-27A engine has a 12:1 expansion ratio nozzle which gives better high altitude performance than the previous 8:1 expansion ratio nozzle.

The "9" indicates 9 GEM (Graphite Epoxy Motor) strap-ons. Allied Techsystems (formerly Hercules Aerospace) builds the GEM strap-ons. They are filament-wound composite cases and have been flying on the Delta since 1990. Hundreds of GEMs have flown, preceded by thousands of the earlier steel-cased Castor strap-ons. Each of the nine GEMs is 1.03 centimeters (40.6-inches) in diameter, 11.09 meters (436.6-inches) long, and holds 11,767 kilograms (25,942 lbs) of propellant.

Six of the GEM motors ignite at liftoff, and the remaining three are ignited at altitude after the six "ground start" motors have been ejected. On recent Deltas the three air-start GEMs have higher expansion ratio nozzles to improve their performance.

The "2" indicates a standard Delta second stage with an Aerojet AJ10-118K liquid propellant engine. It burns the highly toxic monomethyl hydrazine and nitrogen tetroxide hypergolic propellants. Hypergolic propellants are ones which ignite spontaneously when mixed, without requiring an ignition source. They can be stored at any temperature but are highly poisonous. When they're loaded into the launch vehicle the pad area is cleared of all non-essential personnel, and the loading is done wearing protective suits with self-contained oxygen packs.

The "5" indicates a standard third stage, a Thiokol Elkton Star 48B upper stage, also known as PAM—Payload Assist Module. The PAM is a highly reliable spin-stabilized solid propellant stage which has been used from the Delta and space shuttle.

Lost in the Delta 241 accident was the first Block IIR satellite. It had been scheduled for launch last August (see *Satellite Times* "Precision Signals from Space - The GPS Satellites," page 90, March/April 1996), but was delayed due to problems encountered during its testing and checkout. What's "fortunate"—if that's the right word—is that the GPS IIR is an assembly line satellite with plenty of backup capability. Its price to the taxpayers is "only" $40 million—less than half the price of a typical commercial communications satellite. More importantly, it wasn't a one-of-a-kind satellite like the Mars Global Surveyor or Mars Pathfinder, the most recent Delta payloads. The Mars probes each cost over three times as much as the GPS IIR which was lost on Delta 241.

Another fortunate aspect of the incident is that the satellite was intended as a backup to buttress the GPS constellation. The six orbital planes are labeled "A" through "F" with four satellites in each plane. GPS IIR-1 was intended to become F5, a spare satellite in the "F" orbital plane. If it had achieved orbit it would remain dormant until one of the F plane satellites required replacement. At that point its orbit would be adjusted to the proper position.

The value of the Delta 7925 launch vehicle was about $35 million, but it's important to remember that, whether or not the launch is successful, the vehicle is used up in every case. McDonnell Douglas's contract with the Air Force requires it to replace the launch vehicle in the case of a failure. The GPS satellite procurement includes additional satellites, just in case there is a launch vehicle failure or a premature satellite failure in orbit.

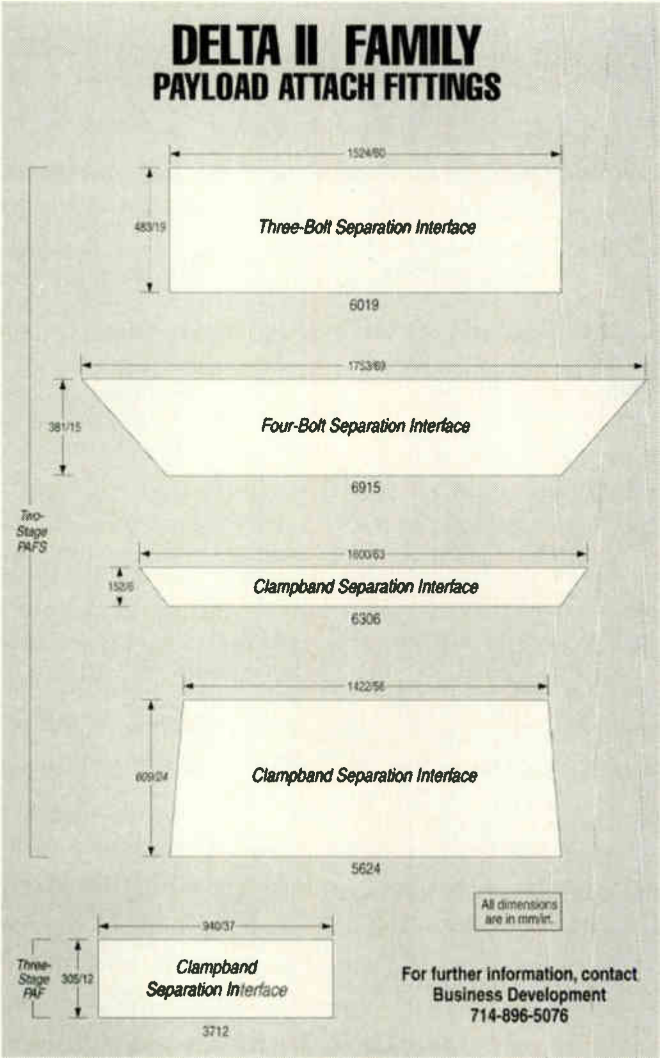
However, it's not all good news. When a rocket fails downrange there's little potential for damage to property or loss of life. The Air Force's Eastern Test Range monitors the downrange for each launch and will not permit a launch if there is more than a one in a million statistical chance that a life will be lost. But Delta 241 failed just 13 seconds into its flight—before it even cleared land.

Most of the Delta vehicle fell in the blast hazard area, a circle with a radius of 847 meters (2780 feet) from the launch pad. The explosion and debris resulted in damage to the launch complex 17 area. Fortunately the two launch gantries do not appear to have been damaged. However, approximately 20 of the 30 cars which were parked near the blockhouse were destroyed, along with several trailers which were used for office space. A cinder block administrative building received some damage from flying debris and overpressure from the blast. The fiber optic cableway which transmits data from the blockhouse to the launch vehicle was damaged, and smoke seeped in to the reinforced blockhouse. The 73 personnel in the blockhouse were forced to put on portable oxygen masks but were not injured.

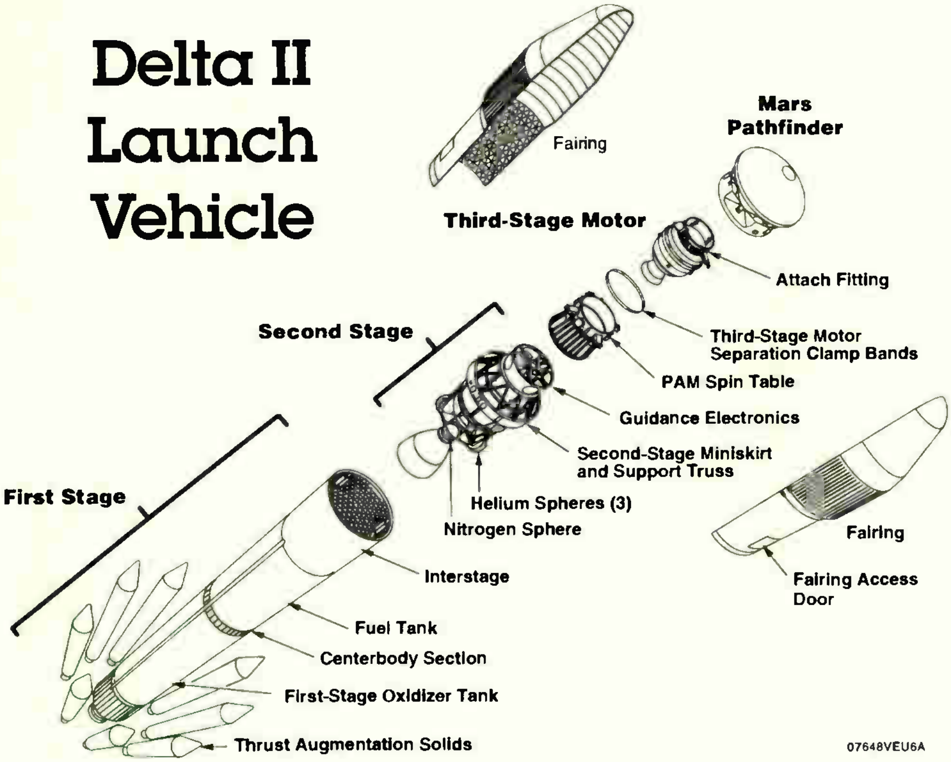
The horizontal processing facility, a building where launch vehicle components are prepared for flight, was partially damaged, but components for the next Delta launch inside were not harmed. Fuel storage vessels were not seriously damaged.

In the surrounding area an inactive blockhouse used for storage was hit by debris, but the Air Force has not provided any detail on the extent of the damage. The Air Force Space and Missile Museum is located very close to the Delta launch complex, but it had minimal damage, with no apparent damage to the exhibits. A 30th anniversary commemoration of the Apollo 1 fire had been scheduled at the museum, but was moved to the Astronaut Memorial due to the Delta failure.

In the short term there will be a major impact on the Delta's



Delta II Launch Vehicle



manifest. Ten launches had been scheduled from Cape Canaveral, Florida, with an additional seven launches from Vandenberg Air Force Base in Florida. The East coast manifest included an additional four GPS launches, a NASA scientific spacecraft, and four commercial customers. With the damages to the launch pad many of those flights will slip into 1998. The West Coast manifest included six launches of satellites for Motorola's Iridium constellation, plus the Air Force ARGOS mission. The ARGOS launch also includes two secondary payloads, the Danish Ørsted satellite, and South African Sunsat amateur radio satellite.

It's likely that, due to the damages to the Complex 17 area, that West Coast launches will resume before Deltas on the East coast are flying again. But there's little doubt in the space industry that Deltas will be flying again soon—and continuing their very strong reliability record.

Delta 241 Launch: *A Timeline*

- January 16, Delta 241 launch scrubbed due to high level winds.
- January 16, 11:20 local time. The countdown comes out of the planned 10 minute hold at T-4 minutes. Everything's go for launch. By coincidence the Mir space station, with the space shuttle Atlantis docked during its STS-81 mission, had flown over the Florida launch site about 15 minutes before the Delta's terminal count began.
- During the terminal launch sequence the vehicle's propellant tanks were pressurized, the spacecraft manager reported that the Block IIR spacecraft was ready to support the launch, and the Range safety personnel gave the final clear to launch.
- At T-10 seconds the igniters were armed.
- At T-2 seconds the Rocketdyne RS-27A main engine was ignited, along with two small vernier thrusters which control the vehicle's roll.
- At T-.25 seconds six of the Allied Tech Systems' solid motor strap-on boosters were ignited. To reduce stress on the vehicle only six solid motors ignite at liftoff; the remaining three ignite after the first six burn out.
- At T-0 seconds, 11:24 a.m. Eastern Standard Time, the vehicle lifted off the launch pad. The air temperature was 8.3 °C (47° F), and the winds were from the North Northwest at 37 km/hr (20 knots). All of the environmental factors, including weather and potential for lightning, were acceptable for launch.
- At T+2 seconds there was a sharp bang aboard the vehicle—which was heard by viewers about a mile from the pad.
- At T+13 seconds the rocket's onboard self-destruct system was activated. Contrary to popular opinion the destruct system does *not* destroy a rocket, it stops propulsion and lets the debris fall in a known and controlled area. (If you destroy a rocket completely you need *lots* of explosives, and leave very little for the investigation board ...) At this point the Delta had achieved an altitude of 484 meters (1,589 feet).
- At T+21 seconds a precautionary Range Safety command was sent, just in case there were still any pieces left. By this time spectators were scrambling for protective shelter, just in case any errant debris went astray.

Within an hour the all-clear signal was given. Winds had carried most of the byproducts of the explosive gasses out to sea. Some debris was reported in the ocean in the cleared area, within the flight hazard zone, and well within the impact limit lines. The blast danger area was littered with pieces of the launch vehicle and satellite, including still-burning pieces of solid propellant.

Measurements by safety personnel indicated that the toxic levels were on the order of one tenth of a part per million—orders of magnitude less than the chlorine level in a swimming pool.

A day later an Air Force failure investigation panel was named. As we go to press they had not released the results of their findings.

Previous Delta Failures

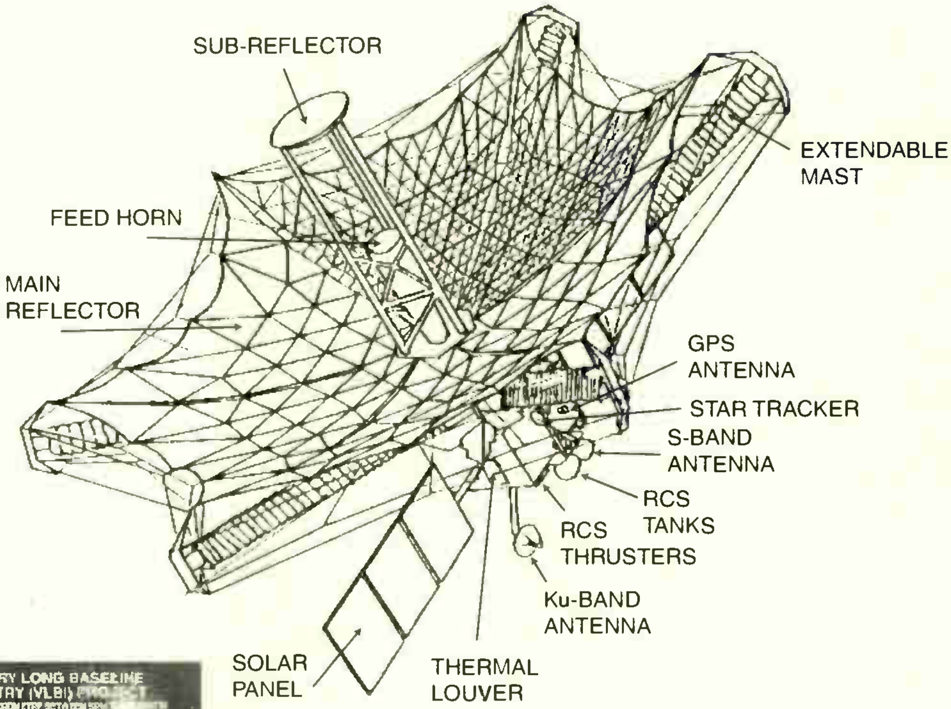
The Delta launch vehicle has been flying since 1960 and has earned an unrivaled reputation in the launch vehicle industry—over 98 percent reliability. Still, it's had its fair share of incidents. The Delta didn't start out with a good track record: in fact, it started out with a failure.

- Delta 1, launched on May 13, 1960, was the first launch of the Delta launch vehicle...and the first Delta failure. The payload was an Echo balloon satellite. The autopilot failed during the second stage coast period. Consequently the third stage never ignited, the spacecraft never separated from the launch vehicle, and the entire system eventually splashed down in the Atlantic Ocean. Delta 2, carrying an identical replacement, was launched successfully on August 12, 1960.
- Delta 24, launched on March 19, 1964, carried the Beacon-Explorer-A spacecraft. Contact was lost 22 seconds after third stage ignition.
- Delta 33 was launched on August 25, 1965 carrying the third Orbiting Solar Observatory (OSO-3) spacecraft. It failed to orbit due to premature ignition of the third stage.
- Delta 59 was launched on September 18, 1968, carrying the first Intelsat 3 communications satellite. At T+102 seconds a malfunction occurred in the pitch axis of the autopilot. Six seconds later the Range Safety officer sent the destruct command.
- Delta 71 was launched on July 25, 1969, carrying the fifth Intelsat 3 comsat. The third stage failed while it was out of contact with the ground station network, and when the spacecraft was eventually found it was in a lower than planned orbit of 3508 by 267 kilometers. The spacecraft reentered on October 14, 1988, without entering service.
- Delta 73 was launched on August 27, 1969, with the Pioneer E spacecraft. The early solar Pioneer spacecraft were launched into orbits around the Sun away from the Earth's magnetosphere. Earlier Pioneers in the series proved to be extremely successful, far outlasting their planned lifetimes. But Pioneer E never made it to orbit. The first stage hydraulics failed. The second stage was able to recover from the violent maneuvering at separation, but was pointed the wrong direction when it ignited. The vehicle was destroyed 484 seconds in to the flight. This mission also carried a secondary payload TETR-C (Test and Training satellite) which was designed to train personnel in NASA's tracking stations around the world.
- Delta 86, launched on November 21, 1971, was the first Delta launched from Vandenberg Air Force Base in California to fail. Its payload was ITOS-B, (Improved TIROS Operational Spacecraft), a polar-orbiting weather satellite. During a planned one-hour coast period, a leak developed in the second stage oxidizer system which was stabilized by the pitch and yaw thrusters. However, once the thrusters ran out of fuel the vehicle tumbled, and the second stage and spacecraft impacted above the Arctic Circle.
- Delta 96, launched on July 16, 1973, with ITOS-E, another polar weather satellite. It lost control out of range of ground stations, but telemetry data indicated that at 270 seconds the second stage hydraulic pump abruptly failed, sending the vehicle in to an uncontrollable tumble.
- Delta 100, launched on January 18, 1974, carried the British Skynet IIA military comsat. A malfunction in the second stage guidance system resulted in the vehicle tumbling out of control.
- Delta 130, launched on April 20, 1977, carried GEOS European scientific satellite. Its purpose was to study propagation paths of high energy particles from the Sun. It was intended to be the first purely scientific spacecraft (i.e., not communications or meteorology) in geosynchronous orbit. The "spin table;" which rotates the third stage and spacecraft for stability during the third stage burn, failed to spin up properly, so the stage burned blindly without any control. Spacecraft controllers were able to reprogram the satellite to fire its onboard motor for the best orbit which could be achieved—a 70,365 by 1,215 kilometer orbit instead of the planned 35,888 x 35,888 kilometer orbit. The spacecraft was able to complete some of its scientific objectives and is still in orbit.
- Delta 134 was launched on September 13, 1977, with the European OTS-1 (Orbital Test Satellite) experimental communications satellite. Until Delta 241 this was the most catastrophic Delta failure. The Delta 3914 launch vehicle used nine steel-cased Castor IV solid motors. One of the solid motors burned through its case, and the vehicle exploded 54 seconds in to its mission.
- Delta 178 was launched on May 3, 1986 with the GOES-G geosynchronous weather satellite. For NASA this was an especially hard time, just four months after the Challenger accident when everyone was hoping to build morale with a successful Delta launch. At this point the Delta had had a success streak of 43 successful launches in a row, a world record. The satellite was critically needed, due to premature failures of a sensor on the orbiting satellites, leaving the United States with only one functional geosynchronous weather satellite. Unfortunately, a short in the first stage electronics caused the vehicle to tumble out of control at T+71 seconds. The range safety command was sent 20 seconds later.
- Delta 228 was launched on August 5, 1995, with the first Korean geosynchronous communications satellite, Koreasat 1. One of the nine solid boosters failed to separate and the vehicle had to carry the dead weight of the empty booster casing through the end of the first stage. The excess weight caused the launch vehicle to leave the satellite in a lower than planned orbit. Satellite engineers were able to use the spacecraft's on-board stationkeeping propellant to nudge the satellite up to geosynchronous orbit, at the expense of drastically reducing its planned operating lifetime.
- Delta 241 was launched on January 17, 1997, carrying the first Navstar Block IIR satellite. It failed 13 seconds into its flight.

What this list doesn't show is the literally hundreds of successful Delta missions, carrying scores of communications, weather, scientific, navigation, and military satellites, and even a handful secondary payloads and planetary probes.

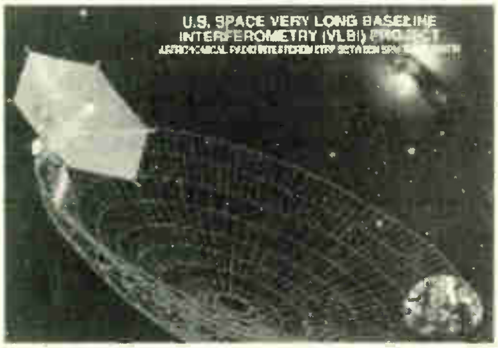
New Radio Telescope is Larger than Earth

NASA and the National Radio Astronomy Observatory are joining with an international consortium of space agencies in support of the launch of a Japanese satellite—Muses B. This new satellite will create the largest astronomical "instrument" ever built—a radio telescope more than two-and-a-half times the diameter of the Earth that will give astronomers their sharpest view yet of the universe.



The launch of the Very Long Baseline Interferometry (VLBI) Space Observatory Program (VSOP) satellite by Japan's Institute of Space and Astronautical Science (ISAS) was scheduled for February 10 at presstime.

The satellite is part of an international collaboration led by ISAS and backed by Japan's National Astronomical Observatory; NASA's Jet Propulsion Laboratory (JPL), Pasadena, CA; the National Science Foundation's National Radio Astronomy Observatory (NRAO), Socorro, NM; the Canadian Space Agency; the Australia Telescope National Facility; the European VLBI Network; and the Joint Institute for Very Long Baseline Interferometry in Europe.



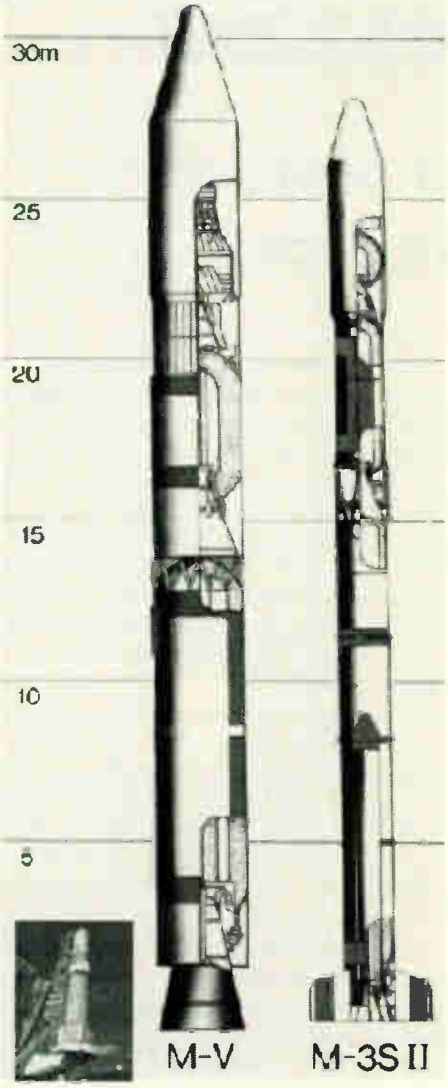
Very long baseline interferometry is a technique used by radio astronomers to electronically link widely separated radio telescopes together so they work as if they were a single instrument with extraordinarily sharp "vision," or resolving power. The wider the distance between telescopes, the greater the resolving power. By taking this technique into space for the first time, astronomers will approximately triple the resolving power previously available with only ground-based telescopes. The satellite system will have resolving power almost 1,000 times greater than the Hubble Space Telescope at optical wavelengths. The satellite's resolving power is equivalent to being able to see a grain of rice in Tokyo from Los Angeles.

"Using space VLBI, we can probe the cores of quasars and active galaxies, believed to be powered by super massive black holes," said Dr. Robert Preston, project scientist for the U.S. Space Very Long Baseline Interferometry project at JPL. "Observations of cosmic masers—naturally-occurring microwave radio amplifiers—will tell us new things about the process of star formation and activity in the heart of other galaxies."

"By the 1980s, radio astronomers were observing the universe with assemblages of radio telescopes whose resolving power was limited only by the size of the Earth. Now, through a magnificent international effort, we will be able to break this barrier and see fine details of celestial objects that are beyond the reach of a purely ground-based telescope array. We anticipate a rich harvest of new scientific knowledge from VSOP," said Dr. Paul Vanden Bout, Director of NRAO.

In the first weeks after launch, scientists and engineers will "test the deployment of the reflecting mesh telescope in orbit, the wide-band data link from the satellite to the ground, the performance of the low noise amplifiers in orbit, and the high-precision orbit determination and attitude control necessary for VLBI observations with an orbiting telescope," according to Dr. Joel Smith, manager of the U.S. Space VLBI project at JPL. Scientific observations are expected to begin in May.

The 26-foot diameter orbiting radio telescope will observe celestial radio sources in



concert with a number of the world's ground-based radio telescopes. The 1,830-pound satellite will be launched from ISAS' Kagoshima Space Center, at the southern tip of Kyushu, one of Japan's main islands, and will be the first launch with ISAS' new M-5 series rocket.

The satellite will go into an elliptical orbit, varying between 20,000 to 1,000 kilometers above the Earth's surface. The orbit will have a 31 degrees inclination. This orbit provides a wide range of distances between the satellite and ground-based telescopes, which is important for producing a high-quality image of the radio source being observed. One orbit of the Earth will take about six hours.

The satellite's observations will concentrate on some of the most distant and intriguing objects in the universe, where the extremely sharp radio "vision" of the new system can provide much-needed information about a number of astronomical mysteries.

For years, astronomers have known that powerful "engines" in the hearts of quasars and many galaxies are pouring out tremendous amounts of energy. They suspect that supermassive black holes, with gravitational fields so strong that not even light can escape them, lie in the centers of these "engines." The mechanism at work in the centers of quasars and active galaxies, however, remains a mystery. Ground-based radio telescopes, notably NRAO's Very Long Baseline Array (VLBA), have revealed fascinating new details in recent years, and VSOP is expected to add a wealth of new information on these objects, millions or billions of light-years distant from Earth.

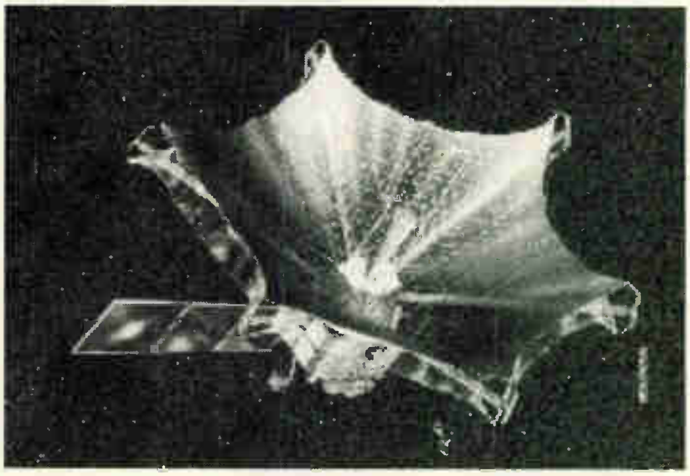
Many of these same objects act as superpowerful particle accelerators to eject "jets" of subatomic particles at nearly the speed of light. Scientists plan to use VSOP to monitor the changes and motions in these jets to learn more about how they originate and interact with their surroundings.

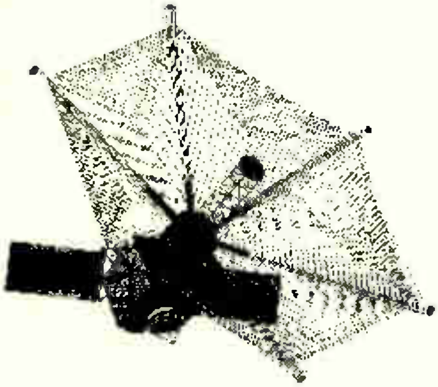
The satellite also will aim at regions in the sky where giant collections of water and other molecules act as natural amplifiers of radio emission much as lasers amplify light. These regions, called cosmic masers, are found in areas where new stars are forming and near the centers of galaxies. Observations can provide the detail needed to measure motions of individual maser "spots" within these regions, and provide exciting new information about the star-forming regions and the galaxies where the masers reside. In addition, high-resolution studies of cosmic masers can allow astronomers to calculate distances to them with unprecedented accuracy, and thus help resolve continuing questions about the size and age of the universe.

The project is a major international undertaking, with about 40 radio telescopes from more than 15 countries having committed time to co-observe with the satellite. This includes the National Science Foundation's Very Long Baseline Array (VLBA), an array of 10 telescopes spanning the United States from Hawaii to Saint Croix; NASA's Deep Space Network (DSN) sites in California, Spain, and Australia; the European VLBI Network, more than a dozen telescopes ranging from the United Kingdom to China; a Southern Hemisphere array of telescopes stretching from eastern Australia to South Africa; and Japan's network of domestic radio telescopes.

In the United States, NASA is funding critical roles in the VSOP mission at both JPL and NRAO. JPL has built an array of three new tracking stations at its DSN sites in Goldstone, California; Madrid, Spain; and near Canberra, Australia. A large existing tracking station at each of these sites has also been converted to an extremely sensitive radio telescope for simultaneous observations with the satellite. JPL also is providing precision orbit determination, scientific and operational planning support to the Japanese, and advice to U.S. astronomers who wish to observe with the satellite. NRAO is building a new tracking station at Green Bank, West Virginia; contributing observing time on the VLBA array of telescopes; modifying existing data analysis hardware and software, and aiding astronomers with the analysis of the VSOP data. Much of the observational data will be processed at NRAO's facility in Socorro, New Mexico, using the VLBA Correlator, a special purpose high-performance computer designed to process VLBI data.

VSOP is the culmination of many years of planning and work by scientists and engineers around the world. Tests using NASA's Tracking and Data Relay Satellite System (TDRSS) proved the feasibility of space VLBI in 1986. Just last year, those old data were used again to test successfully the data-reduction facilities for VSOP.





JPL manages the U.S. Space Very Long Baseline Interferometry project for NASA's Office of Space Science, Washington, D.C. The VLBA, headquartered in Socorro, New Mexico, is part of the National Radio Astronomy Observatory, a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

TABLE 1: VSOP/MUSES-B Mission Details

Program Elements	
Lead Organization - Institute of Space and Astronautical Science (ISAS)	
	Launch Date - February 1997
	Launch Vehicle - M-V Rocket
	Mission Lifetime - 3 years
Mission Characteristics	
	Perigee Altitude - 1,000 Km
	Apogee Altitude - 22,000 Km
	Orbit Inclination - 31 Degrees
	Orbital Period - 6.6 Hours
	Spacecraft Mass - 820 kg
Observing Frequencies (tunable in 1-MHz steps)	
	22.0 - 22.3 GHz
	4.7 - 5.0 GHz
	1.60 - 1.73 GHz
Observing Parameters	
	8 meter antenna
	30-50% Aperture Efficiency
	100-200 K System Temperature
	128 Megabit/s Data Rate
	16-MHz Channel Bandwidth (2 channels)
	Left Circular Polarization
R.M.S. Continuum Sensitivity to 1 VLBA Antenna	
	(32-MHz bandwidth, 90% coherence)
	22.2 GHz - 64 mJy for 150-sec. integration time
	4.8 GHz - 16 mJy for 350-sec. integration time
	1.6 GHz - 13 mJy for 650-sec. integration time

Listening for Meteors at Los Alamos

Chicken Little might have liked Los Alamos National Laboratory researcher Doug ReVelle, a guy who keeps an "ear" to the sky listening for falling objects that travel many times faster than the speed of sound.

And each year at least one fairly large extraterrestrial object comes rumbling into Earth's atmosphere, said ReVelle, who presented information about using very low-frequency sound waves to detect meteors at the Fall 1996 meeting of the American Geophysical Union's in San Francisco.

ReVelle and colleagues Rod Whitaker, Tom Armstrong and Paul Mutschlecner work in the Comprehensive Test Ban Treaty International Monitoring System infrasound program in Los Alamos' Earth and Environmental Sciences Division.

Using data from Los Alamos listening stations originally set up to monitor underground nuclear explosions, ReVelle, a meteorologist in Los Alamos' new Atmospheric and Climate Sciences Group, hears the infrasonic signature created when meteors enter the atmosphere—even if no one is around to see them. The Los Alamos stations, around since 1983, still are enlisted in the nation's nuclear non-proliferation efforts, but have provided a way for scientists to gain insight into the proliferation of bolides, larger-than-average space debris that slams into Earth's atmosphere and creates brilliant fireballs in the sky.

"Each year, we see at least one object entering the atmosphere that's about six meters in diameter," he said. "These make an infrasonic signal similar to what you'd see from a 15-kiloton explosion, an explosion of 15,000 tons of TNT, depending on the object's velocity and density. And each year we see around 10 objects entering the atmosphere that are equivalent to a one-kiloton blast—or about two meters in diameter."

ReVelle often speaks of meteor size in terms of explosive yield because meteors and nuclear tests have something in common: Each creates a sound/pressure wave in the atmosphere that can be "heard."

"Infrasonic waves are very low frequency sounds that exist somewhere in the realm between hearing and meteorology," ReVelle said. "These sounds are well below the range of human hearing, which ends at about 30 Hertz, but actually can be detected as small changes in atmospheric pressure. If you had a barometer that was sensitive enough, you'd be able to see fluctuations of several microbars when the waves arrive."

The United States Air Force operated a network of stations to listen for nuclear weapons tests. The network was the nation's first line of warning during the 1960s and early 1970s—until the rise of the satellite era—ReVelle said. With the array, scientists could determine the size and origin of the infrasonic waves.

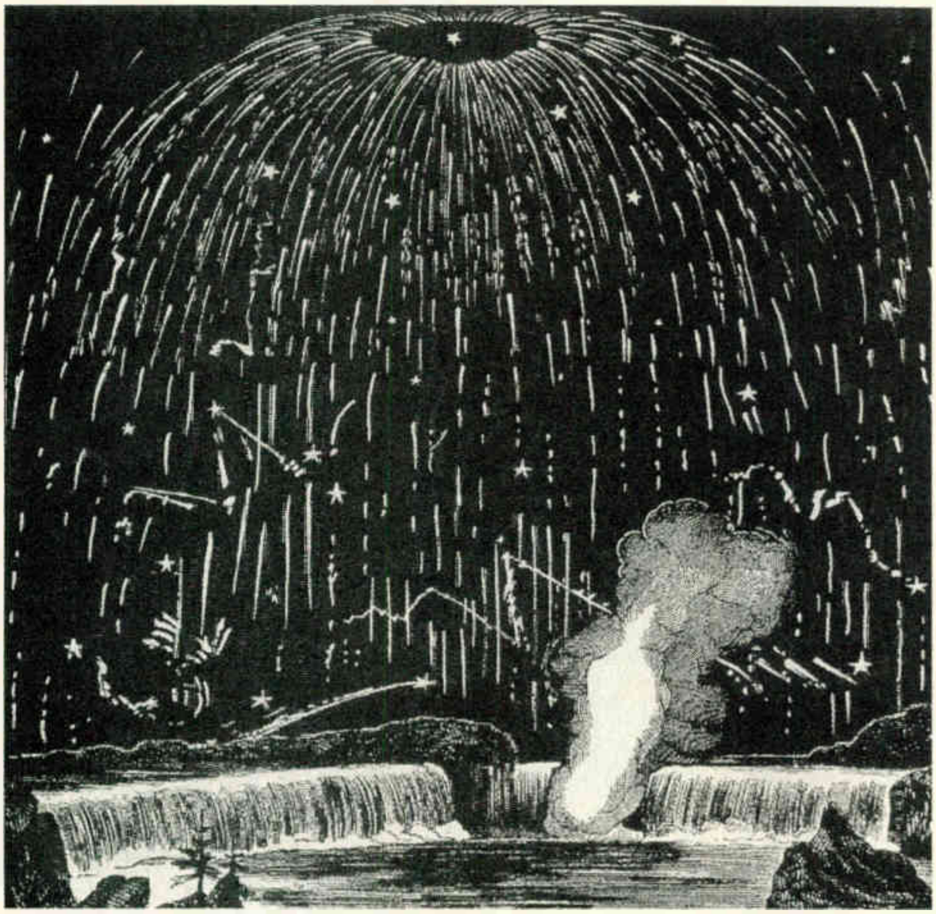
And in the early days of listening for nuclear weapons, the arrival of these very low-frequency sound waves sometimes put the nation on very high alert.

"On Aug. 3, 1963, just before the Bay of Pigs, the stations detected a one-megaton event south of Africa," ReVelle said. "As you can imagine, it must have created quite a stir. It turned out to be a bolide that could have been as large as 25 meters in diameter."

Since infrasound monitoring stations were set up, a number of large events have been recorded, among them:

- On Sept. 26 and 27, 1962, two separate objects with an equivalent explosive force of 20 kilotons and 30 kilotons (each at least six to eight meters in diameter), respectively, entered the atmosphere above the Middle East .

- On April 1, 1965, the network detected the Revelstoke Meteorite, an object somewhere around six meters in diameter. The meteorite yielded enough infrasonic and seismic data that research-



A woodcut of the 1833 Leonid meteor storm, as illustrated by an editor of Mechanic's Magazine. Observers sometimes report that they can actually hear meteors as they burn up in the atmosphere, although most are audible only to specialized equipment such as that at Los Alamos. (Drawing courtesy of Sky and Telescope).

ers were able to plot a trajectory and comb an area of Canadian wilderness in search of the crater.

It was never found, but scientists did find about two grams of the object on the ground. The Revelstoke Meteorite was the smallest ever recovered and it was comprised of a very soft material known as carbonaceous chrondrite, which will crumble when lightly squeezed.

- On February 1, 1994, an object that was about 15 meters in diameter slammed into the atmosphere over the Marshall Islands in the Pacific at a velocity of about 25 kilometers a second. Luckily, the fireball, reported by some witnesses as being brighter than the sun for about a second, most likely came down in the ocean, ReVelle said.

Many large events have been recorded since the 1960s, but 1996 was a particularly good year for fireballs, particularly the nights of Oct. 2 through 4, when nearly a dozen bolides were seen over the Earth.

"The Earth ran into a swarm of these things in October," ReVelle said. "Who knows where they came from; perhaps they were the result of a near-Earth asteroid that had collided with something, maybe the moon."

During that period, at least five separate fireballs were noticed and recorded above California, as well as two above New Mexico and others above the Pacific Northwest. A particularly bright fireball appeared near Little Lake, California, on October 3, 1996, at around 8:45 p.m. PDT, and could be seen above Los Angeles and San Francisco; about 105 minutes earlier, a fireball had appeared in the skies above New Mexico.

The California bolide—estimated to be about three-quarters of a meter in diameter and detected by three infrasound stations that were nearly 600 miles away and 31 California seismic stations—was seen by more than 200 people. Many actually heard the object.

"Sometimes you'll actually hear a hissing or a buzzing noise and you'll turn around, look and see a fireball," he said. "What you're hearing is more of an electrical disturbance caused by the object interacting with Earth's geomagnetic field. The perturbation travels at nearly the speed of light, while the bolide itself only travels 50 to 100 times faster than the speed of sound, and that's why people were able to turn around and see the thing after they heard it."

The October fireballs above California and New Mexico were the subject of plenty of publicity and speculation. Researchers originally believed that one fireball had entered the atmosphere, skipped back into space, orbited Earth once and re-entered the skies again.

ReVelle's infrasonic data and subsequent reports from ground observers indicate, however, that the fireballs seen that night above New Mexico and California came from two different objects—trajectories indicate that the first bolide didn't enter the atmosphere at an angle that would allow it to skip back out into space.

Still, the events intrigue ReVelle and other researchers at Los Alamos, Sandia National Laboratory, the University of California at Los Angeles and the University of Western Ontario.

"There are a number of questions left to be answered about the October 3 fireballs," he said, "and there are some things which don't quite add up. You know, I'm not really sure what was happening in the sky that night."

The four arrays of listening stations operated by Los Alamos—the only such network left in regular operation in the world—can detect meteors that are as small as a few centimeters in diameter. The stations are useful because they can help validate other non-proliferation and verification techniques, and they cost very little to operate and maintain.

"In the realm of non-proliferation, it's a very inexpensive insurance policy, and the array gives us a tremendous opportunity to learn about meteors and atmospheric phenomena as well," ReVelle said.

Los Alamos National Laboratory is operated by the University of California for the U.S. Department of Energy.

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

Truth, Lies, and Amateur Satellitess

The percentage of amateur radio operators who are involved in OSCAR satellite communications is relatively low. One possible explanation this is a general misconception that amateur satellite communications is an expensive activity.

We've all seen photographs in books and magazines of hamshacks displaying impressive antennas and station equipment that cost tens of thousands of dollars, all under the control of computers that do everything but take out the garbage. The truth is, there's more to amateur satellite communications than just buying expensive equipment and paying bills. In fact, as electronic technology advances, it is actually becoming easier and less expensive to become involved in satellite communications, even on microwave frequencies. This fact is well-known in Europe, but doesn't seem widespread in many other parts of the world.

Simple Mode A CW ground station consisting of a Grundig YB-400 portable shortwave receiver and Radio Shack HTX-202 2-meter handheld transceiver. Such a combination is effective for making portable CW contacts through RS-10's Mode A ROBOT.

Receiving is the first step

As a reader of *Satellite Times,* and perhaps also of *Monitoring Times,* it should come as no surprise that those with an interest in satellite communications usually develop their interest by simply monitoring a radio transmission from a satellite, either intentionally or by accident. Just think of how many amateur radio operators, or people involved in commercial two-way communications and broadcasting, got their interest in radio by simply turning on a receiver, tuning across a band, and hearing a signal from a distant location. Radio hobbyists and professionals alike, who hold fond memories of their early days with radio, certainly appreciate the magic and mystique of radio communications, because their earliest experiences were usually with equipment that was simple, cheap, primitive, and probably shouldn't have worked in the first place. But it did work, and that's what made it so special.

Simple is better

It's clear that "simple" and "easy" are good selling points in any field. Unfortunately, too many radio hobbyists are under the impression that satellite communications is expensive and difficult, and complain that OSCAR satellites need to be designed to be easier to use. Actually, there has never been an easier time than now to get involved in amateur satellite communications as there is now. But there's a problem with making things seem too easy. Newcomers are often discouraged when they cannot hear or make a contact through a satellite that's touted as being easily accessible with simple equipment.

The Myth of Mir and SAREX

Shuttle Amateur Radio Experiments (SAREXs) and communications with the amateur radio station on-board the Russian Mir space station are frequent starting points for those with budding interests in amateur satellite communications. Two-meter FM is normally used for these communications because the equipment required is simple, cheap, and plentiful. The elimination of Morse code proficiency for the U.S. Technician Class Amateur Radio Operator's License has even made it easier than ever to earn an FCC license to communicate with astronauts and cosmonauts operating on 2-meter FM from space.

Despite this, contacts with the Mir space station and SAREX packages carried on U.S. space shuttle missions are, by far, the most difficult of all amateur satellite contacts to make! The reason for this is simple. Thousands upon thousands of people try to make contact with Mir or the Space Shuttle simultaneously on the same frequency, and the result is they all end up interfering with one another and no one gets heard. Magazine and newspaper articles are quick to bring the news of successful contacts to everyone's eyes, but it's rare that anything is reported on the majority of operators, who through no fault of their own—never succeed in making a contact. Fortunately, there are other entry-level approaches to amateur satellite work that are easier and far more rewarding.

The RS Satellites

Several Russian Radio Sputnik (RS) satellites are currently active with transponders on 2-meters, 10-meters, and 15-meters from low-earth orbiting platforms. Since the Russian government limits the power level hams may use on the 2-meter band to only several watts, RS satellites with uplinks on the 2-meter band are designed to be very sensitive to low-power uplinks. Since the RS satellites fly not only over Russia, but also within range of every other part of the globe, anyone in the world can enjoy RS satellite access using simple, low-power, low-cost equipment.

One of the simplest approaches to RS satellite communications is pictured in Fig-

The first contact made from New Jersey with this equipment combination was with WB8UWK near Cleveland, Ohio. Although the distance between the ground stations was only 370 miles, the round trip distance the radio signals traveled through the satellite was close to 2000 miles!

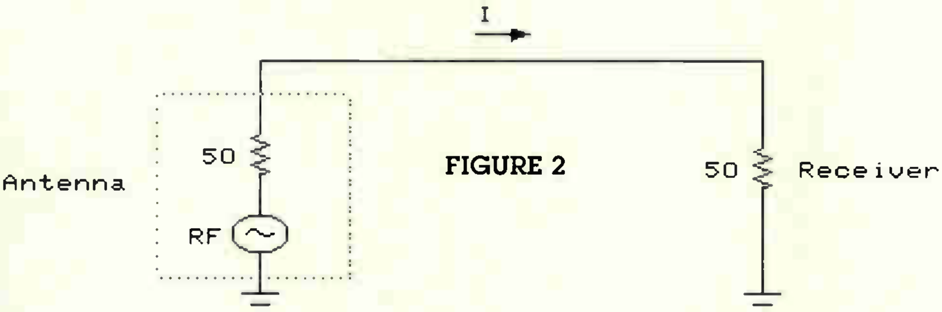


FIGURE 2

Thevenin equivalent circuit of an antenna feeding a receiver with proper impedance match for maximum energy transfer. Only 50 percent of the energy received by the antenna is delivered to the receiver. The rest is re-radiated back into space by the antenna.

ure 1. In this photograph, a Grundig model YB-400 portable shortwave receiver is used to copy RS-10 downlinks on 10-meters, while a Radio Shack HTX-202, 2-meter handheld transceiver is used as an uplink transmitter. Does this simple, low-cost, portable combination provide effective and reliable long distance communications via satellite? You bet it does! Using the push-to-talk (PTT) button on the 2-meter handheld transceiver, a CW signal was produced that was sufficient to activate RS-10's ROBOT (autotransponder). Although RS-10's ROBOT has been inactive for some time, it functions extremely well as a single channel CW transponder. An added bonus is the fact the ROBOT uplink is several kilohertz wide, providing a sufficient uplink window to allow for Doppler shift as well as "chirp" in the CW note of the uplink signal.

The first contact made from New Jersey with this equipment combination was with WB8UWK near Cleveland, Ohio. Although the distance between the ground stations was only 370 miles, the round trip distance the radio signals traveled through the satellite was close to 2000 miles! That's not bad for a 2-1/2 watt HT feeding a rubber duck antenna from an interior room on the lowest floor of a house (my kitchen) where accessing an FM repeater 10 miles away can sometimes be a challenge. CW contacts between W2RS in New Jersey and G3IOR in the northeast corner of England have also been made through RS-10's linear transponder using similar equipment. However, it is important to realize that such trans-Atlantic contacts were planned ahead of time and required considerable skill on both sides of the Atlantic to make a successful two-way contact.

Antennas: Fact and Fiction

There's an old adage in radio that states, "If you can't hear 'em, you can't work 'em." This is true not only of terrestrial communications, but of satellite communications as well. The most important element of a satellite ground station is the one that is the simplest and requires no electronics whatsoever: the antenna system. Even the most expensive and most sophisticated receiver in the world is useless if it isn't connected to an antenna system. Good antenna systems aren't necessarily complex or expensive. In fact, antenna theory, being based on simple laws of physics, hasn't changed very much over the years. Many proven designs have been published in books and magazines, so if money is an issue, it can usually be saved by building, rather than buying an antenna system.

Antennas are devices that convert electrical energy to electromagnetic radiation. They also convert electromagnetic energy to electrical energy. The former property is useful in transmitting applications. The latter, of course, is utilized when receiving.

Antennas provide both modes of energy conversion simultaneously. There's no such thing as a passive antenna system that only receives, or a passive antenna system that only transmits. In fact, it might come as a shock to some readers to learn that resonant antennas that are properly

Gain tells little of how well an antenna will perform in a particular situation. Gain is a measure of how well an antenna concentrates its radiated energy in a particular direction at the expense of other directions. Some applications require high gain and very directive antenna systems, while others do not.

matched to their feedlines (yielding a 1:1 SWR) effectively re-radiate one half of their received energy back into space. The reason for this is simple. At resonance, antennas exhibit an impedance that is purely resistive, and usually equal to that of the feedline and receiver input; this matched condition yields maximum energy transfer between antenna and receiver.

Figure 2 illustrates a Thevenin equivalent circuit of an antenna with a 50 ohm impedance feeding, a receiver with a 50 ohm input impedance. Since the current that flows through the receiver's input is the same as that which flows through the antenna, it is clear that the energy delivered to the receiver is, under ideal conditions, only half of the total received by the antenna. The other half is re-radiated back into space by the antenna. A small portion is also lost in the transmission line connecting the antenna to the receiver.

This property of antennas is not an issue in communication systems. However, it is interesting to point out that with so much emphasis placed on obtaining a 1:1 SWR in communication systems, it is under these very conditions that only a 50 percent system efficiency is realized. If the receiver in this example were replaced by a 50 ohm transmitter, then it is clear that half of the RF generated by the transmitter is radiated by the antenna. The remaining half is lost as heat in the transmitter.

FIGURE 4

The power gain G of an antenna is related to its capture area and wavelength by the following equation:

$$G = \frac{4\pi A_r}{\lambda^2}$$

Where A_r = the effective capture area

λ = wavelength

Gain is a very big selling point when speaking of antennas. However, gain tells little of how well an antenna will perform in a particular situation. Gain is a measure of how well an antenna concentrates its radiated energy in a particular direction at the expense of other directions. Some applications require high gain and very directive antenna systems, while others do not.

When comparing the effectiveness of various antennas on different frequencies, gain is a meaningless figure of merit. It is a well-known fact that as the operating frequency is increased, signals become weaker. Some books and references even refer to "free space path loss," and state the path loss between a transmitter and receiver increases as frequency increases. This couldn't be farther from the truth. There's nothing in free space that can attenuate radio signals. Space is loss free. While signal attenuation attributed to effects of terrain and foliage certainly does increase with increasing frequency, these factors do not normally come into play when speaking in terms of line-of-sight satellite communications. The reason signals over line-of-sight paths get weaker as the operating frequency is increased is because the antenna's capture area is reduced with higher operating frequencies.

FIGURE 3

The effective capture area A_r of an antenna is defined by:

$$A_r = \frac{G\lambda^2}{4\pi}$$

Where G = gain of antenna

λ = wavelength

Effective Capture Area Defined

The effective capture area of an antenna is directly related to its gain and inversely related to operating frequency. Antennas with larger apertures have higher gains. Parabolic reflector antennas (dishes) are a perfect example of this.

Figure 3 mathematically relates effective capture area as a function of antenna

Simple antennas, such as dipoles, can be very effective for receiving Mode A satellite downlink signals on 10-meters. A yagi of at least 10 dB gain is useful on 2-meters, and a slightly higher gain antenna with a high-gain, low-noise receiver is required for the 70-cm band and above.

gain (expressed as a real number, not a decibel, over an isotropic radiator), while Figure 4 relates gain as a function of effective capture area. What is important to realize is that, if gain is held constant, the effective capture area of an antenna decreases by a factor of the wavelength squared. Putting this in real terms, a unity gain dipole on 29 MHz has the same effective capture area as a 2-meter antenna with 14 dB gain over a dipole. By the same token, a 70-cm antenna would need nearly 24 dB gain to match the effective capture area of a dipole on 10-meters. More startling is the fact that a 75-meter dipole can capture more RF than most moonbounce arrays!

While antennas exhibit less capture area on higher frequencies, there still is something to be gained by moving up in frequency. Since atmospheric and galactic noise decreases with increasing frequency, receiver sensitivity can be increased dramatically on higher frequencies, thus somewhat offsetting the decreased capture area of antennas operating on these frequencies. This is important since it is noise, not the lack of signal, that limits the distance at which radio communications can take place. The signal-to-noise ratio of a communications system can be improved by either increasing the signal, lowering the noise, or doing both.

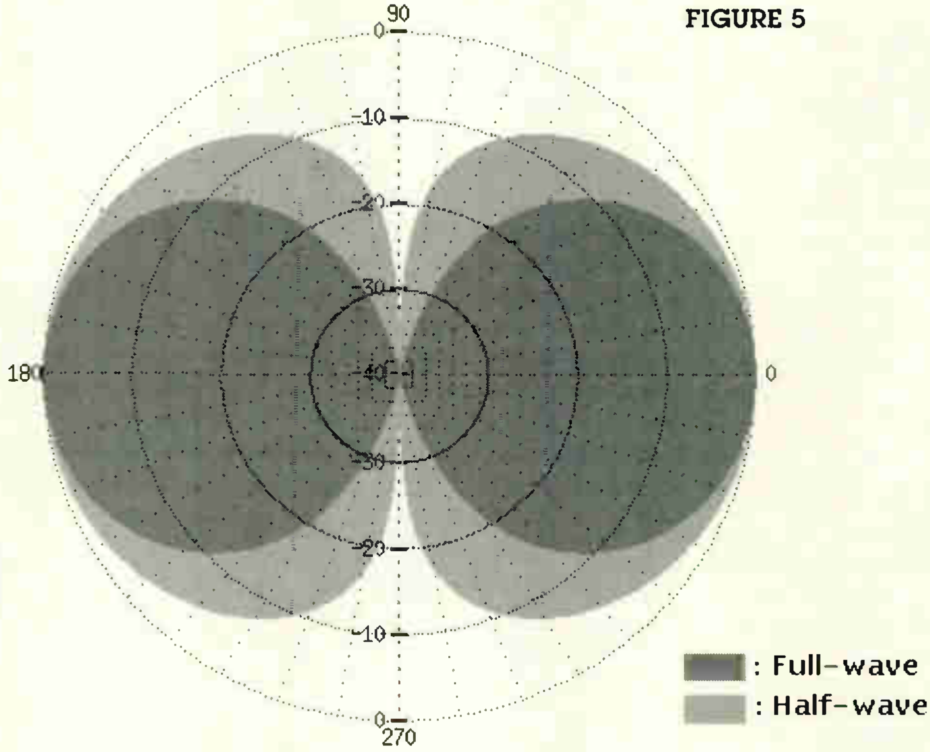
So, what does this have to do with OSCAR satellite communications? Well, it means that simple antennas, such as dipoles, can be very effective for receiving Mode A satellite downlink signals on 10-meters. A yagi of at least 10 dB gain is useful on 2-meters, and a slightly higher gain antenna with a high-gain, low-noise receiver is required for the 70-cm band and above.

Antenna patterns vs. gain

There's one last thing that's more important than antenna gain: radiation pattern. It is important in satellite communications that the antenna system used be responsive to the satellite when it is above the horizon. On 10-meters, where a simple dipole has a large enough aperture to receive OSCAR signals well, knowledge of its radiation pattern can be used to orient the antenna so it responds favorably to satellite passes.

Radiation Patterns Of Vertical Dipoles

FIGURE 5



Theoretical radiation patterns of a vertical half-wave dipole vs. a vertical full-wave dipole. The half-wave antenna, while having lower gain, produces a broad pattern suitable for Mode A satellite reception.

Figure 5 shows the theoretical vertical radiation patterns for a half-wave and a full-wave dipole. Both patterns have been normalized for unity gain. These patterns clearly indicate that the lower gain half-wave dipole provides better uniform coverage of satellite passes. The response null at zenith is not a problem since satellites rarely pass directly overhead, and when they do, they spend little time at high elevations. A half-wave vertical dipole, therefore, can be an very effective, and very inexpensive, Mode A downlink receiving antenna.

Achieving comparable performance on higher frequencies requires the use of antennas with gain. Yagis are typically used, while parabolic reflectors are popular on 2400 MHz. Such antennas are very directive, and so must be under the control of a rotator if a satellite is to be successfully tracked across the sky.

Conclusion

While antenna parameters such as gain and SWR are important selling points, they must be given proper consideration when designing an OSCAR ground station. The antenna is the most important part of a satellite ground station, and can be the lowest cost item if it is built, rather than purchased.

Finally, successful low-power satellite communications require frequencies clear of interference. While Mir and SAREX receive all the media attention, there are plenty of opportunities for simple and effective communications using the OSCAR and RS satellites that are currently in operation.

See you on the birds! ST

By Donald E. Dickerson, N9CUE

Russian Fone — Iridium East

As we approach the year 2001, one would expect almost any city with a population of over 9 million people to offer a modern, reliable phone service. This would especially be true if the city in question was the capital of one of the world's largest nations in land mass—stretching across 6,000 miles and five time zones—and possessing one of the world's most powerful military forces.

However, considering sixty percent of the world's population remains illiterate, it may not be so surprising that this city has an infamously antiquated and unreliable phone system. We in America often forget that the majority of the world's population will never see, in their entire lifetime, a shopping mall or a doctor.

Less than one home in five in this city has a telephone. If you want to call someone but don't have their number or don't remember it, you may as well forget it: Phone directories are virtually nonexistent. On the other hand, this country was the first to successfully launch an Earth orbiting satellite. Eight years later they introduced the world's first direct broadcast TV satellite system, Molniya.

Mockba (Moscow) is just such a city of contrasts. The contrasts don't end there, but stretch all across Russia and the loosely organized countries of the Commonwealth of Independent States (CIS). Russia remains one of the least populated countries in the world. Vast areas of the country are dotted with primitive villages with few of the modern convenience that westerners expect from even the simple life. Most of Russia's 150 million people live in cities, but again, few have phone service.

When you look at the many isolated areas of Russia and the CIS, you realize that communications of any kind are severely limited if they exist at all. The countries of Latvia, Belarus, Georgia, Uzbekistan, Estonia, Moldavia, Kazakhstan, and Lithuania suffer the same shortage as Russia.

While tens of millions of people in the CIS remain on official government waiting lists for telephones, a fledgling new cellular phone industry is beginning to relieve some of the backlog in several countries. The demand, however, far out-paces the ability of the governments of these various states to keep up.

The necessary communications infrastructure required to bring these countries into membership with the new world order and its one-world monetary system, simply do not exist. This is the vacuum that the people of Iridium and its global wireless telecommunications will try to fill.

Iridium is the name of Motorola's space-based worldwide cellular telephone system. Scheduled to be operational by 1998, Iridium plans a constellation of 66 satellites in six orbital planes. Each plane will have 11 spacecraft. They will orbit at 421.5 miles above the earth surface. This constellation can provide worldwide coverage. Any two people with cellular-type phones will be able to communicate anytime, 24 hours a day, anywhere in the world.

A space-based system of orbiting satellites will make building the old-fashioned, hard-wired telephone system unnecessary and cost-prohibitive. Wireless, space-based "satfones" will be used instead. The satfones will be able to operate on regular terrestrial-based cellular telephone systems where available. The satfone will seamlessly switch to the satellites as needed without the user even knowing it. The satfones will use QPSK modulation with FDMA/TDMA transmission modes at 2400 baud.

The Iridium system uses complex spacecraft to do signal processing, switching, satellite crosslink, account verification, and ground station interrogation. This allows the ground stations to remain relatively simple and flexible enough to interface with various public telephone systems worldwide. Iridium satfones will operate in the L-band near 1.5 GHz for communication with the spacecraft. The ground stations use Ka-band to keep in touch with the satellites.

Each spacecraft carries three antenna arrays that will be pointed toward the Earth. Each antenna consists of 16 spot beams. This means the users will be handed off to one of 48 spot beams as they travel through the coverage area of each satellite. This uninterrupted handoff is an important feature of the system. As the spacecraft swiftly orbits the Earth, it will be the motion of the satellite, more than the motion of the mo-

The vast expanse of Russia would be well served by individually-owned, satellite-based phone systems. Even small isolated villages could sponsor a solar-powered portable phone, centrally located, for contact with the rest of the world.

bile user, that determines when and to which satellite the user will be switched—not a simple process.

The satellites will also be networked together to relay calls. They will use the 23 GHz band, which is allocated for satellite crosslink communications. Your phone call will be relayed through several satellites if you are calling overseas.

To save power, this interwoven web of 66 orbiting satellites will automatically be switched off as the spacecraft round the poles where there are virtually no users or population. They will switch on again as they approach populated areas.

As with any satellite system, a second type of ground station is required for tracking, telemetry, and control (TT&C). These stations keep in contact with each satellite in the system and control what is called "housekeeping" functions: checking the orbit, power supply, and consumption of each satellite, as well as other TT&C functions. Telesat Canada will be providing the first two stations for TT&C. One will be located at Yellowknife and the other at Iqaluit in the Northwest Territories. A third station will be built in Hawaii before the first satellite launch which is tentatively set for mid-'97.

Building a ground station to interface with a nation's current landline and cellular system is much easier and much less costly than trying to build a complete conventional landline system from the ground up, and there is money to be made in the process, as each country involved will own its own gateway stations.

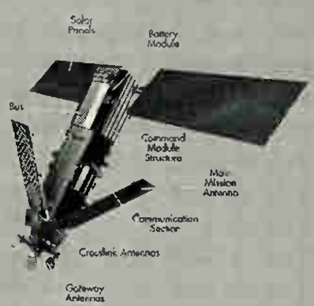
Iridium will enable countries with less developed communications systems and even third world countries to leapfrog into the 21st century. A single satfone will be capable of not only regular voice communications but paging, fax, and data transmissions as well.

In a communication published in a recent issue of *Iridium Today*, the First Deputy Minister of Telecommunications, A. Krupnov, stated there were several technical and security aspects of their agreement with Iridium to be worked out. The Russian ministry wants to ensure that the Russian national operator can control the security of their segment of the system to prevent unauthorized access to the information channels. They also want assurance that the Iridium system will not be used for surveillance purposes. In addition, they want protection of each user's national economic interest and territory rights in the Russian Federation. These and other protections will be studied and recommendations made by the Russian Communications Administration.

The vast expanse of Russia would be well served by individually-owned, satellite-based phone systems. Even small isolated villages could sponsor a solar-powered portable phone, centrally located, for contact with the rest of the world.

Appropriately enough, Russia's Baikonur Cosmodrome, located in Kazakhstan, will launch and deploy 21 of the planned 66 satellites of the Iridium system on their Proton launch vehicle.

IRIDIUM® SYSTEM FAST FACTS



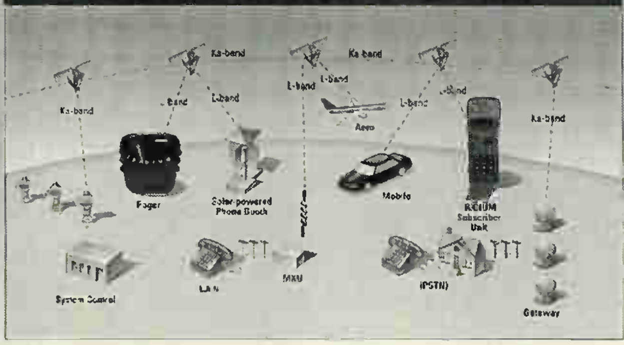
COMMENCEMENT OF SERVICE
—First satellite launch: 1996
—Commercial service: 1998

SPACE SEGMENT
—Constellation of 66 satellites
—Six orbital planes, 11 operational satellites, and one on-orbit spare per plane
—Polar orbit: 780 kilometers (421.5 miles)
—System designed by Motorola, Inc.

SATELLITE CHARACTERISTICS
—Spot beams per satellite footprint: 48 for high signal quality and spectrum efficiency
—Link margin: average 16 dB for voice
—Intersatellite links: provide true global connectivity
—Weight: approximately 689 kilograms (1,500 pounds)
—Lifetime: design life five to eight years
—Multiple launchers
1. McDonnell Douglas: Delta II rockets, each carrying five satellites
2. Khrunichev State Research and Production Space Center: Proton rockets, each carrying seven satellites
3. China Great Wall Industry Corporation: Long March 2C/SD rockets, each carrying two satellites

IRIDIUM HANDHELD TELEPHONE
—Dual-mode: satellite and terrestrial wireless compatible
—Digital voice: includes data port for transmitting facsimile and computer files
—Transmission rates: voice; data (2400 baud)
—Modulation: QPSK with Frequency Division/Time Division Multiple Access (FDMA/TDMA)

IRIDIUM® SYSTEM OVERVIEW



IRIDIUM SYSTEM GATEWAYS
—Interface with public switched telephone networks (PSTNs)
—Interlinked by the IRIDIUM satellite constellation

COMMUNICATION LINKS
—L-band: IRIDIUM telephone communication
—Ka-band: Intersatellite links, gateways, and feeder link connections

By Keith Stein
kstein@erols.com

Stretching Your Monitoring Limit

How good is your setup for monitoring? Do you have the best coax cable? Top of the line receiver? A huge array of antennas? Just looking at your configuration really isn't going to tell you how well your equipment will perform. Hitting the power switch, scanning the bands, turning the knobs, and getting some help from mother nature, will give you the best results. It doesn't matter if you spent $500 or $5,000 dollars; your results will vary day to day, and hour by hour.

In this issue of *ST* I want to talk about some monitoring targets that may present a bit of a challenge to the average monitor.

Space Shuttle Solid Rocket Boosters

The next time you see a shuttle launch, pay close attention to the first few seconds when the three main engines ignite. During the last six seconds of the countdown you can see the whole vehicle rock from side to side, and then, !BOOM!, those big solid rocket boosters fire and it's gone.

About 2 minutes and 5 seconds after launch, the SRB's run out of propellant and separate from the shuttle and external tank. Look out below, you're about to get hit with a large white rocket case falling into the ocean off the coast of Florida.

HF monitors worldwide always jump to their receiver to monitor the SRB recovery vessels. Well, residents in Florida and the surrounding area may want to check on the UHF-band. The two frequencies below are used so recovery ships can locate the boosters. Maybe you can find them before they do?

240.000 MHz   242.000 MHz

White Sands Missile Range

NASA operates three major areas located on the U.S. Army's White Sands Missile Range in New Mexico: the White Sands Test Facility (WSTF), White Sands Space Harbor (WSSH), and the White Sands Ground Terminal (WSGT).

The WSTF is used for Shuttle propulsion, power, and material testing.

The WSSH is one of the primary training areas for space shuttle pilots. The dry desert runway, named Northrup, also serves as an alternate shuttle landing site during actual missions.

The WSGT is one of the master control stations for NASA's Tracking and Data Relay Satellite (TDRS) constellation. These satellites are controlled from this ground station to relay data and communications from manned and unmanned satellites.

If you're in the local area of White Sands, or just a few hundred miles away, stretch your ears to some of these frequencies and let us know what you hear:

267.300 (AM)	Air-to-Ground
296.800 (AM)	Air-to-Ground communications for NASA test
320.700 (AM)	Air-to-Ground communications for NASA test

Wallops Flight Facility

Wallops, part of NASA's Goddard Space Flight Center, is one of the oldest launch sites in the world. Established in 1945, Wallops manages NASA's sounding rocket program, scientific balloon program, aeronautical research, and airborne scientific research. Future plans call for the facility to support the Conestoga and Pegasus launch vehicles as they carry small lightweight spacecraft into low earth orbit.

I have made several trips out to Wallops during major events and have picked up on some pretty interesting stuff. But even if you don't get out to the site, some of the aircraft operations can still be monitored several hundred miles away. I live about a 3-1/2 hour drive from the facility, and I'm able to monitor a lot of interesting research flights being performed up and down the east coast of Delaware, Virginia, and Maryland. Just another reason to stretch your monitoring to the limit.

121.700	Ground Control
121.950	Radar Surveillance Aircraft
123.400	Radar Surveillance Aircraft
126.500	Tower
127.950	Patuxent Approach, Departure Control
132.550	Washington Center, Cape Charles, VA
156.600	NASA Control
164.700	Range Safety Net
170.350	Security
170.400	Paging System
171.000	Security
311.200	Ground Operations
326.300	121.950 backup
394.300	Tower
416.500	Command Destruct

Transceiver Experiment Satellite (TEX)

One of three stacked satellites (P87-2), this 150 lb U.S. Air Force spacecraft was launched April 11, 1990, aboard an Atlas-E booster from Vandenberg Air Force Base, Calif. Orbiting 400 nautical miles above the Earth, inclined 90 degrees, its mission objective is to investigate ionospheric effects on signal propagation.

In mid-1992 the system experienced low power levels and was shut down; it may be reactivated for short periods.

The Department of Defense Joint Spectrum Center in Annapolis, MD, responsible for resolving interference problems with DOD systems around the world, have been investigating a problem occurring on 328.250 MHz and apparently originating from a low earth orbiting satellite: could it be TEX?

327.250 MHz 328.250 MHz

Christmas Aboard the Mir Space Station

U.S. astronaut John Blaha provided everyone with some very interesting transmissions during his stay aboard the Russian Mir

HF monitors worldwide always jump to their receiver to monitor the Shuttle Rocket Booster recovery vessels. Well, residents in Florida and the surrounding area may want to check on the UHF-band. ... Two frequencies (see text) are used so recovery ships can locate the boosters. Maybe you can find them before they do.

space station. Here is a detailed report from an SLP regular; all transmissions received on 145.200 MHz with a Radio Shack Discone antenna and PRO-62 handheld scanner.

"This is John Blaha, Valeriy and Sasha aboard the Mir space station, we wish you a Merry, Merry Christmas and a Happy New Year. Learned today that some carpet is coming out of my dining room, and we're getting a new floor put in. My favorite amateur radio conversations are over the U.S.A. because the language contact is easier, but we talk to people all around the world, Europe, Africa, some in South America, Australia, New Zealand, and in Russia.

"Had a full day, just got done with dinner about an hour and a half ago, and just got thru talking to my wife in Houston, and they had a little bit of snow flurries down there, nothing on the ground of course, but down to 18 degrees, so thats cold for Houston."

Thanks to Dave Stein for this report from his listening post in Springfield, Virginia.

Replacement Russian Navsat Launched

International Designator	1996-071A
Catalog Number	24677
Name	Cosmos 2336
Launch Date	Friday, December 20, 1996
Perigee	979 km
Apogee	1,012 km
Inclination	82.9 degrees
Launch Site	Plesetsk Cosmodrome
Launch Vehicle	Cosmos
Manufacturer	Polyot
Spacecraft Bus	Parus
Downlink Frequency	149.970/399.920 MHz
Customer	Ministry of Defense of the Russian Federation

Status Report - December 22, 1996

The Russian "Musson" Navigation Satellite Constellation

Military NavSats

Plane 1-150.030/400.08 MHz	Cosmos 2334 (replaces 2327 which transmitted on 149.97 MHz)
Plane 2-149.91/399.76 MHz	Cosmos 2184
Plane 3-149.94/399.84 MHz	Cosmos 2218
Plane 4-149.97/399.92 MHz	Cosmos 2336 (replaces Cosmos 2173 which transmitted on 149.97 MHz)
Plane 5-150.03/400.08 MHz	Cosmos 2142
Plane 6149.94/399.84 MHz	Cosmos 2279

Civilian NavSats

Plane 11-150.00/400.00 MHz	Cosmos 2315
Plane 12-150.00/400.00/1544.50 MHz	Nadezhda 3
Plane 13-150.00/400.00 MHz	Tsikada
Plane 14-150.00/400.00/1544.50 MHz	Nadezhda 4

Note 1: Planes 1-6 are spaced 30 degrees apart to cover one Earth hemisphere. Planes 11-14 are spaced 45 degrees apart to cover the other hemisphere..Only one satellite is active in each plane.

Note 2: Signal is 50 bits/sec. 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.

Note 3: Nadezhda satellites carry COSPAS-SARSAT transponders with a 1544.50 MHz downlink. This downlink should only be active when the satellite is receiving a distress beacon on 121.5/243.0/406 MHz.

Source information provided by John Corby, Larry Van Horn, Ivan Artner, The Satellites Encyclopedia (Jean-Phillipe Donnio) and monitoring by the HearSat-L Group.

Listening Post Intercepts (all times in UTC)

Abbreviations

APT	Automatic Picture Transmission
K	Kilohertz
USB	Upper Side Band
STS	Space Transportation System
CEETA	Communication Electronics Evaluation and Test Activity

K2622	USB 9:16 Cape Radio calling *Liberty Star* (*Liberty Star* not heard (Les Butler-S.E. Lower MI)
K3041	DOD Cape working King1, King2, Clearance1, and Air Boss, performing a simulated space shuttle return-to-launch-site abort (RTLS) (STS-81). DOD Cape advises units "orbiter hatch has been blown, stand by for crew bailout." After crew bailout, DOD Cape reports "orbiter impact at 28 46 02 North, 080 10 55 West (Keith Stein-Woodbridge, VA)
K4582	Ho Ho 1 (Santa Claus) calling Florida CAP 967 at 2336. FLCAP 967 tells Ho Ho 1 to overfly the space shuttle on pad 39B in Cape Canaveral (Greg Auerbach-FL) NASA also opened up the shuttle runway in case Santa needed it for an emergency landing-Keith
K5711	USB 0938 *Liberty Star* reporting positions of booster rocket. I believe they were 78.77W & 30.15N Liberty also said they were enroute to boosters at this time (Butler-MI)
K7765	DOD Cape working USCG Cutter *Tampa* and USS *Duwart*, 0425, USB. DOD Cape could not reach *Duwart*, so they switched to K6934 (Butler-MI)

"This is John Blaha, Valeriy and Sasha aboard the Mir space station, we wish you a Merry, Merry Christmas and a Happy New Year ... My favorite amateur radio conversations are over the U.S.A. because the language contact is easier, but we talk to people all around the world, Europe, Africa, some in South America, Australia, New Zealand, and in Russia."

K9043 1542, USB, *Liberty Star* has the boosters and they are pumping air (Butler-MI)

K10780 Cape Radio active at 1450 with STS-81 Solid Rocket Booster recovery operations (Gary R. Hahn-Milwaukee, WI)

K13218 Abnormal 40 (Kwajalein Tech. Control) working Abnormal 20 (Vandenberg AFB, CA) for phone patch to "Satcom" 2107, USB (Jeff Jones-San Francisco, CA)

K14973 USB 1529 Cape Radio calling *Liberty Star* contact established (Butler-MI)

K29352 RS-15 CW beacon heard weak at 2332, USB (David Bate-Bowmanville, Canada)

K29408 RS-12/13 CW beacon heard at 2325, USB (Bate-Canada)

M119.100 NASA1 seven miles out for landing runway 18, AM mode, 1835, Washington National Airport Tower (K Stein-VA)

M130.167 0520-0528, U.S. astronaut John Blaha aboard Mir space station talking to space shuttle crew after docking (Nick Quinn, G0BAF-UK)

M136.650 Old U.S. navigation satellite Transit 5B 5 heard at 1008, NFM, during north-bound pass (Lawrence Harris-United Kingdom)

M136.770 U.S. weather satellite NOAA 12 beacon heard at 1244, NFM (Bate-Canada)

M137.500 U.S. weather satellite NOAA 12 APT heard at 2159, NFM (Bate-Canada)

M137.620 U.S. weather satellite NOAA 14 APT heard at 1658, NFM (Bate-Canada)

M137.770 U.S. weather satellite NOAA 14 beacon heard at 1827, NFM (Bate-Canada)

M137.850 Russian weather satellite METEOR 3-5 APT heard at 2200, NFM (Bate-Canada)

M137.950 Argentina's first satellite, named Mu-sat-1 (Microsat 1), was heard during several passes. The beacon signal comprises a few seconds of CW "HI, HI DE MUSAT." The beacon signal is sent every 90 seconds with silence in between signal bursts (John Corby-Caledon, Toronto, Canada) *Nice catch John, first report I've seen on this one-Keith*

M142.400 Defense CEETA callsign "40" request "Delta" to check P block loading dock, 20-2, 20-3, and see if the monitor is on-line (K Stein-Woodbridge, VA)

M145.200 Russian cosmonaut voice heard from Mir space station at 2025, NFM "first spacewalk was 6 hours, and second walk about 7 hours, over" (David Stein-Springfield, VA)

M145.550 Packet telemetry heard from Mir space station, 1444, NFM (Bate-Canada)

M145.800 Russian Mir space station packet heard at 1511, NFM, new frequency as of 11/01/96 (Bate-Canada)

M145.825 Amateur radio satellite DO-17 packet AFSK transmission heard at 1539, NFM. UO-11 packet transmission also heard at 2202, NFM (Bate-Canada)

M145.985 AO-13 engineering beacon carrier heard at 2258, NFM, CW was present later (Bate-Canada)

M149.875 Possible unknown satellite transmission heard at 0345, NFM (Kevin-Fresno, CA)

M149.910 Russian navigation satellite Cosmos 2184 heard at 0630, NFM (K Stein-VA)

M149.940 Russian navigation satellite Cosmos 2218 heard at 0815, NFM. Also heard Cosmos 2279 at 0300, NFM, and M399.840 (K Stein-VA)

M149.970 New Russian navigation satellite Cosmos 2336 was heard at 0828, NFM (Sven Grahn-Sollentuna, Sweden) *Nice catch, only two days after launch-Keith*

M150.000 Russian navigation satellite Nadezhda 3 heard at 2210, NFM (Bate-Canada)

M259.700 Voice downlink from space shuttle (mission STS-81) heard during launch at 0934, AM mode "single engine press 104" (K Stein-VA)

M261.750 Monitored ground and air support units during STS-81 launch at 0927, NFM. Callsigns heard; DOD Cape, King 4, 5, 6 (C-130's). There was also a "Tantum 1 Whiskey ??" who was calling "Cape-Osborne" but had no joy. About 20 seconds after lift-off, the following message was broadcast: "King 4, King 5, King 6 this is DOD Cape, we have a launch, we have a launch" (Johan Drost-Holland)

M265.450 2005, NFM, heard transmission from FLTSATCOM F8 sounding like Russian. Some kind of telephone call maybe (David Rogers)

M435.175 Amateur radio satellite KO-23 heard at 1819, NFM (Bate-Canada)

M437.950 Heard voice Christmas greeting message and some packet telemetry from the Mir space station at 17:35, NFM (Paul Erkiert G4BKS-United Kingdom)

G11.780 At 1256 backhaul of Delta/Iridium launch was viewed on SBS 6 (Chris Kalmar)

G11.930 Anik E2, channel 23, H, occ. use (Keith Knipschild)

G11.939 Anik E2, channel 24, H, Ontario Legislature (Knipschild)

G11.974 Anik E2, channel 25, H, TFO (Knipschild)

G12.000 Anik E2, channel 26, H, TVO (Knipschild)

G12.061 Anik E2, channel 28, H, occ. use (Knipschild)

G12.096 Anik E2, channel 29, H, ASN (Atlantic Satellite Network, Halifax) (Knipschild)

G12.122 Anik E2, channel 30, H, Telesat Canada Stationkeeping (GLACS) (Knipschild)

G12.157 Anik E2, channel 31, H, occ. use (Knipschild)

G12.183 Anik E2, channel 32, H, occ. use by CBC News (Knipschild)

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

INTRODUCTION

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

How to Use the Satellite Service Guide

The various sections of the SSG include:

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

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

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

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

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

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

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

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

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

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

Satellite Radio Guide

By Robert Smathers and Larry Van Horn

AUDIO SUBCARRIERS

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

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

Classical Music

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

Satellite Computer Services

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

Contemporary Music

Radio Romance (from Philippines)	G4, 24 (Ku-band)	6.20
SuperAudio—*Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
Upbeat music (no identification)	C4,5	5.58
WYEZ-FM 96.9 South Bend, IN	G4, 15	6.48, 7.30 (DS)

Country Music

SuperAudio—*American Country Favorites*	G5, 21	5.04/7.74 (DS)
Transtar III radio network	S3, 9	5.76/5.94 (DS)
WOKI-FM (100.3) Oak Ridge-Knoxville, TN., ID-*The Hit Kicker*	G6, 7	6.20
WSM-AM (650) Nashville, TN	C4, 24	7.38, 7.58

Easy Listening Music

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

Foreign Language Programming

Arab Network of America radio network	G6, 10	5.80
CBC Radio-East (French)	E2, 1	5.38/5.58 (DS)
	E2, 1	7.36
DZMM-Radyo Patrol (from Philippines)	G4, 24 (Ku-band)	6.80
French language audio service	E2, 11	6.12
Indian Sangeet Sager	E2, 16 (Ku-band)	6.12
Irish music (Sat 1430-0000 UTC)	S3, 3	6.20
KAZN-AM (1300) Pasadena, CA—Asian Radio	GE-1, 22 (Ku-band)	6.20
Northern Native Radio (Ethnic)	E2, 26 (Ku-band)	6.43/6.53 (DS)
RAI Satelradio (Italian)	G7, 14	7.38
Radio Canada (French)	E2, 11	5.40/5.58 (DS), 5.76
Radio Dubai (Arabic)	G7, 10	7.48
Radio Maria (Italian-Religious programming)	G7, 10	5.80
Radio Maria	G7, 10	8.03
Radio Sedeye Iran (Farsi)	S3, 15	6.20 (N)
Radio Tropical (Haitian Creole)	S2, 11	7.60
Reteotto Network (Italian)	T402R, 18	5.80
Russian-American radio network	SBS5, 12 (Ku)	6.20
Trinity Broadcasting radio service (Spanish) SAP—religious	G5, 3	5.96
WLIR-AM (1300) Spring Valley, NY (Ethnic)	GE1,18 (C-band)	7.60
WOPA-AM (1200) Chicago, IL (Spanish)	GE1, 8 (C-band)	6.80
XEW-AM (900) Mexico City, Mexico (Spanish), ID-*LV de la America Latina*	M2, 14	7.38
XEW-FM (96.9) Mexico City, Mexico (Spanish), ID-*W-FM 96.9*	SD1, 7	7.38
XEWA-AM (540) Monterrey, Mexico (Spanish), ID-*Super Estelar*—contemporary music	M2, 8	7.38

Jazz Music

Jazz Worldbeat Radio	T402R, 6	6.20 (occasnl.)
KLON-FM (88.1) Long Beach, CA., ID-*Jazz-88*	G5, 2	5.58/5.76 (DS)
Superaudio—*New Age of Jazz*	G5, 21	7.38/7.56 (DS)

News and Information Programming

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

Religious Programming

Ambassasor Inspirational Radio	S3, 15	5.96, 6.48 (DS)
Brother Staire Radio	G5, 6	6.48
CBN Radio Network/Standard News	G5, 11	6.12
Christian Music Network Lakeland, FL	GE-1, 14	6.20, 7.60
KHCB-FM (105.7) Houston, TX	C1, 10	7.28
Salem Radio Network	S3, 17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
WHME-FM (103.1) South Bend, IN, ID-*Harvest FM*	G4, 15	5.58/5.78
WROL-AM (950) Boston, MA (occasional Spanish)	S3, 3	6.20
WWRL-AM (1600) New York City—Black Gospel	S3, 9	6.30/6.48 (DS)
Z-musis—Christian rock	G1, 6	7.38/7.56

Rock Music

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

Speciality Formats

Aries In Touch Reading Service	C4,10	7.87
California State Legislature audio	S4, 24	6.80
In-Store Networks	S3, 24	5.04, 5.21, 5.40
Los Angeles Kings Radio Network	C1, 7	7.38 (occasional)
SuperAudio—Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
The Weather Channel-USA—occasional audio	C3, 13	6.80
The Weather Channel-USA—classical music	C3, 13	7.78
Voice Print Reading Service	E2, 6	7.44 (N)
Yesterday USA—nostalgia radio	G5, 7	6.80
	T402R, 11	5.80

Talk Programming

American Freedom Radio network	GE-1, 7	5.80
Amerinet Broadcasting	G1R, 17	8.10
People's Radio Network (Chuck Harder)—talk and information	C1, 2	7.50
Prime Sports Radio—sports talk and information	S3, 24	5.80
Talk America Radio Network #1—talk programs	S3, 9	6.80
Talk America Radio Network #2—talk programs	S3, 9	5.41
Talk Radio Network—talk programs	C1, 5	5.80
WOKIE Network (tech talk)	SBS6, 13B (Ku)	6.20 (occasional network on when Megabingo is present)
Worldwide Freedom Radio network	GE-1, 7	7.56
WWTN-FM (99.7) Manchester, TN—news and talk	G5, 18	7.38, 7.56

Variety Programming

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

Satellite Radio Guide/SCPC Services Guide

FM SQUARED (FM²) AUDIO SERVICES

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

Spacenet 3 Transponder 13

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

Spacenet 3 Transponder 17

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

Spacenet 3 Transponder 18

Data Transmissions: 4.800 MHz

Galaxy 4 Transponder 3 (Ku-band)

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

Galaxy 4 Transponder 4 (Ku-band)

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

Galaxy 4 Transponder 16 (Ku-band)

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

Anik E1 Transponder 7 (Ku-band)

Nova Network FM Squared Services

FM CUBED (FM³) AUDIO SERVICES

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

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

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

Spacenet 2 Transponder 12-Vertical (C-band)

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

Spacenet 3 Transponder-Horizontal 13 (C-band)

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

Galaxy 4 Transponder 1-Horizontal (C-band)

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

Galaxy 4 Transponder 3-Horizontal (C-band)

1405.00 (55.0)	Illinois News network/Chicago Blackhawks NHL radio network
1404.80 (55.2)	KOA-AM (850)/KTLK-AM (760) Denver, Colo—news and talk/Univ. of Colorado sports
1404.60 (55.4)	WGN-AM (720) Chicago, IL—news/talk/ Northwestern Univ. sports
1404.20 (55.8)	Tribune Radio Networks
1403.00 (57.0)	KSJN-FM (99.5) Minneapolis/St. Paul, MN—Minnesota Public Radio classical music service
1402.70 (57.3)	WLAC-AM (1510) Nashville, TN—news/ talk/Tennessee Volunteers sports
1402.10 (57.9)	KNOW-FM (95.3) St. Paul, MN—fine arts, Minnesota Public Radio
1401.80 (58.2)	Michigan News Network//Michigan State sports/Central Michigan University sports
1401.50 (58.5)	Occasional Audio/Agrinet/USA Radio Network
1399.20 (60.8)	Talk America radio network
1399.00 (61.0)	Sports Byline USA/Sports Byline Weekend/"On Computers" radio show
1398.80 (61.2)	United Broadcasting radio network—talk
1398.50 (61.5)	Occasional audio/Denver Nuggets NBA radio network
1398.30 (61.7)	WSB-AM (750) Atlanta, GA—news/talk/ University of Georgia sports/Atlanta Hawks NBA radio network

(Continued on Page 42)

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

(Continued from Page 41)

1398.00 (62.0)	Occasional audio
1397.80 (62.2)	Occasional audio/Colorado Avalanche NHL radio network
1397.50 (62.5)	Minnesota Talking Book network
1397.30 (62.7)	Clemson University sports
1397.10 (62.9)	WTMJ-AM (620) Milwaukee, WI - talk/ Univeristy of Wisconsin sports/Wisconsin Radio Network
1396.90 (63.1)	Occasional audio
1396.40 (63.4)	Georgia Network News (GNN)
1396.20 (63.8)	WCNN-AM (680) Atlanta, GA—all sports talk radio/Georgia Tech sports
1396.00 (64.0)	WHO-AM (1040) Des Moines, IA—talk/ Iowa News Network/University of Iowa sports
1395.80 (64.2)	WTMJ-AM (620) Milwaukee, WI - talk/ University of Wisconsin sports/Wisconsin Radio Network
1395.60 (64.4)	WGST-AM/FM (640/105.7) Atlanta, GA—news/talk
1395.40 (64.6)	Michigan News Network/University of Michigan sports radio network
1395.00 (65.0)	Occasional audio
1394.70 (65.3)	WJR-AM (760) Detroit, MI—news/talk
1394.50 (65.5)	XEPRS-AM (1090) Tijuana, Mexico—Spanish language
1394.00 (66.0)	KSJN-FM (99.5) Minneapolis/St. Paul, MN—Minnesota Public Radio classical music service
1391.00 (69.0)	Occasional audio
1388.90 (71.1)	Data transmissions (burst)
1387.80 (72.2)	Data transmissions (constant)
1384.40 (75.6)	KOA-AM (850)/KTLK-AM (760) Denver, CO—news/talk/University of Colorado sports
1384.20 (75.8)	WSB-AM (750) Atlanta, GA—news and talk/University of Georgia sports/Atlanta Hawks NBA radio network
1383.70 (76.3)	Motor Racing Network (occasional audio)
1383.40 (76.6)	United Broadcasting Network—talk
1381.10 (76.9)	KIRO-AM (710) Seattle, WA— news/talk
1382.90 (77.1)	Michigan News Network/Detroit Pistons NBA radio network
1382.60 (77.4)	Soldiers Radio Satellite (SRS) network—U.S. Army information and entertainment
1382.00 (78.0)	University of Tennessee sports/University of Kentucky sports
1381.80 (78.2)	WHO-AM (1040) Des Moines, IA - news/ talk/Iowa News Network/University of Iowa sports
1381.60 (78.4)	KEX-AM (1190) Portland, OR—news/ talk/Portland Trailblazers NBA radio network
1381.40 (78.6)	Occasional audio
1381.20 (78.8)	KJR-AM (950) Seattle, WA - sports talk/ Seattle Supersonics NBA radio network
1377.40 (82.6)	Data transmission (packet burst/tones)
1377.10 (82.9)	In-Touch—reading service for blind
1376.90 (83.1)	Data Transmissions
1376.00 (84.0)	Kansas Audio Reader Network
1375.40 (84.6)	USA Radio Network/Agrinet Ag service/ James Madison Univ. college sports

Galaxy 4 Transponder 4-Vertical (C-band)

1376.00 (64.0)	Data transmissions

Anik E2 Transponder 11-Horizontal (C-band)

1245.50 (54.5)	Canadian Broadcasting Company (CBC) Radio—Yukon service

Anik E2 Transponder 13-Horizontal (C-band)

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

Anik E1 Transponder 17-Horizontal (C-band)

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

Anik E2 Transponder 23-Horizontal (C-band)

1006.00 (54.0)	Radio Canada International (ISWBC)

Anik E1 Transponder 21-Horizontal (C-band)

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

SBS5 Transponder 2-Horizontal (Ku-band)

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

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2)	RFD Radio Service
1404.60 (55.4)	Wyoming News Network/University of Wyoming sports
1400.60 (59.4)	Learfield Communications/Indiana University sports
1400.40 (59.6)	Learfield Communications/Missouri Net
1400.20 (59.8)	Occasional audio/Data transmissions
1400.00 (60.0)	Learfield Communications/University of Purdue sports
1396.60 (63.4)	Kansas Information Network/Kansas Agnet/Kansas State sports/SW Missouri State sports
1396.40 (63.6)	Nebraska Agriculture Network/University of Nebraska sports
1396.20 (63.8)	Missouri Network
1396.00 (64.0)	Occasional audio
1395.90 (64.1)	Wyoming News Network/University of Wyoming sports
1395.70 (64.3)	Missouri Net/WIBW-AM (580) Topeka, KS—news and talk
1386.40 (73.6)	Learfield Communications/Kansas sports
1386.20 (73.8)	Radio Iowa/University of Iowa sports
1385.00 (74.0)	People's Radio Network—talk
1384.80 (75.4)	Capitol Sports Network/North Carolina State sports/Eastern Carolina sports
1384.00 (76.0)	Occasional audio/ABC Direction Network
1383.80 (76.2)	Occasional audio/Oklahoma State sports
1383.60 (76.4)	WRAW-FM (590), Albany, NY - news/talk
1383.40 (76.6)	Capitol Sports Network/North Carolina University sports
1382.90 (77.1)	Missouri Net/University of Missouri sports
1382.30 (77.7)	Virginia News Network/Virginia sports
1382.10 (77.9)	Learfield Communications/Missouri Net/ Blues NHL radio network
1378.10 (81.9)	Occasional audio

RCA C5 Transponder 21-Vertical (C-band)

1045.00 (55.0)	Occasional audio
1043.60 (56.4)	Unistar Music Radio — *Today's Hits, Yesterday's Favorites*
1043.40 (56.6)	CNN Radio Network
1043.20 (56.8)	Unistar Music Radio — *Today's Hits, Yesterday's Favorites*
1042.80 (57.2)	Unistar Music Radio — *Greatest Music of All Time*
1042.60 (57.4)	Unistar Music Radio — *Greatest Music of All Time*
1042.40 (57.6)	Unistar Music Radio — *Good Times and Great Oldies*
1042.20 (57.8)	Data transmissions
1042.00 (58.0)	Unistar Music Radio — *Good Times and Great Oldies*
1041.80 (58.2)	CNN Radio Network
1039.00 (61.0)	Occasional audio
1034.40 (65.6)	Unistar Music Radio — *Hits from 60s, 70s, 80s, and Today*
1034.20 (65.8)	Data transmissions
1034.00 (66.0)	Unistar Music Radio — *Hits from 60s, 70s, 80s, and Today*
1033.20 (66.8)	Unistar Music Radio — *Country and Western*
1032.80 (67.2)	Data transmissions
1032.40 (67.6)	Unistar Music Radio — *Country and Western*

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

Alphastar (United States)

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

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

Programming: A&E Network, ABC (WJLA Washington DC), Alpha Preview Channel, Asian Television Network, C-Span 1 (US House), C-Span 2 (US Senate), Cartoon Network, CBS (WRAL Raleigh, NC), Cinemax, Cinemax 2, Cinemax West, Classic Sports Network, CNBC, CNN, CNN International/CNN fn, Comedy Central, Country Music Television, Court TV, Discovery Channel, Disney Channel (E), Disney Channel (W), E! Entertainment Television, Egyptian Satellite Channel, Encore, Encore Plus, ESPN, ESPN2, Family Channel, FOX Network (Foxnet), Fox Sports Southwest, Fox Sports Northwest, Fox Sports Rocky Mountain, Fox Sports Midwest, Fox Sports Intermountain West, Fox Sports West, Fox Sports Pittsburgh,
Golf Channel, HBO, HBO 2, HBO 2 West, HBO 3, HBO West, Headline News, History Channel, Home Tean Sports, International Channel, Learning Channel, Lifetime, Madison Square Garden, MSNBC, MTV, Nashville Network, NBC (WNBC New York), New England Sports Network, Nickelodeon / Nick at Nite, Nike Drama, Nile TV, PBS Network (National), Playboy TV, 10 PPV Channels, Sci-Fi Channel, Showtime, Showtime 2, Showtime West, Starz!, Sundance Film Channel, Sunshine Network, TBS Atlanta, The Movie Channel, The Movie Channel West, Turner Classic Movies, Turner Network Television (TNT), TV Land, USA Network, Venus (adult), VH-1, Weather Channel, WGN-Chicago, 30 DMX Channels

DirecTV and USSB (United States)

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

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

100	Direct Ticket Previews (DTV)	Previews
101-199	Direct Ticket Pay Per View (DTV)	PPV
120/121	Letterbox (LTBX)	
140-142	Unknown service (LC)	
200	Direct Ticket Previews (DTV)	Previews
201	DirecTV Information Updates (DTV)	Promo
202	Cable Network News (CNN)	News
203	Court TV (CRT)	Speciality
204	CNN Headline News (HLN)	News
205	DirecTV Special Events Calendar (DTV)	Promo
206	ESPN 1 (ESPN)	Sports
207	ESPN Alternate (ESNA)	Sports
208	ESPN 2 (ESN2)	Sports
210	DirecTV Sports Schedule (DTV)	Promo
212	Turner Network Television (TNT)	TV programming
213	Home Shopping Network (HSN)	Home Shopping
214	Home and Garden TV (HGTV)	Home Improvement
215	E! Entertainment TV (E!)	Speciality
216	MuchMusic (MUCH)	Music Videos
217	Black Entertainment TV (BET)	Entertainment
219	American Movie Classics (AMC)	Movies
220	Turner Classic Movies (TCM)	Movies
221	Arts and Entertainment (A&E)	TV
222	The History Channel (HIST)	History
223	The Disney Channel East (DIS1)	Movies/Kids
224	The Disney Channel West (DIS2)	Movies/Kids
225	The Discovery Channel (DISC)	Science/TV documentary
226	The Learning Channel (TLC)	Science/TV documentary
227	Cartoon Network (TOON)	Cartoons
229	USA Network (USA)	TV
230	Trio (TRIO)	TV
232	The Family Channel (FAM)	TV
233	WTBS-Ind Atlanta, Ga.(TBS)	Superstation
235	The Nashville Network (TNN)	Country/Outdoors
236	Country Music TV (CMT)	Country Music Videos
240	The Sci-Fi Channel (SCFI)	Science Fiction
242	C-SPAN 1 (CSP1)	Congress-House of Representatives
243	C-SPAN 2 (CSP2)	Congress-U.S. Senate
245	Bloomberg Information Television (BIT)	News
246	CNBC (CNBC)	Financial/Talk
247	MSNBC (MSNBC)	News
248	The Weather Channel (TWC)	Weather
250	Newsworld International (NWI)	News
252	CNN International (CNNI)/CNN fN	News/Financial
254	America's Health Network	Health
258	Bravo (BRAV)	Arts
266	Independent Film Channel (IFC)	Movies
268	Direct Ticket Previews (DTV)	Previews
269	STARZ! - West (STZW)	Movies
270	STARZ! (STZE)	Movies
271	Encore (ENCR)	Movies
272	Encore-Love Stories (LOVE)	Movies
273	Encore-Westerns (WSTN)	Movies
274	Encore-Mystery (MYST)	Movies
275	Encore-Action (ACTN)	Movies
276	Encore-True Stories (TRUE)	Movies
277	Encore-WAM! (WAM!)	Movies
278	Plex Encore 1	
282	WRAL Raleigh, NC (CBS)	Network TV
283	KPIX San Francisco, CA (CBSW)	Network TV
284	WNBC New York, NY (NBC)	Network TV
285	KNBC Los Angeles, CA (NBCW)	Network TV
286	PBS National Feed (PBS)	Network TV
287	WJLA Washington, DC (ABC)	Network TV
288	KOMO Seattle, WA (ABCW)	Network TV
289	FoxNet. (FOX)	Network TV
297	Informational Channel	
299	In-store dealer info channel (DTV)	Retailers only
300-399	Regional and PPV Sports	Sports
300	DirecTV Sports Offers (DTV)	Promo
301	Sports Special Events Calendat (DTV)	Promo
302	Special Events Calendar (DTV)	Promo
303	Newsport (NWSP)	Sports
304	The Golf Channel (GOLF)	Sports
305	Classic Sports Network (CSN)	Sports
306	Speedvision (SV)	Sports
307	Outdoor Life Channel (OL)	Sports
309	SportsChannel New England (SCNE)	Sports
310	Madison Square Garden (MSG)	Sports
311	New England Sports Network (NESN)	Sports
312	SportsChannel New York (SCNY)	Sports
313	Empire Network (EMP)	Sports
314	SportsChannel Philadelphia (SCPH)	Sports
315	Fox Sports Pittsburgh (PKBL)	Sports
316	Home Team Sports (HTS)	Sports
317	SportsSouth (SPTS)	Sports
318	Sunshine (SUN)	Sports
319	SportsChannel Florida	Sports
320	Pro AM Sports (PASS)	Sports
321	SportsChannel Ohio (SCOH)	Sports
322	SportsChannel Cincinnati (SCCN)	Sports
323	SportsChannel Chicago (SCCH)	Sports
324	Midwest SportsChannel (MSC)	Sports
325	Fox Sports Southwest (PSSW)	Sports
326	Fox Sports Midwest/Rocky Mountain/ Intermountain West (PS)	Sports
329	Fox Sports Arizona	Sports
330	Fox Sports Northwest (PSNW)	Sports
331	Fox Sports West (PSW)	Sports
332	SportsChannel Pacific (SCP)	Sports
330-348	NFL Sunday Ticket	Sports

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

335	DirecTV Sports Schedule (DTV)	Promo
350	NFL Sunday Ticket/NBA League Pass	Sports
356	NFL Sunday Ticket/NBA League Pass	Sports
380	DirecTV Sports Schedule (DTV)	Promo
401	Spice (SPCE)	Adult
402	Playboy (PBTV)	Adult
501	Music Choice — Hit List (MC1)	Audio
502	Music Choice — Dance (MC2)	Audio
503	Music Choice — Rap (MC3)	Audio
504	Music Choice — R&B Hits (MC4)	Audio
505	Music Choice — Reggae (MC5)	Audio
506	Music Choice — Blues (MC6)	Audio
507	Music Choice — Jazz (MC7)	Audio
508	Music Choice — Lite Jazz (MC8)	Audio
509	Music Choice — New Age (MC9)	Audio
510	Music Choice — Eclectic Mix (MC10)	Audio
511	Music Choice — Alternative Rock (MC11)	Audio
512	Music Choice — Metal (MC12)	Audio
513	Music Choice — Classic Rock (MC13)	Audio
514	Music Choice — The 80s (MC14)	Audio
515	Music Choice — The 70s Super Hits (MC15)	Audio
516	Music Choice — Solid Gold Oldies (MC16)	Audio
517	Music Choice — Soft Rock (MC17)	Audio
518	Music Choice — Today's Country (MC18)	Audio
519	Music Choice — Country Horizons (MC19)	Audio
520	Music Choice — Classic Country (MC20)	Audio
521	Music Choice — Easy Listening (MC21)	Audio
522	Music Choice — Big Bands (MC22)	Audio
523	Music Choice — Singers and Standards (MC23)	Audio
524	Music Choice — Show Tunes (MC24)	Audio
525	Music Choice — Classics Favorites (MC25)	Audio
526	Music Choice — Classical Masterpieces (MC26)	Audio
527	Music Choice — Contemp. Christian (MC27)	Audio
528	Music Choice — For Kids Only (MC28)	Audio
529	Music Choice — Sounds of the Seasons (MC29)	Audio
530	Music Choice — Spectrum I (MC30)	Audio
531	Music Choice — Spectrum II (MC31)	Audio
550	Music Choice — Lite Classical	Audio
551	Music Choice — EE - Vocals	Audio
552	Music Choice — Soft Album Mix	Audio
553	Music Choice — The Trend	Audio
554	Music Choice — Tropical	Audio
555	Music Choice — Mexicana	Audio
599	NRTC Radio Service (NRTC)	For private use only
757	Microsoft TV	
790	RealNet — Real Estate Channel (REAL)	

USSB

USSB

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

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

EchoStar (United States)

ECHOSTAR

The new Echostar 1/2 high power DBS (Ku-band 12.2-12.7 GHz) satellites are now operational at 119° West. Echostar's service is called "TheDISH (Digital Satellite Network) Television Network.

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

100	DISH on Demand Previews	Promo
102	USA Network	TV
104	Comedy Central	Comedy
106	TVLand	Variety
108	Lifetime	TV
110	TV Food Network	Food
112	Home and Garden Network	Speciality
114	E! Entertainment TV	TV
116	Game Show Network	TV
118	Arts and Entertainment	TV
120	History Channel	History
122	Sci-Fi Channel	Science Fiction
124	Black Entertainment TV	TV
132	Turner Classic Movies	Movies
138	Turner Network Television	TV
140	ESPN	Sports
141	ESPN Alternate	Sports
142	ESPN2	Sports
143	ESPN2 Alternate	Sports
144	ESPNews	Sports
160	MusicTV (MTV)	Music Videos
162	VH-1	Music Videos
166	Country Music Television	Music Videos
168	The Nashville Network	Country
170	Nickelodeon	Kids
172	The Disney Channel	Movies/Kids
176	The Cartoon Network	Cartoons
178	The Learning Channel	Science/TV Documentary
180	The Family Channel	TV
182	The Discovery Channel	Science/TV Documentary
184	Animal Planet	Specialty
200	Cable News Network	News
202	CNN Headline News	News
204	Court TV	Speciality
206	CNN International/CNNfn	News/Financial
208	CNBC	Financial/Talk
210	C-SPAN	Government
212	C-SPAN 2	Government
214	The Weather Channel	Weather
216	National Empowerment TV (NET)	Politics
220	The Travel Channel	Travel Shows
222	Home Shopping Network (HSN)	Home Shopping
230	WTBS Atlanta, GA	Superstation
232	KTLA Los Angeles, CA	Superstation
234	WPIX New York, NY	Superstation
236	WSBK, Boston	Superstation
240	WGN Chicago, IL.	Superstation
241	WNBC-NBC New York, NY	Network TV
242	KNBC-NBC Los Angeles, CA	Network TV
243	WRAL-CBS Raleigh, NC	Network TV
244	KPIX-CBS San Francisco, CA	Network TV

Direct Broadcast Satellite (DBS) Systems

245	WJAL-ABC Washington, DC	Network TV
246	KOMO-ABC Seattle, WA	Network TV
247	FOXNet	Network TV
249	PBS	Network TV
260	Trinity Broadcasting Network	Religious
261	Eternal Word TV Network	Religious
267	American Family Radio	Sky Angel
268	Calvary Chapel Radio	Sky Angel
269	Bob Jones University Radio	Sky Angel
270	The Worship Channel	Sky Angel
271	Praise TV	Sky Angel
272	FamilyNet	Sky Angel
273	Cornerstone TV	Sky Angel
274	100 Plus Ministries	Sky Angel
275	Dominion Variety and International Home School Channel	Sky Angel
300	HBO East	Movies
301	HBO2 East	Movies
302	HBO3 East	Movies
303	HBO West	Movies
304	HBO2 West	Movies
310	Showtime East	Movies
311	Showtime West	Movies
312	Showtime East 2	Movies
318	Sundance	Movies
319	FLIX	Movies
320	Cinemax East	Movies
321	Cinemax East 2	Movies
322	Cinemax West	Movies
330	The Movie Channel East	Movies
331	The Movie Channel West	Movies
401	The Golf Channel	Sports
412	Madison Square Garden (MSG)	Sports
414	Fox Sports Rocky Mountain	Sports
416	Fox Sports Southwest	Sports
417	Fox Sports West	Sports
418	Fox Sports Midwest	Sports
420	Fox Sports South	Sports
422	Sunshine Network	Sports
424	Home Team Sports	Sports
426	Fox Sports Northwest	Sports
428	Fox Sports Pittsburgh	Sports
430	Pro-Am Sports (PASS)	Sports
432	Empire Sports Network	Sports
434	New England Sports Network	Sports
436	Midwest Sports Channel	Sports
500	PPV 1 DISH-on-Demand (events)	Pay per view
501	PPV 2 DISH-on-Demand	Pay per view
502	PPV 3 DISH-on-Demand	Pay per view
503	PPV 4 DISH-on-Demand	Pay per view
504	PPV 5 DISH-on-Demand	Pay per view
505	PPV 6 DISH-on-Demand	Pay per view
506	PPV 7 DISH-on-Demand	Pay per view
507	PPV 8 DISH-on-Demand	Pay per view
508	PPV 9 DISH-on-Demand	Pay per view
509	PPV 10 DISH-on-Demand	Pay per view
600	RAI (Italy)	International
602	ART (Arab Radio and Television)	International
604	Antenna TV Greece	International
620	MTV Latino	International
622	Univision	U.S. Spanish-language Network
624	Galavision	U.S. Spanish-language Network
626	Fox Sports Americas	International
628	Telemundo	International
700	DISH 2 (Showroom Promo Channel)	Promo
900	Business TV 1	Financial
901	Business TV 2	Financial
DISH CD ‡		
950	Young Country	Audio
951	Country Classics	Audio
952	Country Currents	Audio
953	Jukebox Gold	Audio
954	70's Song Book	Audio
955	Adult Favorites	Audio
956	Adult Contemporary	Audio
957	Adult Alternative	Audio
958	HitLine	Audio
959	Classic Rock	Audio
960	The Edge	Audio
961	Power Rock	Audio
962	Non-Stop Hip Hop	Audio
963	Urban Beat	Audio
964	Latin Styles	Audio
965	Fiesta Mexicana	Audio
966	Eurostyle	Audio
967	Jazz Traditions	Audio
968	Contemporary Jazz Flavors	Audio
969	Expressions	Audio
970	Contemporary Instrumentals	Audio
971	Concert Classics	Audio
972	Light Classical	Audio
973	Easy Instrumentals	Audio
974	Big Band Era	Audio
975	Contemporary Christian	Audio
976	KidZone	Audio
977	LDS Radio Network	Audio
978	Blues	Audio
979	Reggae	Audio
980	New Age	Audio

ExpressVu (Canada)

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

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

Galaxy Latin America (Mexico, Central and South America)

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

Programming: GLA Coming Attractions/ Programming, TNT Latin America, TeleUno, Sony Entertainment TV (SET), WBTV (The Warner Channel), MAS Mexican Channel, GEMS, TVE Television Espanola, Antena 3 Espana, RAI Italia, Deutsche Welle, RTPI, TVN Chile, TV Azteca Canal 7 Mexico, TV Azteca Canal 13 Mexico, Cartoon Network, ZAZ, Locomotion, MTV Latino, ESPN International, CBS Telenoticias, BBC World Service, CNN International, Bloomberg, Travel Channel, Discovery Channel, MultiPremier, Bravo, MultiCinema, Cine Latino, HBO Ole West, HBO Ole East, HBO Ole 2, Cinemax West, Cinemax East, AdultVision, CL@SE Educational channel for Latin America, CineCanal 1, CineCanal 2, Telecine 1, Telecine 2, Playboy, ABC, NBC, CBS, HBO Brasil, HBO Brasil 2, ESPN South, TV Senado, CMT, MTV Brasil,

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

Bravo Brasil, E! Entertainment, Mundo, National Geographic, CNA - Canal de Noticias de TVA, Canal de Noticias NBC, Bloomberg Business TV in Portuguese, Cinemax Brasil, CNN en Espanol, RBN News (Brasil), Televen International, Univision, Venevision International, Zeta, 60 CD-Quality audio channels, ESPN Dos

Primestar (United States)

PRIMESTAR®

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

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

1	HBO (East)	Movies
2	HBO 2 (East)	Movies
3	HBO 3	Movies
7	Cinemax (East)	Movies
8	Cinemax 2	Movies
13	TV Japan (English) month package	Not included in $50 a
14	TV Japan (Japanese) month package	Not included in $50 a
15	Future service (Also 15/17/19/56/149)	
27	Starz!	Movies
31	Encore 3 — Westerns	Movies
32	Encore 4 — Mystery	Movies
33	Encore	Movies
34	The Disney Channel (East)	Movies/Kids
35	The Disney Channel (West)	Movies/Kids
40	The Golf Channel	Sports
47	C-SPAN	Congress
48	CNBC—occasional service	Financial/Talk
49	The Weather Channel (TWC)	Weather
50	CNN International (CNNI)/CNN fN	News/Financial
51	Cable Network News (CNN)	News
52	CNN Headline News	News
	Ingenius News Service	Data Wire Services
55	PreVue Channel	Program Guide
58	Turner Network Television (TNT)	TV
59	Turner Classic Movies (TCM)	Movies
60	TV Land	TV
61	Comedy Central	TV
63	WTBS-Ind Atlanta, GA (TBS)	Superstation
65	The Discovery Channel (TDC)	Science/TV documentary
66	The Learning Channel (TLC)	Science/TV documentary
68	Arts & Entertainment (A&E)	TV
70	USA Network	TV
71	The Sci-Fi Channel	Science Fiction
72	The Family Channel	TV
73	The Cartoon Channel	Cartoons
74	Nickelodeon/Nick at Nite	Kids
75	E! Entertainment Network	Speciality
76	Lifetime	TV
77	The Nashville Network (TNN)	Country/Outdoors
78	Country Music TV (CMT)	Country music videos
80	MTV	Music Videos
83	Odyssey	Religious
84	QVC—occasional service	Home Shopping
111	WHDH-NBC Boston, MA	Network TV
112	WSB-ABC Atlanta, GA	Network TV
117	WUSA-CBS Washington, DC	Network TV
120	KTVU-FOX Oakland/San Francisco, CA	Network TV
124	WHYY-PBS Philadelphia, PA	Network TV
131	ESPN	Sports
133	ESPN2	Sports
137	Classic Sports Network (occ)	Sports
138	Mega+1	Sports
141	New England Sports Network (NESN)	Sports
142	Madison Square Garden Network (MSG)	Sports
143	Empire Sports Network	Sports
144	Fox Sports Pittsburgh	Sports
145	Home Team Sports (HTS)	Sports
146	Fox Sports South	Sports
147	Sunshine	Sports
148	Pro American Sports (PASS)	Sports
152	Fox Sports Midwest	Sports
153	Fox Sports Rocky Mountain	Sports
154	Fox Sports Southwest	Sports
155	Fox Sports Inter-Mountain West	Sports
156	Fox Sports Northwest	Sports
157	Fox Sports Arizona	Sports
158	Fox Sports West	Sports
159	Midwest SportsChannel	Sports
181	HBO en Espanol	Movies
182	HBO2 en Espanol	Movies
183	HBO3 en Espanol	Movies
187	Cinemax Selecciones	Movies
188	Cinemax2 Selecciones	Movies
190	Univision	Spanish language
201	Viewer's Choice	PPV
202	Request 1	PPV
203	Request 5	PPV
204	Hot Choice	PPV
205	Continuous Hits 1	PPV
207	Continuous Hits 3	PPV
208	Request 2	PPV
210	Request 4	PPV
221	Playboy—occasional service	Adult
301	Superadio—Classical Hits	Audio
302	Superadio—America's Country Favorites	Audio
303	Superadio—Lite 'n' Lively Rock	Audio
304	Superadio—Soft Sounds	Audio
305	Superadio—Classic Collections	Audio
306	Superadio—New Age of Jazz	Audio
311	DMX Audio—Lite Jazz	Audio
312	DMX Audio—Classic Rock	Audio
313	DMX Audio—70's Oldies	Audio
314	DMX Audio—Adult Contemporary	Audio
315	DMX Audio—Hottest Hits	Audio
316	DMX Audio—Modern Country	Audio
317	DMX Audio—Traditional Blues	Audio
318	DMX Audio—Salsa	Audio
527	Testing Channel	Tests

To be added soon with move to the GE-2 satellite:

TV Food Network, Court TV, 16 more music services, Outdoor Life, Speedvision, VH1, History Channel, Black Entertainment TV, CNN/SI, Showtime, Showtime 2, Sundance Channel, Home and Garden TV, WGN, Game Show Network, MSNBC, World Satellite Network

Ku-band Satellite Transponder Services Guide

By Robert Smathers

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

Spacenet 2 (S2) 69° West

19	11740-H	Data transmissions
21	11900-H	TV ASAHI [Leitch]
22	11980-H	Occ video
23	12060-H	Occ video
24	12140-H	Occ video

SBS 6 (SBS6) 74° West

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

SBS 4 (SBS4) 77° W. (Inclined orbit)

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

GE K2 (K2) 81° West

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

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

Spacenet 3R (S3) 87° West

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

Telstar 402R (T402) 89°West

Alphastar DBS uses many T402 Ku-band transponders

1	11730-V	AT&T Tridom [digital]
2	11743-H	AT&T Tridom [digital]
3	11790-V	AT&T Tridom [digital]
4	11803-H	AT&T Tridom [digital]
7	11910-V	PBS (analog lower half/digital upper half)
15	12157-V	DMX for Business [digital data]

Galaxy 7 (K7) 91° West

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

Galaxy 3R (G3R) 95° West

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

Galaxy 4 (K4) 99° West

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

Spacenet 4 (S4) 101° West

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

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

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

GE-1 (GE1) 103° West

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

GSTAR-4 (GST4) 105° West

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

Anik E2 (A1) 107.3° West

1	11717-V	Telesat Canada DVC: MovieMax!, Family Channel E&W, SuperChannel [digital video compression]
2	11743-V	DirectPC [digital]
3	11778-V	Data transmissions
4	11804-V	CBC feeds
5	11839-V	Canadian Parliamentary Access Channel, Youth TV E&W, Vision TV, CHSC Shopping [digital video compression]
6	11865-V	Moviepix!; The Movie Network [digital video compression]
7	11900-V	Rogers Network [digital video compression]
8	11926-V	Rogers Network [digital video compression]
9	11961-V	Data transmissions
10	11987-V	Data transmissions
11	12022-V	Expressvu (summer 1997)
12	12048-V	Saskarchewan CommunicaNetwork
13	12083-V	Data transmissions
14	12109-V	Data transmissions
15	12144-V	Telesat Canada stationkeeping (GLACS)
16	12170-V	Knowledge Network
17	11730-H	Bravo Canada, MuchMusic [digital video compression]
18	11756-H	Showcase E&W/Discovery Channel Canada/Life Network [digital]
19	11791-H	Occ video
20	11817-H	Shaw Digital Video Compression
21	11852-H	Data transmissions
22	11878-H	Data transmissions
23	11913-H	Expressvu (summer 1997)
24	11939-H	Ontario Legislature
25	11974-H	La Chaine (TV Ontario's French lanaguage service)
26	12000-H	TV Ontario (English)
27	12035-H	Data transmissions
28	12061-H	Data transmissions
29	12096-H	Atlantic Satellite Network (ASN)
30	12122-H	Telesat Canada stationkeeping (GLACS)
31	12157-H	CBC Newsworld feeds
32	12183-H	Expressvu (summer 1997)

Solidaridad 1 SO1 109.2° West

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

Anik E1 (A2) 111° West

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

1	11717-V	Data transmissions
2	11743-V	Data transmissions
3	11778-V	Data transmissions
4	11804-V	Data transmissions
5	11839-V	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 compression]
18	11756-H	Data transmissions
19	11791-H	Data transmissions
20	11817-H	SCPC/Data transmissions/New Country Network, Access Network of Alberta [Shaw digital video compression]
29	12096-H	Occ video
30	12122-H	RDI feeds

Solidaridad 2 (SO2) 112.9° West

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

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

(This satellite rarely has video transmissions)

7	11900-V	Occ video

Morelos 2 (M2) 116.8° West

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

EchoStar 1/2 119°West

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

SBS 5 (SBS5) 123° West

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

GSTAR-2 (GST2) 125° West

6	12035-H	Occ video
9	11744-V	Data transmissions
11	11866-V	GSTAR-2 ID slate
13	11988-V	Occ video
14	12049-V	Occ video
15	12110-V	Occ video
16	12171-V	Occ video

Satellite Transponder Guide

By Robert Smathers

	Spacenet 2 (S2) 69°	Galaxy 6 (G6) 7 4°	Spacenet 3 (S3) 87°	Telstar 402R (T4) 89°	Galaxy 7 (G7) 91°	Galaxy 3R (G3R) 95°	Telstar 302 (T2) 97°	Galaxy 4 (G4) 99°	Spacenet 4 (S4) 101°	GE-1 (GE1) 103°	Anik E2 107.…
1	(none)	Tokyo BS New York feeds	(none)	FOX feeds	Sega Channel Interactive [digital]	TVN Theatre 1 [V2+]	o/v	SCPC services	Data Transmissions	U.S. Information Agency (USIA)	CBC-H En… Easter…
2	(none)	o/v	American Independent Network (AIN) [CLI Spectrumsaver]	o/v	CBS West [occ VC1]	TVN Theatre 2 [V2+]	o/v	Buena Vista TV distribution	STARZ! 2 [V2+]	Data Transmissions	The Sports… (TSN) [SA…
3	USIA Worldnet TV	o/v	WSBK-Ind Boston [V2+]	XXXplore TV (adult [V2+]	Action PPV [V2+]	TVN Theatre 3 [V2+]	o/v	SCPC services	Data Transmissions	(none)	Telesat [digi… compres…
4	(none)	o/v	Nebraska Educational TV (NETV) [digital]	Shop at Home	fX East	TVN Theatre 4 [V2+]	o/v	Data Transmissions	Encore-Westerns [V2+]	SC Ohio/Cincinnati/Florida [V2+]	Cancom Compressi… MPE…
5	NASA Contract Channel-o/v [Leitch]	CNN feeds/o/v	Univision [V2+]	FOX feeds	fX West	TVN Theatre 5 [V2+]	o/v	4 Media Company feeds	Data Transmissions	Hero Teleport [digital]	Telesat [dig… compres…
6	Data Transmissions	NHK (TV Japan) feeds	Data Transmissions	The X! Channel (adult) [V2+]	Game Show Network [V2+]	TVN Theatre 6 [V2+]/TVN Promos (occ) [fixed key V2+]	o/v	Shepherd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	WNBC-NBC New York (PT24E) [V2+]	CBC News…
7	(none)	Video Catalog Channel (VCC)	Data Transmissions	Cable Video Store/Adam & Eve/Spice (adult) [digital]	The Golf Channel [V2+]	Guthy-Renker TV (infomercials)	o/v	Warner Brothers Dom TV/WB Network	Basil Bassett Bingo	Cornerstone TV (Rel)	CBC-M E…
8	Data Transmissions	Horse Racing [digital]	Data Transmissions	ABC feeds East [LEITCH]	o/v	Pandamerica Home Shopping	o/v	Telemundo [SA MPEG]	KOMO-ABC Seattle (PT24W) [V2+]	SC Chicago [V2+]	Globa… [Leitch] Glo…
9	NASA TV	MuchMusic U.S. [V2+]	WPIX-Ind New York [V2+]	Horse Racing [digital]/Fashion Network TV/o/v	Eye on People Network [digital]	TVN Theatre 9 [V2+]	o/v	o/v	Data Transmissions	Fox Sports South [V2+]	CBC-B E… Atlan…
10	Data Transmissions	Arab Network of America (ANA)	(none)	FOX News Edge	United Arab Emirates TV Dubai	TVN Theatre 10 - adulTVision (adult) [V2+]	o/v	Keystone/Paramount/UPN network feeds	FOXNet (PT24E) [V2+]	WJLA-ABC Washington (PT24E) [V2+]	Canco… Compress… MP…
11	SC Philadelphia [V2+]	Keystone o/v	CNN/SI	Outdoor Channel	International Channel [V2+]	o/v	o/v	o/v	STARZ! East [V2+]	Univision [digital]	CBC-A I…
12	Data Transmissions	TV Asia [digicipher]	Data Transmissions	Horse Racing [digital]/o/v	Romance Classics [V2+]	MCI Andover o/v/RAI TV	o/v	o/v	Hero Teleport Contract Channel	TurnerVision Promo Channel (occ)/o/v	Cancom… Compress… MPE…
13	Data Transmissions	RTPi	SCPC/FM2 services	FOX feeds West	CSN/Kaleidoscope/Fox Sports/The Box [digicipher]	Horse Racing [o/v digital]/o/v	o/v	o/v	Data Transmissions	Fox Sports South Alternate (occ)/o/v	CBC-C E… Pac…
14	Data Transmissions	Horse Racing [digital]/o/v	(none)	ABC NewsOne Channel	Independent Film Channel [V2+]	o/v	o/v	o/v	WWOR-TV New York/UPN [V2+]	SC New England [V2+]	Cancom… Compress… MP…
15	(none)	Midwest Sports Channel [V2+]	KTLA-Ind Los Angeles [V2+]	o/v [digital]/o/v	[digital video compression]	o/v	o/v	World Harvest TV (Rel)	Data Transmissions	ABC East hot backup [LEITCH]	
16	Data Transmissions	Horse Racing [digital]/o/v	CNN International/CNN fN [V2+]	Eurotica (adult) [V2+]	Access Television [digicipher]	HBO 2 East [V2+]	o/v	CBS West [occ VC1]	NPS Promo Channel	SC Pacific [V2+]	Cancom… Compress… MP…
17	Data Transmissions	Keystone (occ)	FM2 services	FOX feeds	ESPN Intl Pacific Rim [B-MAC]	Cinemax 2 East [V2+]	o/v	CBS East [occ VC1]	Data Transmissions	SC Alternates (occ)/o/v	CBC-D…
18	(none)	Gospel Music TV [V2+]	(none)	PBS Schedule X	Teleport Minnesota/CBS feeds/o/v	Inforamerica TV (Informercials)	o/v	CBS feeds/Eyemark Syndicated feeds	STARZ! West [V2+]	SC New York [V2+]	True Blu… [V2…
19	Data Transmissions	University Network/Dr. Gene Scott (Rel)	SSN Extra [V2+]	Venus (adult) [V2+]	CBS East [occ VC1]	HBO 3 [V2+]	o/v	CBS East [occ VC1]	Data Transmissions	National Empowerment TV (Net)	Telesat [di… compre…
20	(none)	CNN Headline News Clean Feed [V2+]	La Cadena de Milagro	FOX feeds	FOX News Channel	HBO 2 West [V2+]	o/v	CBS East [occ VC1]	Data Transmissions	AFRTS [BMAC]	o…
21	Hero Teleport Contract Channel	o/v	SSN Pro Am Sports (Pass) [V2+]	ABC feeds West [LEITCH]	BET on Jazz	Infoamerica TV (Informercials)	o/v	CBS feeds/o/v	Data Transmissions	Univision feeds	Telesat [… comp…
22	SC NY Plus [V2+]/o/v	Horse Racing [digital]	American Collectibles Network (ACN)	ABC feeds East [LEITCH]	WBIS NY Superstation o/v	Horse Racing [digital]	o/v	Paramount feeds/o/v	Data Transmissions	Global Access (occ)	Exxxtas… [V2…
23	NHK TV Japan secondary feeds	Worship TV/Praise TV (Rel) [digicipher]	SSN Home Teams Sports (HTS) [V2+]	FOX feeds East	fX Movies [V2+]	3 Angels Broadcasting	o/v	SCOLA [Wegener]/Blue & White Network (occ)	Data Transmissions	ABC West hot backup [LEITCH]	CBC-E…
24	o/v	Horse Racing [digital]/o/v	America One	ABC feeds	International Channel [digicipher]	Horse Racing [o/v digital]/ACN o/v	o/v	CBS Newspath feeds	KPIX-CBS San Francisco (PT24W) [V2+]	WRAL-CBS Raleigh (PT24E) [V2+]	Inactive… transp…

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Satellite Services Guide

Satellite Transponder Guide

By Robert Smathers

(A1)	Solidaridad 1 (SD1) 109.2°	Telesat E1 (A2) 111°	Morelos 2 (M2) 116.8°	Galaxy 9 (G9) 123°	Galaxy 5 (G5) 125°	Satcom C3 (F3) 131°	Galaxy 1R (G1) 133°	Satcom C4 (F4) 135°	Satcom C1 (F1) 137°	Satcom C5 (F5) 139°	
glish n	(none)	Data Transmissions	Data Transmissions	Global Access o/v	Disney East [V2+]	Family Channel West [SA MPEG]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	Prime Network [V2+]	(none)	1
etwork MPEG]	(none)	(Inactive)	Data Transmissions	Global Access (occ)/BBC Breakfast News (occ)	Playboy (adult) [V2+]	The Learning Channel	Univision/Galavision [SA MPEG]	Request TV PPV [digicipher]	KMGH-ABC Denver [V2+]	(none)	2
al video sion]	SCPC services	Data Transmissions	Data Transmissions	NHK TV Japan	Trinity Broadcasting (Rel)	Viewer's Choice PPV [digital]	Encore [V2+]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2+]	SCPC services	3
Video on [SA-G]	(none)	Data Transmissions	Data Transmissions	General Communication [digital]	Sci-Fi [V2+]	Lifetime West [V2+]	TV Food Network [digicipher]	Lifetime East [V2+]	(none)	SCPC services	4
tal video sion]	o/v	Data Transmissions	Data Transmissions	(none)	CNN [V2+]	Odyssey (Rel)	Classic Arts Showcase	Deutsche Welle TV (German)	KDVR-Fox Denver [V2+]	(none)	5
sworld	(none)	(Inactive)	Data Transmissions	o/v	WTBS-Ind Atlanta [V2+]	Court TV [digicipher]	Z-Music	Madison Square Garden [V2+]	KCNC-CBS Denver [V2+]	(none)	6
nglish	XEQ-TV canal 9	Data Transmissions	Data Transmissions	TVN Video Compression [digital]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN FOX Sports West [V2+]	(none)	7
TV bal feeds	(none)	(Inactive)	XHGC canal 5	General Communication [digital]	HBO West [V2+]	QVC-2 Fashion Channel	Cartoon Network [V2+]	Prevue Guide	NBC-East	(none)	8
nglish tic	o/v	(Inactive)	(none)	TVN Video Compression [digital]	ESPN [V2+]	Music Choice [digital]	ESPN2 Blackout [V2+]/SAH	QVC Network	FOX Sports Net Base	(none)	9
Video on [SA-G]	Mexican Parliament	(Inactive)	XEIPN canal 11	TVN Video Compression [digital]	MOR Music	Home Shopping Club Spree	MSNBC [V2+]	Home Shopping Network (HSN)	SSN FOX Sports SW [V2+]	SCPC services	10
rench	(none)	(Inactive)	(none)	TVN Video Compression [digital]	Family Channel East [V2+]	Newsport [V2+]	Eternal Word TV Network (Rel)	SpeedVision [V2+]	Network One 'N1'	(none)	11
Video ion [SA-G]	Data Transmissions	(Inactive)	Data Transmissions	General Communication [digital]	Discovery West [V2+]	History Channel [V2+]	Valuevision	Global Shopping Network	Data Transmissions	(none)	12
nglish fic	(none)	(Inactive)	(none)	TVN Video Compression [digital]	CNBC [V2+]	The Weather Channel [V2+]	Encore [digicipher]	Travel Channel [V2+]	Fox Sports Midwest [V2+]	(none)	13
Video ion [SA-G]	Data Transmissions	o/v	XEW canal 2	Sundance Channel [V2+]	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Blackout [V2+]/SAH	Animal Planet [V2+]	KUSA-NBC Denver [V2+]	SCPC services	14
v	Multivision [digicipher]	(Inactive)	Data Transmissions	Showtime West [V2+]	HBO East [V2+]	Showtime East [V2+]	Turner Broadcasting [digital]	Request TV 1 [V2+]	SC Florida [V2+]	DART services	15
Video ion [SA-G]	Data Transmission	CTV Network [digital]	XEIMT Canal 22	General Communication [digital]	Cinemax West [V2+]	M2: Music Television	Turner Classic Movies [V2+]	MTV East [V2+]	FOX Sports Arizona/America [digicipher]	SCPC services	16
feeds	o/v	(Inactive)	(none)	Nickelodeon West [V2+]	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	Viewer's Choice [digicipher]	SSN FOX Sports (Alternates) [V2+]/Cal Span	(none)	17
e (adult) +]	o/v	(Inactive)	Clara Vision (Rel)	The Movie Channel West [V2+]	TNN [V2+]	TVLand	HBO Multiplex [digicipher]	C-SPAN 2	FOX Sports Rocky Mountain	o/v	18
gital video ssion]	Multivision [digicipher]	TV Northern Canada [digital]	(none)	MTV West [V2+]	USA East [V2+]	Showtime/MTV [digicipher]	Cinemax East [V2+]	Showtime 2 [V2+]	FOXNet [V2+]	SEDAT services	19
v	(none)	o/v	Data Transmissions	General Communication [digital]	BET [V2+]	Jones Intercable [digicipher]	Home and Garden Network [V2+]	Discovery East [V2+]	(none)	(none)	20
gital video ssion]	(none)	SCPC services/ Data Transmissions	Mexican Cable [digicipher]	ESPNews [V2+]	Knowledge TV	Comedy Central East [V2+]	USA West [V2+]	FLIX [V2+]	FOX Sports West 2 [V2+]	SCPC services	21
(adult) +]	(none)	(Inactive)	XHIMT canal 7	Global Access (occ)	CNN/HN [V2+]	Your Choice TV/Animal Planet [digicipher]	Nostalgia Channel	VH-1 [V2+]	SSN FOX Sports NW [V2+] (occ)	(none)	22
English	(none)	(Inactive)	Mexican Cable [digicipher]	(none)	A&E [V2+]	E! Entertainment TV [V2+]	[digital video compression]	CMT [V2+]	KWGN-Ind Denver [V2+]	SEDAT services	23
(failed onder)	(none)	(Inactive)	XHDF canal 13	General Communication [digital]	Showtime/Movie Channel [SA MPEG]	Digital Music Express Radio (DMX) [digital]	Global Shopping Network	Global Shopping Network	SSN Sunshine [V2+]	Alaskan Rural/Alaska One [SA-MPEG]	24

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International Shortwave Broadcasters via Satellite

By Larry Van Horn and Robert Smathers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

International Shortwave Broadcasters via Satellite

TRANS WORLD RADIO (TWR)

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

TUNIS INTERNATIONAL RADIO

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

VATICAN RADIO

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

VOICE OF AMERICA (United States Information Agency)

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

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

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

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

VOICE OF THE ARABS

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

VOICE OF SAHEL

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

VOICE OF THE IRAQI PEOPLE (CLANDESTINE)

Programming has been reported on Arabsat 1C at 31.0 east on a FDM transmission centered at 3940 MHz RHCP. Transmissions have been noted from 24.5 kHz to 2700 kHz in USB between 1300-0100 UTC.

WORLD HARVEST INTERNATIONAL RADIO, WHRI-South Bend, Indiana

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

WORLD RADIO NETWORK

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

WRN 1 North American English Program Schedule

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

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

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

WRN European Service

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

WRN Asia-Pacific Service

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

WRN Middle East and Africa Service

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

WORLDWIDE CATHOLIC RADIO - WEWN

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

YLE RADIO FINLAND

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

Geostationary Satellite Locator Guide

By Larry Van Horn

This guide shows the orbital locations of 242 active geostationary/synchronous satellites at publication deadline. Synchronous satellite location information is supplied to *Satellite Times* by NASA's Goddard Space Flight Center-Orbital Information Group (Mr. Adam Johnson). We are particularly grateful to the following individuals for providing payload information and analysis: Earth News: Philip Chien; Molniya Space Consultancy: Mr. Phillip Clark; JSC NASA: Dr. Nicholas Johnson; University of New Brunswick: Mr. Richard B. Langley; Havard-Smithsonian Center for Astrophysics: Jonathan McDowell; U.S. Space Command/ Public Affairs; Naval Space Command/Public Affairs; NASA NSSDC/WDC-A, Goddard Space Flight Center; and the *Satellite Times* staff.

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

Radio Frequency Band Key

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

Satellite Service Key

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

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
21140	1991-015B Meteosat 5 (MOP 2)	0.1E#	Met (L)
23730	1995-067A Telecom 2C (France)	2.9E	Dom FSS/Gov-Mil (X/C/Ku)
23712	1995-060A USA 115 (DFS-2/Milstar-2)	4.0E/i	Mil-Comm (P/S/K)
19919	1989-027A Tele X (Sweden)	5.0E	Reg DTH/FSS (Ku)
20193	1989-067A Sirius/Marcopolo 1(BSB R-1)	5.1E	Reg DTH (Ku)
22921	1993-076A USA 98 (NATO 4B)	6.0E/i	Mil-Comm (P/S/X)
20929	1990-095A DSP F-15 (USA)	6.6E#	Mil-Early Warning (S/X)
22028	1992-041B Eutelsat II F4	7.0E	Reg FSS (Ku)
21056	1991-003B Eutelsat II F2	9.9E	Reg FSS (Ku)
22557	1993-013A Raduga 29 (Russia)	11.4E#	Dom FSS/Gov-Mil (X/C)
19596	1988-095A Raduga 22 (Russia)	12.0E/i	Dom FSS/Gov-Mil (X/C)
22269	1992-088A Cosmos 2224 (Russia)	12.2E#	Mil-Earl Warning (X)
24665	1996-067A Hot Bird 2 (Eutelsat II F7)	13.1E	DTH (Ku)
20777	1990-079B Eutelsat II F1	13.1E	Reg FSS (Ku)
21055	1991-003A Italsat F1 (Italy)	13.1E	Dom-Telephone (S/K/Ka)
24208	1996-044A Italsat F2 (Italy)	13.2E	Dom-Telephone-Mob (S/K/Ka)
23537	1995-016B Hot Bird 1 (Eutelsat II F6)	14.4E	DTH (Ku)
21803	1991-083A Eutelsat II F3	16.5E	Reg FSS (Ku)
23686	1995-055A Astra 1E	19.1E	Reg DTH (Ku)
22653	1993-031A Astra 1C	19.2E	Reg DTH (Ku)
19688	1988-109B Astra 1A	19.2E	Reg DTH (Ku)
21139	1991-015A Astra 1B	19.2E	Reg DTH (Ku)
23331	1994-070A Astra 1D	19.2E	Reg DTH (Ku)
23842	1996-021A Astra 1F	19.3E	Reg DTH (Ku)
19331	1988-063B Eutelsat 1 F5 (ECS 5)	21.5E#	Reg FSS (VHF/Ku)
22175	1992-066A DFS 3 (Germany)	23.7E	Dom BSS (S/Ku/K)
18351	1987-078B Eutelsat 1 F4 (ECS 4)	25.5E/i	Reg FSS (VHF/Ku)
20659	1990-054A Gorizont 20 (Russia)	25.8E/i	Dom/Gov FSS (C/Ku)
23948	1996-040A Arabsat 2A (Arabsat)	26.0E	Reg FSS/BSS (C/Ku)
20706	1990-063B DFS 2/Kopernikus (Germany)	28.4E	Dom BSS (S/Ku/K)
24652	1996-062A Arabsat 2B (Arabsat)	30.4E	Reg FSS/BSS (C/Ku)
21894	1992-010B Arabsat 1C (Arabsat)	30.9E	Reg FSS/BSS (S/C)
23200	1994-049B Turksat 1B (Turkey)	31.6E	Reg FSS (Ku)
20263	1989-081A Gorizont 19 (Russia)	33.6E/i	Dom/Gov FSS (C/Ku)
19765	1989-004A Gorizont 17 (Russia)	34.4E/i	Dom/Gov FSS (C/Ku)
21821	1991-087A Raduga 28 (Russia)	34.8E/i	Dom FSS/Gov-Mil (X/C)
22963	1993-002A Gals 1 (Russia)	35.8E	Dom BSS (Ku)
23717	1995-063A Gals 2 (Russia)	35.9E	Dom BSS (Ku)

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
23775	1996-005A Gorizont 31 (Russia)	39.8E#	Dom/Gov FSS (C/Ku)
23949	1996-040B Turksat 1C (Turkey)	41.9E	Reg FSS (Ku)
22981	1994-008A Raduga 1-3 (Russia)	48.9E#	Dom FSS/Gov-Mil (X/C)
23880	1996-034A Gorizont 32 (Russia)	52.5E#	Dom/Gov FSS (C/Ku)
19687	1988-109A Skynet 4B (UK)	53.0E/i	Mil-Comm (P/S/X/Ka)
23305	1994-064A Intelsat 703	57.2E	Int FSS (C/Ku)
13040	1982-006A DSCS II E15 (USA)	57.0E/i	Mil-IOR reserve operational (S/X)
20203	1989-069B DSCS III A2 (USA 44)	57.0E/i	Mil-IOR primary operational (P/S/X)
20667	1990-056A Intelsat 604	60.0E	Int FSS (C/Ku)
22913	1993-074A DSCS III B10 (USA 97)	60.0E/i	Mil-IOR primary operational (P/S/X)
20315	1989-087A Intelsat 602	62.9E	Int FSS (C/Ku)
23839	1996-020A Inmarsat 3 F1	63.9E/i	Int Mar (L/C)
13636	1982-106A DSCS II F16 (USA 43)	65.2E/i	Mil-IOR reserve operational (S/X)
23461	1995-001A Intelsat 704	66.0E	Int FSS (C/Ku)
23636	1995-040A PanAmSat 4 (PAS 4)	68.4E	Int FSS (C/Ku)
23448	1994-087A Raduga 32 (Russia)	70.4E#	Dom FSS/Gov-Mil (X/C)
20083	1989-048A Raduga 1-1 (Russia)	70.4E/i	Dom FSS/Gov-Mil (X/C)
20410	1990-002B Leasat 5 (USA)	71.6E/i	Mil-IOR reserve (P/S/X)
22787	1993-056A USA 95 (UFO-2)	72.1E/i	Mil-IOR primary (P/S)
23589	1995-027A USA 111 (UFO-5)	72.8E/i	Mil-IOR reserve (P/S/K)
22027	1992-041A Insat 2A (India)	73.8E	Dom FSS/BSS/Met (S/C)
13595	1982-097A Intelsat 505	73.9E/i/d	Int FSS/Mar (L/C/Ku)
12474	1981-050A Intelsat 501	74.0E/i/d	Int FSS (C/Ku)
23327	1994-069A Elektro 1 (Russia)	76.4E#	Met (L)
23680	1995-054A Luch 1-1 (Russia)	76.5E/i	Tracking & Relay SDRN-2 (Ku)
23314	1994-065B Thaicom 2 (Thailand)	76.9E	Reg FSS (C/Ku)
22931	1993-078B Thaicom 1 (Thailand)	78.4E	Reg FSS (C/Ku)
21759	1991-074A Gorizont 24 (Russia)	79.8/i	Dom/Gov FSS (C/Ku)
24435	1996-058A Express 2 (Russia)	79.8E	Int FSS (C/Ku)
23653	1995-045A Cosmos 2319 (Russia)	79.9E#	Data Relay (C)
20643	1990-051A Insat 1D (India)	82.9E	Dom FSS/BSS/Met (S/C)
22836	1993-062A Raduga 30 (Russia)	84.8E#	Dom FSS/Gov-Mil (X/C)
19548	1988-091B TDRS F3 (USA)	85.2E/i	Gov (C/S/Ku)
18922	1988-014A PRC 22 DFH2-1(China)	87.6E/i	Dom FSS (C)
22880	1993-069A Gorizont 28 (Russia)	90.1E#	Dom/Gov FSS (C/Ku)
23765	1995-003A Measat 1 (Malaysia)	91.4E	Dom FSS/DTH (C/Ku)
23731	1995-067B Insat 2C (India)	93.4E	Dom FSS/BSS/Met (S/C)
22724	1993-048B Insat 2B (India)	93.5E	Dom FSS/BSS/Met (S/C)
23426	1994-082A Luch 1 (Russia)	95.2E#	Tracking & Relay CSDRN (Ku)
22245	1992-082A Gorizont 27 (Russia)	96.5E#	Dom/Gov FSS (C/Ku)
20473	1990-011A PRC 26 DFH2A-1 (China)	97.8E#	Dom FSS (C)
22210	1992-074A Ekran 20 (Russia)	98.5E#	Dom BSS (P)
23723	1995-064A AsiaSat 2	100.5E	DTH (C/Ku)
21922	1992-017A Gorizont 25 (Russia)	103.4E/i	Dom/Gov FSS (C/Ku)
20558	1990-030A Asiasat 1	105.2E	DTH (C/Ku)
21668	1991-060A BS-3B (Yuri 3B)(Japan)	107.2E	Dom BSS (Ku)
20570	1990-034A Palapa B2R	108.0E	Reg FSS (C)
20771	1990-077A BS-3A (Yuri 3A)(Japan)	109.7E	Dom BSS (Ku)
19710	1988-111A PRC 25 DFH2-2 (China)	110.1E#	Dom FSS (C)
23768	1996-003A Koreasat 2 (Mugunghwa 2)	112.5E	Dom FSS (Ku)
23864	1996-030A Palapa C2	112.7E	Reg FSS (C/Ku)
14985	1984-049A Chinasat 5 (Spacenet 1)	115.5E	Dom FSS (C/Ku)
23639	1995-041A Koreasat 1 (Mugunghwa 1)	115.8E	Dom FSS (Ku)
21964	1992-027A Palapa B4	117.8E	Reg FSS (C)
20217	1989-070A GMS-4 (Himawari 4)	119.2Ei	Met (P/L)
23649	1995-043A JCSAT 3 (Japan)	127.9E	Dom FSS (Ku)
21132	1991-014A Raduga 27 (Russia)	128.1E/i	Dom FSS/Gov-Mil (X/C)
22907	1993-072A Gorizont 29 (Rimsat 1)	129.3E#	Reg FSS (C/Ku)
23651	1995-044A N-Star A (Japan)	131.9E	Dom/Mob FSS (S/C/Ku/Ka)
23943	1996-039A Apstar 1A (China)	133.9E	Reg FSS (C)
23781	1996-007A N-Star B (Japan)	135.7E	Dom/Mob FSS (S/C/Ku/Ka)
19508	1988-086A CS 3B (Sakura 3B) (Japan)	135.7E	Dom FSS (C/K)
23185	1994-043A APStar I (China)	137.9E	DTH (C)
23522	1995-011B GMS-5 (Himawari 5)	139.8E#	Met (P/L)
20953	1990-102A Gorizont 22 (Russia)	139.9E/i	Dom/Gov FSS (C/Ku)
23108	1994-030A Gorizont 30 (Rimsat 2)	142.5E#	Reg FSS (C/Ku)
17706	1987-029A Palapa B-2P	143.9E	Reg FSS (C)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
20923	1990-094A Gorizont 21 (Russia)	144.8E/i	Dom/Gov FSS (C/Ku)
20066	1989-046A DSP F-14 (USA)	145.4E/i	Mil-Early Warning (S/X)
24653	1996-063B Measat-2 (Malaysia)	148.1E	Dom FSS/DTH (C/Ku)
23779	1996-006A Palapa C1	149.9E	Reg FSS (C/Ku)
19874	1989-020A JCSAT 1 (Japan)	150.0E	Dom FSS (Ku)
18316	1987-070A ETS V/Kiku 5 (Japan)	150.2E/i	Experimental (L/C)
18350	1987-078A Optus A3 (Aussat K3)	151.9E#	DTH (Ku)
20402	1990-001B JCSAT 2 (Japan)	153.7E	Dom FSS (Ku)
23227	1994-055A Optus B3 (Australia)	155.9E	DTH/Mob (L/Ku)
12994	1981-119A Intelsat 503	156.8E/i	Int FSS (C/Ku)
22253	1992-084A Superbird A1 (Japan)	158.0E	Dom FSS (Ku/K)
22087	1992-054A Optus B1 (Aussat B1)	159.9E	DTH/Mob (L/Ku)
21893	1992-010A Superbird B1 (Japan)	162.0E	Dom FSS (Ku/K)
16275	1985-109C Optus A2 (Aussat 2)	163.9E/i	DTH (Ku)
23175	1994-040A PanAmSat 2 (PAS-2)	168.9E	Int FSS (C/Ku)
12046	1980-087A OPS 6394 (FltSatCom F4)(USA)	171.7E/i	Mil-POR reserve (P-Bravo/S/X)
22871	1993-066A Intelsat 701	173.9E	Int FSS (C/Ku)
22719	1993-046A DSCS III B9 (USA 93)	175.0E/i	Mil-WPAC primary operational (P/S/X)
23124	1994-034A Intelsat 702	177.0E	Int FSS (C/Ku)
24674	1996-070A Inmarsat 3 F3	177.9E/i	Int Mar (L/C)
20918	1990-093A Inmarsat 2 F1	179.4E#/d	Int Mar-IOR (L/C)
21814	1991-084B Inmarsat 2 F3	179.5E#	Int Mar-POR (L/C)
16117	1985-092C DSCS III B5 (USA 12)	180.0E/i	Mil-WPAC reserve operational (P/S/X)
15873	1985-055A Intelsat 511	179.9E/i	Int FSS (C/Ku)
23467	1995-003A USA 108 (UFO-4) (USA)	177.6W/i	Mil-POR (P/S/K)
19121	1988-040A Intelsat 513	177.1W#	Int FSS (C/Ku)
21639	1991-054B TDRS F5 (USA)	174.4W	Int FSS/Gov (C/S/Ku)
23613	1995-035B TDRS F7 (USA)	171.1W#	Int FSS/Gov (C/S/Ku)
18631	1987-100A Raduga 21 (Russia)	170.1W/i	Dom FSS/Gov-Mil (X/C)
20499	1990-016A Raduga 25 (Russia)	169.6W/i	Dom FSS/Gov-Mil (X/C)
21392	1991-037A Satcom C5 (Aurora II)(USA)	139.1W	Dom FSS (C)
20945	1990-100A Satcom C1 (USA)	137.1W	Dom FSS (C)
23581	1995-025A GOES 9 (USA)	134.9W	Met (P/L/S)
22096	1992-057A Satcom C4 (USA)	134.9W	Dom FSS (C)
21873	1992-006A DSCS III B14 (USA 78)	135.0W/i	Mil-EPAC primary operational (P/S/X)
23016	1994-013A Galaxy 1R (USA)	133.0W	Dom FSS (C)
22117	1992-060B Satcom C3 (USA)	131.0W	Dom FSS (C)
13637	1982-106B DSCS III A1 (USA)	129.9W/i	Mil-EPAC reserve operational (P/S/X)
21906	1992-013A Galaxy 5 (USA)	125.1W	Dom FSS (C)
16649	1986-026A Gstar 2 (USA)	124.9W#	Dom FSS (Ku)
23877	1996-033A Galaxy 9 (USA)	123.1W	Dom FSS (C)
19484	1988-081B SBS 5 (USA)	122.8W	Dom FSS (Ku)
22988	1994-009A USA 99 (DFS-1/Milstar 1)	120.0W	Mil-Comm (P/S/K)
15826	1985-048D Telestar 3D (USA)	119.9W#	Dom FSS (C)
24313	1996-055A Echostar 2 (USA)	119.0W	DTH (Ku)
23754	1995-073A EchoStar 1 (USA)	119.0W	DTH (Ku)
16274	1985-109B Morelos 2 (Mexico)	116.8W	Dom FSS (C/Ku)
13652	1982-110C Anik C3 (Canada)	114.8W/i	Dom FSS (Ku)
23313	1994-065A Solidardad 2 (Mexico)	113.0W	Dom FSS (L/C/Ku)
21726	1991-067A Anik E1 (Canada)	111.1W	Dom FSS (C/Ku)
22911	1993-073A Solidaridad 1 (Mexico)	109.2W	Dom FSS (L/C/Ku)
21222	1991-026A Anik E2 (Canada)	107.3W	Dom FSS (C/Ku)
08746	1976-023A LES 8 (USA)	106.7W/i	Mil-Exp comm (P/Ka)
23846	1996-022A MSAT M1 (Canada)	106.5W	Mobile (L/X)
03029	1967-111A ATS 3 (USA)	106.0W/i	Exp comm (VHF/C)
08697	1976-017A Marisat 1	105.9W/i	Int Mar-AOR (P/L/C)
15677	1985-035A Gstar 1 (USA)	105.3W#	Dom FSS (Ku)
20946	1990-100B Gstar 4 (USA)	105.0W	Dom FSS (Ku)
23696	1995-057A USA 114 (UFO-6)	104.7W/i	Mil-CONUS (P/S/K)
08747	1976-023B LES 9 (USA)	104.1W/i	Mil-Exp comm (P/Ka)
24315	1996-054A GE-1 (USA)	103.1W	DOM FSS (C/Ku)
23435	1994-084A DSP F-17 (USA)	102.6W#	Mil-Early Warning (S/X)
19483	1988-081A Gstar 3 (USA)	101.4W/i/d	Dom FSS/Mob (L/Ku)
22930	1993-078A DBS 1 (USA)	101.3W	DTH (Ku)
21227	1991-028A Spacenet 4 (USA)	101.1W	Dom FSS (C/Ku)
23553	1995-019A AMSC 1 (USA)	101.0W	Mobile (L/X)
23598	1995-029A DBS 3 (USA)	101.0W	DTH (Ku)
23192	1994-047A DBS 2 (USA)	100.8W	DTH (Ku)
22796	1993-058B ACTS (USA)	100.1W	Exp Comm (C/K/Ka)
17181	1986-096A USA 20 (FltSatCom F7)(USA)	100.0W/i	Mil-CONUS primary (P/S/X/K)
22694	1993-039A Galaxy 4 (USA)	99.0W	Dom FSS (C/Ku)
23741	1995-069A Galaxy 3R (USA)	95.0W	Dom/DTH (C/Ku)
16650	1986-026B SBTS 2 (Brazil)	92.0W	Dom FSS (C)
15237	1984-093D Telestar 3C (302) (USA)	91.4W#/d	Dom FSS (C)
22205	1992-072A Galaxy 7 (USA)	91.0W	Dom FSS (C/Ku)
23670	1995-049A Telstar 402R (USA)	89.1W	Dom FSS (C/Ku)
18951	1988-018A Spacenet 3R (USA)	87.1W	Dom FSS (L/C/Ku)
16276	1985-109D Satcom K-2 (USA)	84.9W	Dom FSS (Ku)
16482	1986-003B Satcom K-1 (USA)	84.5W#	Dom FSS (Ku)
15561	1985-015B SBTS 1 (Brazil)	79.0W#	Dom FSS (C)
15235	1984-093B SBS 4 (USA)	77.2W/i	Dom FSS (Ku)
12309	1981-018A Comstar D4 (USA)	76.2W/i	Dom FSS (C)
14133	1983-059B Anik C2 (Argentina)	75.8W/i	Dom FSS (Ku)
23051	1994-022A GOES 8 (USA)	74.5W#	Met (P/L/S)
20872	1990-091A SBS 6 (USA)	74.1W	Dom FSS (Ku)
20873	1990-091B Galaxy 6 (USA)	74.0W	Dom FSS (C)
15642	1985-028B Anik C1/Nahuel II (Argentina)	71.9W	Dom FSS (Ku)
15385	1984-114A Spacenet 2 (USA)	71.9W	Dom FSS (C/Ku)
23199	1994-049A Brazilsat B1 (Brazil)	71.8W	Dom FSS (C)
23536	1995-016A Brasilsat B2 (Brazil)	65.1W	Dom FSS (C/X)
21149	1991-018A Inmarsat 2 F2	55.1W/i	Int Mar-AOR-W (L/C)
21940	1992-021B Inmarsat 2 F4	54.0W/i	Int Mar-AOR-W (L/C)
23571	1995-023A Intelsat 706	53.0W	Int FSS (C/Ku)
23628	1995-038A DSCS III B7 (USA)	52.5W/i	Mil-WLANT primary operational (P/S/X)
23915	1996-035A Intelsat 709	50.0W	Intl FSS (C/Ku)
22314	1993-003B TDRS F6 (USA)	46.9W	Gov (C/S/Ku)
19217	1988-051C PanAmSat 1 (PAS 1)	45.0W	Int FSS (C/Ku)
23764	1996-002A PanAmSat 3R (PAS 3R)	43.0W	Int FSS (C/Ku)
16116	1985-092B DSCS III B4 (USA 11)	42.5W/i	Mil-ATL reserve operational (P/S/X)
19883	1989-021B TDRS F4 (USA)	41.0W#	Int FSS/Gov (C/S/Ku)
12089	1980-098A Intelsat 502	40.6W/i	Int FSS (C/Ku)
23413	1994-079A Orion 1 (USA)	37.7W	Int FSS (Ku)
20523	1990-021A Intelsat 603	34.6W	Int FSS (C/Ku)
20401	1990-001A Skynet 4A	34.0W/i	Mil-comm (P/S/X/Ka)
14077	1983-047A Intelsat 506	31.5W/i	Int FSS/Mar (L/C/Ku)
22112	1002-059A Cosmos 2209 (Russia)	31.0W#/d	Mil-Early Warning (X)
22116	1992-060A Hispasat 1A (Spain)	30.0W	Dom BSS/FSS (Ku)
22723	1993-048A Hispasat 1B (Spain)	30.0W	Dom BSS/FSS (Ku)
21765	1991-075A Intelsat 601	27.6W	Int FSS (C/Ku)
21653	1991-055A Intelsat 605	24.6W	Int FSS (C/Ku)
23967	1996-042A USA 127 (UFO-7)	23.8W/i	Mil-AOR (P/S/K)
20253	1989-077A USA 46 (FltSatCom 8)	22.9W/#	Mil-AOR primary (P-Charlie/S/X/K)
21989	1992-032A Intelsat K	21.6W	Int FSS (Ku)
19772	1989-006A Intelsat 515	21.3W	Int FSS (C/Ku)
15391	1984-115A NATO III D	21.3W/i	Mil-Comm (P/S/X)
20705	1990-063A TDF 2 (France)	18.8W	DTH (Ku)
23528	1995-013A Intelsat 705	18.1W	Int FSS (C/Ku)
21047	1991-001A NATO IV A	17.8W/i	Mil-Comm (P/S/X)
20391	1989-101A Cosmos 2054 (Russia)	16.0W/i	Tracking & Relay WSDRN (Ku)
24307	1996-053A Inmarsat 3 F2	15.6W/i	Int Mar (L/C)
15386	1984-114B Marecs B2	15.5W/i	Int Mar-AOR (L)
23132	1994-035A USA-104 (UFO-3)(USA)	14.6W/i	Mil-AOR primary (P/S)
23319	1994-067A Express 1 (Russia)	14.2W	Int FSS (C/Ku)
23267	1994-060A Cosmos 2291 (Russia)	13.5 W#	Data Relay (C)
22009	1992-037A DSCS III B12 (USA 82)	12.0W	Mil-ELANT primary operational (P/S/X)
22041	1992-043A Gorizont 26 (Russia)	11.1W#	Dom/Gov FSS (C/Ku)
21813	1991-084A Telecom 2A (France)	8.1W	Dom FSS/Gov-Mil (X/C/Ku)
22912	1993-073B Meteosat 6 (ESA)	5.2W#	Met (L)
21805	1991-080B DSP F-16 (USA)	6.9W#	Mil-Early Warning (S/X)
21939	1992-021A Telecom 2B (France)	5.0W	Dom FSS/Gov-Mil (X/C/Ku)
24209	1996-044B Telecom 2D (France)	4.9W	Dom-FSS/Gov-Mil (C/X/Ku)
23865	1996-030B Amos 1 (Israel)	4.1W	Dom FSS (C)
23816	1996-015A Intelsat 707	1.0W	Int FSS (C/Ku)
20776	1990-079A Skynet 4C (UK)	1.1W#	Mil (P/S/X/Ka)
20762	1990-074A Thor 1/Marcopolo 2 (BSB R-2)	0.9W	Reg BSS (Ku)
20168	1989-062A TV Sat 2 (Germany)	0.6W	Dom BSS (Ku)

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Satellite	Mode	Frequencies																
OSCAR 10 (AO-10) (Notes 1 & 12)	B (u/V)	Dn	145.825	835	845	855	865	875	885	895	905	915	925	935	945	955	965	145.975
		Up	435.179	169	159	149	139	129	119	109	099	089	079	069	059	049	039	435.029
	Bcn	145.810 (Steady unmodulated carrier)																

Satellite	Mode								
RS 10/11 (Notes 2, 3, 4 and 12)		Dn	29.360	370	380	390	29.400		29.403
		Up	145.860	870	880	890	145.900	(CW)	145.820
	Bcn	29.357 (CW)							
RS-12/13 (Notes 2, 5 & 6)		Dn	29.410	420	430	440	29.450		29.454
		Up	21.210	220	230	240	21.250	(CW)	21.129
	Bcn	29.408							
RS-15 (Note 12)	A (v/a)	Dn	29.354	29.364	29.374	28.384	29.394		
		Up	145.858	145.868	145.878	145.888	145.898		
UoSat 11 (UO-II) (Note 13)	Bcns	Dn	145.826	435.025	2401.500				
		Up	None						
PACSAT (AO-16) (Notes 7, 8 & 10)	[a]	Dn	437.025 (Sec)437.050						
		Up	145.900	145.920	145.940	145.960			
DOVE (DO-17) (Notes 9 & 10)	[b,c]	Dn	145.825	2401.220					
		Up	None						
WEBERSAT (WO-18) (Note 10)	[a]	Dn	437.075	437.100 (Sec)					
		Up	None						
LUSAT (LO-19) (Notes 7 & 10)	[a]	Dn	437.125	437.150 (Sec)					
		Up	145.840	145.860	145.880	145.900			

NOTES

1. The AO-10 beacon is an unmodulated carrier. This satellite has suffered computer damage making it impossible to orient the satellite for optimum service or solar illumination. In order to preserve it as long an possible, do not transmit to it when you hear the beacon FMing.
2. RS-10/11 and RS-12/13 are each mounted on common spaceframes, along with comunication and navagation packages.
3. RS-10 has been in Mods A for some months, but also has capability for Mode T (21.160-21.200 Uplink, 145.860-145.900 Downlink), Mode K (21.160-21.200 Uplink, 29.360-29.400 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
4. RS-11 is currently turned off. If activated, it has capability for Mods A (145.910-145.950 Uplink, 29.410-29.450 Downink), Mode T (21.210-21.250 Uplink, 145.910-145.950 Downlink), Mode K (21.210-21.250 Uplink, 29.410-29,450 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
5. RS-12 has been in Mode K for some months, but also has capability for Mode A (145.910-145.950 Uplink, 29.410-29.450 Downlink), Mode T (21.210-21.250 Uplink, 145.910-145.950 Downlink) an well as combined Modes K/A and K/T using these same frequency combinations.
6. RS-13 is currently turned off. If activated, it has capability for Mode A (145.960-146.000 Uplink, 29.460-29.500 Downlink), Mode K (21.260-21.300 Uplink, 29.460-29.500 Downlink), Mode T (21.210-21.250 Uplink, 145.960-146.000 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
7. Transmitters on both AO-16 & LU-19 are currently using Raised Cosine Mode.
8. AO-16 users are encouraged to select 145.900, 145.920 and 145.940 for uploading and 145.960 for directory and/or file requests.
9. DOVE is designed to transmit digital voice messages, but due to hardware and software difficulties, it has not yet met this objective except for a few short tests. Recently, it has been transmitting telemetry in normal AX-25 AFSK packet.
10. Letters in [ ] represent digital formats, as follows:
    [a] 1200 bps PSK AX-25
    [b] 1200 bps AFSK AX-25
    [c] 9600 bps FSK
    [d] Digitized voice (Notes 8 & 9)
11. PO-28 is available to amateurs on an intermittent, unscheduled basis.
12. Modes of operation used include: CW,/USB/FAX/Packet/RTTY
13. Modes of operation used include: FM (AFSK) & PSK Data.
14. Modes of operation used include: Packet & FM Voice.

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

Compiled by
AMSAT
The Radio Amateur Satellite Corp.
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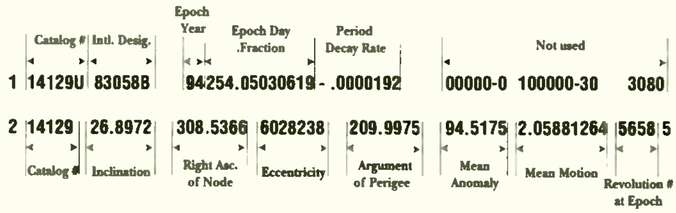
Amateur and Weather Satellite Two-Line Orbital Element Sets

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.

OSCAR 10 (AMSAT OSCAR 10, AO-10)
1 14129U 83058B 96299.11613815 -.00000305 00000-0 10000-3 0 4631
2 14129 25.8792 182.5891 6052907 60.2572 346.3435 2.05882271 72548
OSCAR 11 (UoSAT 2, UoSAT 11, UOSAT OSCAR-11, UO-11)
1 14781U 84021B 97035.53105716 .00000102 00000-0 25055-4 0 9486
2 14781 97.8193 22.1814 0012926 67.0859 293.1695 14.69521544691779
Russian Mir Space Station
1 16609U 86017A 97038.26670343 .00000501 00000-0 12279-4 0 286
2 16609 51.6525 19.1001 0012021 50.0945 310.1156 15.60473057626749
RS-10/11 (Radio Sputnik 10/11, Cosmos 1861)
1 18129U 87054A 97036.35500212 .00000035 00000-0 22156-4 0 3136
2 18129 82.9271 336.1827 0010162 225.2713 134.7616 13.72374093482151
OSCAR 16 (PACSAT, AMSAT OSCAR-16, AO-16)
1 20439U 90005D 97036.77974202 -.00000020 00000-0 91225-5 0 432
2 20439 98.5441 123.8987 0010611 235.9738 124.0438 14.29997385367459
OSCAR 17 (DOVE, DOVE OSCAR-17, DO-17)
1 20440U 90005E 97035.79929007 -.00000011 00000-0 12658-4 0 441
2 20440 98.5485 123.7112 0010652 237.9384 122.0765 14.30139868367347
OSCAR 18 (WEBERSAT, WEBERSAT OSCAR-18, WO-18)
1 20441U 90005F 97036.77368714 .00000018 00000-0 23863-4 0 472
2 20441 98.5486 124.5832 0011363 234.2912 125.7214 14.30108300367485
OSCAR 19 (LUSAT, LUSAT OSCAR-19, LO-19)
1 20442U 90005G 97037.80083724 -.00000018 00000-0 98327-5 0 449
2 20442 98.5480 126.1906 0011435 232.1076 127.9074 14.30220747367655
OSCAR 20 (JAS 1B, FUJI 2, FUJI OSCAR 20, FO-20)
1 20480U 90013C 97036.50249024 -.00000036 00000-0 -10365-5 0 9405
2 20480 99.0254 22.9568 0540395 315.7906 40.1201 12.83236222327814
RS-12/13 (Radio Sputnik 12/13, Cosmos 2123)
1 21089U 91007A 97037.00244248 .00000037 00000-0 23477-4 0 9545
2 21089 82.9200 15.9350 0028602 305.6442 54.2046 13.74076885301147
OSCAR 22 (UoSAT-F, UoSAT-5, UOSAT OSCAR 22, UO-22)
1 21575U 91050B 97037.20852397 .00000005 00000-0 16047-4 0 7497
2 21575 98.3179 102.2642 0007333 293.5584 66.4832 14.37055548291674
OSCAR 23 (KITSAT-A, KITSAT-1, KITSAT OSCAR-23, KO-23)
1 22077U 92052B 97037.51320930 -.00000037 00000-0 10000-3 0 6391
2 22077 66.0775 58.8420 0014460 244.1596 115.7936 12.86300717210947
OSCAR 27 (EYESAT-A, EYESAT-1, AMSAT OSCAR-27, AO-27
1 22825U 93061C 97034.20802165 -.00000037 00000-0 27462-5 0 5347
2 22825 98.5612 111.3323 0007938 280.4115 79.6166 14.27716024174959
OSCAR 26 (ITAMSAT, ITAMSAT OSCAR-26, IO-26)
1 22826U 93061D 97034.74733072 .00000006 00000-0 19852-4 0 5323
2 22826 98.5609 112.0732 0008676 278.3114 81.7084 14.27825654175047
OSCAR 25 (KITSAT-B, KITSAT-2, KITSAT OSCAR-25, KO-25)
1 22828U 93061F 97036.77523386 -.00000026 00000-0 70927-5 0 5116
2 22828 98.5528 114.1279 0009486 252.3299 107.6830 14.28166800143453
OSCAR 28 (POSAT, POSAT OSCAR-28, PO-28)
1 22829U 93061G 97037.21523070 -.00000024 00000-0 79476-5 0 5270
2 22829 98.5562 114.6401 0009262 251.6632 108.3541 14.28149551175433
RS-15 (Radio Sputnik 15)
1 23439U 94085A 97037.87084954 -.00000039 00000-0 10000-3 0 1964
2 23439 64.8136 3.5660 0153148 156.9273 203.8624 11.27526305 87244

OSCAR 29 (FUJI 3, FUJI OSCAR-29, FO-29)
1 24278U 96046B 97034.18232339 -.00000008 00000-0 26556-4 0 552
2 24278 98.5611 93.5814 0351561 173.2696 187.3350 13.52629046 23000
OSCAR 30 (MEXICO OSCAR-30, MO-30)
1 24305U 96052B 97038.14893126 .00000204 00000-0 20364-3 0 701
2 24305 82.9345 90.6953 0029315 205.0015 154.9706 13.73088118 21210

WEATHER/IMAGING SATELLITES
Geostationary Satellites
GOES 7 (Standby Geostationary Spacecraft-USA)
1 17561U 87022A 97037.53318161 -.00000175 00000-0 10000-3 0 2714
2 17561 3.5261 67.8514 0004807 326.4201 200.3517 1.00271266 19651
GOES 8 (Operational East-USA)
1 23051U 94022A 97035.26724968 -.00000258 00000-0 10000-3 0 6375
2 23051 0.2605 268.3768 0003144 6.9243 240.8802 1.00271466 17696
GOES 9 (Operational West-USA)
1 23581U 95025A 97033.25000000 .00000088 00000-0 10000-3 0 3139
2 23581 0.0869 93.9251 0002160 246.8851 106.6342 1.00259624 6238
ELEKTRO (Operational-Russia)
1 23327U 94069A 97035.75288407 -.00000110 00000-0 00000+0 0 2423
2 23327 0.5027 98.3329 0000990 16.7735 7.2789 1.00271713 8333
Meteosat 5 (Operational ESA, aka MOP-2)
1 21140U 91015B 97031.52211458 -.00000001 00000-0 00000+0 0 3199
2 21140 1.0004 78.5609 0001847 175.8252 64.4801 1.00278571 23896
Meteosat 6 (Operational-ESA)
1 22912U 93073B 97 30.58304859 .00000000 00000-0 10000-3 0 5977
2 22912 0.2745 333.8247 0002482 159.7150 200.2978 1.00421244 10142
GMS 4 (Standby-Japan, aka Himawari 4)
1 20217U 89070A 97025.96951389 -.00000369 00000-0 10000-3 0 5235
2 20217 2.2204 73.7286 0004417 334.1663 185.9284 1.00263653 27652
GMS 5 Operational-Japan, aka Himawari 5)
1 23522U 95011B 97 37.32246473 .00000000 00000-0 10000-3 0 2040
2 23522 0.5195 32.3514 0001968 354.6256 5.3761 1.00266876 6801

NEAR POLAR/POLAR ORBITING IMAGING SPACECRAFT
NOAA 12 (Operational morning spacecraft-USA 137.500 MHz)
1 21263U 91032A 97038.11365508 .00000052 00000-0 42384-4 0 2642
2 21263 98.5451 56.3232 0012539 316.7164 43.3028 14.22688404297868
NOAA 14 (Operational afternoon spacecraft-USA 137.620 MHz)
1 23455U 94089A 97038.10997082 .00000144 00000-0 10374-3 0 9304
2 23455 98.9743 349.2145 0009107 305.4086 54.6237 14.11645347108598
Meteor 2-21(Off at last report)
1 22782U 93055A 97034.41419447 .00000036 00000-0 19414-4 0 5415
2 22782 82.5484 163.8895 0023531 51.3123 309.0136 13.83067021173096
Meteor 3-5 (Operational-Russia 137.850 MHz)
1 21655U 91056A 97037.83050411 .00000051 00000-0 10000-3 0 9549
2 21655 82.5533 154.7465 0013239 309.5907 50.4043 13.16850616263554
Meteor 3-6 (Off at last report)
1 22969U 94003A 97037.71161412 .00000051 00000-0 10000-3 0 3201
2 22969 82.5602 95.0420 0016144 15.7673 344.3949 13.16741740145918
DMSP B5D2-7 (DoD meteorological polar orbiter: downlink encrypted)
1 23233U 94057A 97038.14443965 .00000083 00000-0 68260-4 0 1079
2 23233 98.7972 99.1143 0011790 233.0851 126.9246 14.12775307126000
DMSP B5D2-8 (DoD meteorological polar orbiter: downlink encrypted)
1 23533U 95015A 97038.07300704 -.00000010 00000-0 18368-4 0 8580
2 23533 98.8450 43.5622 0007904 105.5370 254.6675 14.12773469 96795

EARTH RESOURCES IMAGING SATELLITES
OKEAN 1-7 (Okean 4-Russia 137.400 MHz)
1 23317U 94066A 97036.88856703 .00000064 00000-0 62532-5 0 2188
2 23317 82.5434 204.0202 0027555 41.9883 318.3434 14.74073458124962
SICH-1 (Oceanographic satellite-Russia 137.400 MHz-off until March 97)
1 23657U 95046A 97037.88631054 .00000174 00000-0 23222-4 0 1447
2 23657 82.5328 344.5239 0029144 10.7981 349.3843 14.73528219 77391
IRS-1C (Remote Sensing-India)
1 23751U 95072A 97035.59135158 -.00000044 00000-0 00000+0 0 1611
2 23751 98.7037 112.6053 0000905 79.6649 280.4634 14.21632481 57457
IRS-P3 (Remote Sensing-India)
1 23827U 96017A 97038.23841049 -.00000044 00000-0 00000+0 0 1207
2 23827 98.7697 118.0179 0001769 34.3140 325.8151 14.21602927 45889
1 23827U 96017A 96343.21652064 -.00000044 00000-0 00000+0 0 1008
2 23827 98.7798 57.3509 0001105 113.4773 246.6521 14.21595129 37212
TOMS-EP (Total Ozone Mapping Spectrometer-USA)
1 23940U 96037A 97038.22673455 .00001715 00000-0 78242-4 0 839
2 23940 97.4264 306.7769 0011406 243.2027 116.8044 15.21927412 33376
ADEOS (Advanced Earth Observation Satellite-Japan 2200, 8150, 8250, and 8350 MHz)
1 24277U 96046A 97038.24483736 -.00000044 00000-0 00000+0 0 1407
2 24277 98.6085 117.7991 0001654 132.8193 227.3129 14.27640400 24828

Satellite Launch Schedules

By Keith Stein

Space Transportation System (STS-NASA)

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

Mission Number	Launch Date/ Orbiter	Inclination/ Altitude	Mission Duration	Mission/Cargo Bay/Payloads
STS-83	April 1997 Columbia*	28.5/160	16 days	MSL-01, CRYOFD
STS-84	May 1997 Atlantis**	51.6/213	9+1 days	S/MM-06

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

**Crew Assignment: CDR: Charles J Precourt, PLT: Eileen M Collins, MS: C Michael Foale (U), MS: Carlos I Noriega, MS: Edward T Lu, MS: Jean-Francois Clervoy (ESA), MS: Elena Kondakova (Russia).

STS	Downlink Frequency Assignments:
VHF Voice	121.75 (WBFM), 130.167 MHz (STS-84 only)
VHF Voice	145.55, and 145.84 (amateur radio)
UHF Voice	243.0 (AM), 259.7 (AM), 279.0 (AM), and 296.8 (AM)
UHF Boosters	240.0, and 242.0 MHz (recovery beacons)
S-band TLM	2217.5, 2250.0, and 2287.5 MHz.
C-band TRK	5400-5900.0 MHz

Mir***	Downlink Frequency Assignments:
VHF Voice MHz	139.208, 143.625, 145.2, 145.55, 145.8, 145.85

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March 1997	Delta II	VAFB	Iridium #2 (3)
March 1997	Pegasus XL	VAFB	SWAS
March 1997	Pegasus XL	TAFB	MINISAT 1
March 1997	Pegasus XL	VAFB	FORTE
April 1997	Delta II	CCAS	THOR-IIA
April 1997	Delta II	VAFB	Iridium #3
April 1997	LMLV 1	VAFB	Clark
April 1997	Atlas I	CCAS	GOES-K
May 1997	Atlas IIA	CCAS	Telstar-5
May 1997	Taurus	VAFB	GeoSat-FO

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

Iridium	Downlink Frequency Assignments
L-band	1616 - 1626.500 MHz
Ka-band	19.4 - 19.6 GHz

Pegasus XL	Downlink Frequency Assignments
S-band TLM	2269.500, and 2288.500 MHz
C-band TRK	5765.000 MHz

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

SWAS	Downlink Frequency Assignments
S-band TLM	2215.0 MHz

Thor-IIA	Downlink Frequency Assignments
Ku-band	11.786 - 12.091 GHz

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

GOES	Downlink Frequency Assignments
S-band	2208.586 & 2209.086 MHz

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March 1997	Start-1	Svobodny	EarlyBird-1
April 1997	Proton	Baikonur	Tempo
May 1997	Soyuz	Baikonur	Progress M-35
May 1997	Proton	Baikonur	Telstar-5

Progress M-35	Downlink Frequency Assignments
VHF-band	166.000 MHz
L-band	922.750 & 926.050 MHz

Satellite Launch Schedules

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March 1997	Ariane 44LP	Kourou	Thaicom-3 & BSAT 1A
April 1997	Ariane 44P	Kourou	PAS-6
May 1997	Ariane 44L	Kourou	INMARSAT 3F4 & INSAT 1D

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

List of Abbreviations and Acronyms

BSAT	Japanese telecommunications satellite
C-band	3700 to 6500 MHz.
CCAS	Cape Canaveral Air Station, FL
CDR	Commander
CLARK	This high resolution satellite will locate utility pipelines & cables, and help town planners at construction sites.
CRYOFD	Cryogenic Flexible Diode Heat Pipe Experiment will evaluate the performance of 2 Cryogenic Flexible Diode Heat Pipes (CFDHP). 1st CFDHP is an oxygen heat pipe & will be operated around 60K. 2nd CFDHP is a methane heat pipe combined with a thermal storage unit & will be operated around 120K.
(D)	Crew member coming down from Russian Space Station MIR.
EarlyBird	Earth imaging satellite.
ESA	European Space Agency
INMARSAT	International Maritime Satellite, commercial satellite series providing global maritime and aviation communications.
INSAT 1D	Indian satellite, communication and meteorological satellite for the government of India.
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.
GEOSAT-FO	The GEOSAT Follow-On program is the Navy's initiative to develop an operational series of radar altimeter satellites to maintain continuous ocean observation from the GEOSAT Exact Repeat Orbit.
GOES-K	Geostationary Operational Environmental Satellite, NOAA weather satellite.
MHz	Megahertz
MINISAT	Program under the Interministerial Commission for Science & Technology (INTA). The spacecraft will carry a Extreme Ultraviolet Radiation Detector and Low Energy Gamma Ray Imager.
MS	Mission Specialist, a member of Shuttle flight crew primarily responsible for Orbiter subsystem and payload activities.
MSL-01	Microgravity Science Laboratory-01 is a payload which remains attached to the Shuttle to perform materials processing experiments in low-g.
PAS	U.S. telecommunications satellite for Pan American Satellite of Connecticut.
PLC	Payload Commander, a member of the Shuttle crew having overall crew responsibility for planning, integration, and on-orbit coordination of payload mission activities.
PLT	Pilot, a member of the Shuttle crew whose primary responsibility is to pilot the Orbiter.
PROGRESS	Unmanned resupply satellite for crew aboard Russian Space Station MIR.
PS	Payload Specialist, a member of the Shuttle crew, who is not a NASA astronaut, but whose presence is required to perform specialized functions with respect to one or more payloads or other mission unique activities.
S-band	2000 to 2300 MHz
S/MM-06	Shuttle mission to the Russian Space Station MIR to support design and assembly of the International Space Station.
SWAS	Submillimeter Wave Astronomy Satellite will study how molecular clouds collapse to form stars and planetary systems.
Telstar	AT&T communications satellite, provides communication services to the continental U.S., Alaska, Hawaii, and Puerto Rico.
Tempo	A high power DTH satellite owned by Tempo, a subsidiary of Tele-Communications Inc.
Thaicom	A Thailand telecommunications satellite designed to provide domestic phone, TV, cable TV, voice, video, data, VSAT services.
THOR-IIA	U.S. Hughes built telecommunications satellite for the country of Norway.
TLM	Telemetry
TRK	Tracking
(U)	Crew member going up to Russian Space Station MIR.
UHF	Ultra High Frequency (390 to 499 MHz)
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
WBFM	Wide-band FM

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

East WEFAX (GOES-8) Schedule

Effective October 10, 1996

The following WEFAX broadcasts schedule was provided by the Dallas Remote Imaging Group.

Time (UTC)	Product
0002	GOES-9 2100Z NH IR
0006	MET-5 0000Z D3 IR
0010	MET-5 0000Z D4 IR
0014	MET-5 0000Z D5 IR
0018	GOES-9 2100Z FD IR
0022	MET-5 0000Z D7 IR
0026	MET-5 0000Z D8 IR
0030	MET-5 0030Z D2 IR
0034	MET-5 0030Z D9 IR
0038	MET-5 0030Z D1 IR
0042	MET-5 0030Z D3 IR
0046	GOES-8 2345Z NH IR
0050	W500 48 HR 250MB HT/TEMP/WND
0100	W501 72 HR SLP/1000-500TK
0105	W502 72 HR 500MB HT/TEM/WND
0110	GOES-8 2345Z NE IR
0114	GOES-8 2345Z SE IR
0118	GOES-8 2345Z NW IR
0122	GOES-8 2345Z SW IR
0126	GOES-8 2345Z 4KM US IR
0130	GOES-8 2345Z 16KM FD IR
0134	GOES-8 2345Z NH WV
0138	GOES-8 2345Z NE WV
0142	GOES-8 2345Z SE WV
0146	GOES-8 2345Z NW WV
0150	GOES-8 2345Z SW WV
0154	GOES-8 0045Z NH IR
0158	GOES-8 2345Z 16KM FD WV
0202	GOES-9 0000Z NH IR
0206	GOES-9 0000Z FD IR
0210	NOAA-14 POLAR VIS NH 010E-080W W026
0214	NOAA-14 POLAR NIR SH 010E-080W W027
0218	NOAA-14 POLAR DIR NH 010E-080W W028
0222	NOAA-14 POLAR DIR SH 010E-080W W029
0226	NOAA-14 POLAR DIR MER 010E-060W W030
0230	GOES-9 0000Z FD WV
0235	GOES-8 0145Z NH IR
0240	ICE CHART
0245	ICE CHART
0250	ICE CHART
0255	ICE CHART
0300	W064 SIG WX PROG FL250-600
0305	SIG WX PROG FL250-600
0310	MET-5 0300Z D4 IR
0314	MET-5 0300Z D5 IR
0318	NOAA-14 POLAR VIS MER 040W-110W W031
0322	MET-5 0300Z D7 IR
0326	MET-5 0300Z D8 IR
0330	MET-5 0330Z D2 IR
0334	MET-5 0330Z D9 IR
0338	MET-5 0330Z D1 IR
0342	GOES-8 0245Z NH IR
0346	GOES-8 0245Z NE IR
0350	GOES-8 0245Z SE IR
0354	GOES-8 0245Z NW IR
0358	GOES-8 0245Z SW IR
0402	GOES-8 0245Z 4KM US IR
0406	GOES-8 0245Z 16KM FD IR
0410	MET-5 0400Z E1 MOIST
0414	MET-5 0400Z E2 MOIST
0418	MET-5 0400Z E3 MOIST
0422	MET-5 0400Z E4 MOIST
0426	MET-5 0400Z E5 MOIST
0430	MET-5 0430Z D2 IR
0434	MET-5 0430Z D1 IR
0438	GOES-9 0300Z NH IR
0442	MET-5 0430Z E6 MOIST
0446	MET-5 0430Z E7 MOIST
0450	MET-5 0430Z E8 MOIST
0454	MET-5 0430Z E9 MOIST
0458	GOES-8 0345Z NH IR
0506	GOES-9 0300Z FD IR
0514	NOAA-14 POLAR VIS NH 080W-170W W034
0518	NOAA-14 POLAR VIS SH 080W-170W W035
0522	NOAA-14 POLAR NIR NH 080E-010E W036
0526	NOAA-14 POLAR NIR SH 080E-010E W037
0530	NOAA-14 POLAR VIS MER 100W-170W W038
0534	NOAA-14 POLAR NIR MER 080E-010E W039
0538	NOAA-14 POLAR DIR NH 080W-170W W040
0542	NOAA-14 POLAR DIR SH 080W-170W W041
0546	NOAA-14 POLAR NIR MER 140E-070E W032
0550	NOAA-14 POLAR DIR MER 040W-110W W033
0558	GOES-8 0445Z NH IR
0606	MET-5 0600Z C03 VS
0610	MET-5 0600Z D1 IR
0614	MET-5 0600Z D3 IR
0618	MET-5 0600Z D4 IR
0622	MET-5 0600Z D5 IR
0626	MET-5 0600Z D6 IR
0630	MET-5 0630Z D2 IR
0634	MET-5 0630Z C02 VS
0638	MET-5 0630Z C03 VS
0642	MET-5 0630Z C3D VS
0646	MET-5 0630Z C2D VS
0650	MET-5 0630Z D3 IR
0654	MET-5 0630Z D1 IR
0658	GOES-8 0545Z NH IR
0702	GOES-8 0545Z NE IR
0706	GOES-8 0545Z SE IR
0710	GOES-8 0545Z NW IR
0714	GOES-8 0545Z SW IR
0718	GOES-8 0545Z 4KM US IR
0722	GOES-8 0545Z 16KM FD IR
0726	GOES-8 0545Z FD WV
0730	GOES-9 0600Z NH IR
0734	GOES-9 0600Z FD IR
0738	GOES-8 0645Z NH IR
0742	GOES-9 0600Z FD WV
0746	NOAA-14 POLAR DIR MER 100W-170W W042
0750	W006 24 HR PRECIP ACCUM VT00Z
0755	W007 24 HR SFC/1000-500THK
0800	W008 24 HR 500MB HT/WD/TMP
0805	W009 24 HR 250MB HT/WD/TMP
0810	W014 24 HR 250 MB PROG.
0815	W015 24 HR 250 HT ISOTACHS
0820	W016 24 HR TROP PRESS/VWS
0825	W017 24 HR TROP PRESS/VWS
0830	W018 24 HR 300 STM/ISOTACHS
0835	W019 24 HR 300 STM ISOTACHS
0840	W020 24 HR 200 STM ISOTACHS
0845	W021 24 HR 200 STM ISOTACHS
0850	W022 24 HR 500 STM ISOTACHS
0855	W023 24 HR 500 STM ISOTACHS
0900	W010 24 HR 850 STM ISOTACHS
0905	W011 24 HR 850 STM ISOTACHS
0910	MET-5 0900Z D1 IR
0914	NOAA-14 POLAR DIR NORTH POLE W043
0918	MET-5 0900Z D4 IR
0922	MET-5 0900Z D5 IR
0926	NOAA-14 POLAR DIR SOUTH POLE W044
0930	MET-5 0930Z D2 IR
0934	MET-5 0930Z C02 VS
0938	GOES-8 0745Z NH IR
0945	W012 24 HR 700 STM/ISOTACHS
0950	W013 24 HR 700 STM ISOTACHS
0955	W100 00Z MSL PRES/1000-500TK
1000	W101 00Z MSL PRES/1000-500TK
1005	W102 24HR MSL PRES/1000-500TK
1010	W103 24HR MSL PRES/1000-500TK
1015	W104 48HR MSL PRES/1000-500TK
1020	W105 48HR MSL PRES/1000-500TK
1026	GOES-8 0845Z NH IR
1030	GOES-8 0845Z NE IR
1034	GOES-8 0845Z SE IR
1038	GOES-8 0845Z NW IR
1042	GOES-8 0845Z SW IR

1046	GOES-8 0845Z 4KM US IR
1050	GOES-8 0845Z 16KM FD IR
1054	SCHEDULE FILE PART-1
1058	SCHEDULE FILE PART-2
1102	WEFAX MESSAGE FILE
1106	GOES-8 0945Z NH IR
1110	W503 48 HR SLP/1000-500TK
1115	W504 48 HR 500MB HT/TMP/WND
1122	NOAA-14 POLAR VIS NH 170W-100E W001
1126	NOAA-14 POLAR VIS SH 170W-100E W002
1130	NOAA-14 POLAR NIR NH 010E-080W W003
1134	NOAA-14 POLAR NIR SH 010E-080W W004
1138	NOAA-14 POLAR VIS MER 170W-120E W005
1142	NOAA-14 POLAR NIR MER 020E-050W W006
1146	NOAA-14 POLAR DIR NH 170W-100E W007
1150	NOAA-14 POLAR DIR SH 170W-100E W008
1154	NOAA-14 POLAR DIR MER 170W-120E W009
1158	GOES-8 1045Z NH IR
1202	GOES-9 0900Z NH IR
1206	MET-5 1200Z C03 VS
1210	MET-5 1200Z D1 IR
1214	MET-5 1200Z D3 IR
1218	MET-5 1200Z D4 IR
1222	MET-5 1200Z D5 IR
1226	GOES-9 0900Z FD IR
1230	MET-5 1230Z D2 IR
1234	MET-5 1230Z C02 VS
1238	MET-5 1230Z C03 VS
1242	MET-5 1230Z C3D VS
1246	MET-5 1230Z C2D VS
1250	MET-5 1230Z C1D VS
1254	MET-5 1230Z D1 IR
1258	GOES-8 1145Z NH IR
1302	GOES-8 1145Z NE IR
1306	GOES-8 1145Z SE IR
1310	GOES-8 1145Z NW IR
1314	GOES-8 1145Z SW IR
1318	GOES-8 1145Z 4KM US IR
1322	GOES-8 1145Z 16KM FD IR
1326	GOES-8 1145Z NH VS
1330	GOES-8 1145Z NH WV
1334	GOES-8 1145Z NE WV
1338	GOES-8 1145Z SE WV
1342	GOES-8 1145Z NW WV
1346	GOES-8 1145Z SW WV
1350	GOES-8 1245Z NH IR
1354	GOES-8 1245Z NH VS
1358	GOES-8 1145Z FD WV
1402	GOES-9 1200Z NH IR
1406	GOES-9 1200Z FD IR
1422	TBUS NOAA-12
1426	TBUS NOAA-14
1430	W505 48 HR 250MB HT/TMP/WND
1435	GOES-8 1345Z NH IR
1440	GOES-8 1345Z NH VS
1445	W506 72 HR SLP/1000-500TK
1450	W507 72 HR 500MB HT/TMP/WND
1455	W508 72 HR 250MB HT/TMP/WND
1500	W066 SIG WX PROG FL250-600
1505	SIG WX PROG FL250-600
1510	MET-5 1500Z D1 IR
1514	GOES-9 1200Z FD WV
1518	MET-5 1500Z D4 IR
1522	MET-5 1500Z D5 IR
1526	MET-5 1500Z D6 IR
1530	MET-5 1530Z D2 IR
1534	MET-5 1530Z C02 VS
1538	GOES-8 1445Z NH IR
1542	GOES-8 1445Z NE IR
1546	GOES-8 1445Z SE IR
1550	GOES-8 1445Z NW IR
1554	GOES-8 1445Z SW IR
1558	GOES-8 1445Z 4KM US IR
1602	GOES-8 1445Z 16KM FD IR
1606	GOES-8 1445Z NH VS
1610	GOES-8 1445Z NE VS
1614	GOES-8 1445Z SE VS
1618	GOES-8 1445Z NW VS
1622	GOES-8 1445Z SW VS
1626	GOES-8 1545Z NH IR
1630	GOES-8 1545Z NH VS
1638	GOES-9 1500Z NH IR
1642	GOES-9 1500Z FD IR
1706	NOAA-14 POLAR VIS MER 130E-060E W010
1710	NOAA-14 POLAR NIR MER 040W-110W W011
1714	NOAA-14 POLAR DIR MER 130E-060E W012
1718	NOAA-14 POLAR VIS NH 100E-010E W013
1722	NOAA-14 POLAR VIS SH 100E-010E W014
1726	NOAA-14 POLAR NIR NH 080W-170W W015
1730	NOAA-14 POLAR NIR SH 080W-170W W016
1734	NOAA-14 POLAR VIS MER 070E-000E W017
1738	NOAA-14 POLAR NIR MER 100W-170W W018
1742	GOES-8 1645Z NH IR
1746	GOES-8 1645Z NH VS
1758	MET-5 1800Z D2 IR
1802	MET-5 1800Z D1 IR
1806	MET-5 1800Z D3 IR
1810	MET-5 1800Z D4 IR
1814	MET-5 1800Z D5 IR
1818	MET-5 1800Z D6 IR
1822	MET-5 1800Z D7 IR
1826	MET-5 1800Z D8 IR
1830	MET-5 1830Z D2 IR
1834	MET-5 1830Z D9 IR
1838	GOES-8 1745Z NH IR
1842	GOES-8 1745Z NE IR
1846	GOES-8 1745Z SE IR
1850	GOES-8 1745Z NW IR
1854	GOES-8 1745Z SW IR
1858	GOES-8 1745Z 4KM US IR
1902	GOES-8 1745Z 16KM FD IR
1906	GOES-8 1745Z NH VS
1910	GOES-8 1745Z NE VS
1914	GOES-8 1745Z SE VS
1918	GOES-8 1745Z NW VS
1922	GOES-8 1745Z SW VS
1926	GOES-8 1845Z NH IR
1930	GOES-8 1845Z NH VS
1934	GOES-8 1745Z FD WV
1938	GOES-9 1800Z NH IR
1942	GOES-9 1800Z FD IR
1950	GOES-9 1800Z FD WV
1954	NOAA-14 POLAR DIR NH P 100E-010E W019
1958	NOAA-14 POLAR DIR SH P 100E-010E W020
2005	W047 24 HR SFC/1000/500THK
2010	W048 24 HR 500MB HT/WD/TMP
2015	W049 24 HR 250MB HT/WD/TMP
2020	W054 250 HT ISOTACHS
2025	W055 250 HT ISOTACHS
2030	W056 24HR TROP PRES/VWS
2035	W057 24HR TROP PRES/VWS
2040	W058 24HR 300 STM/ISOTACHS
2045	W059 24HR 300 STM/ISOTACHS
2050	W060 24HR 200 STM/ISOTACHS
2055	W061 24HR 200 STM/ISOTACHS
2100	W062 24HR 500 STM/ISOTACHS
2105	W063 24HR 500 STM/ISOTACHS
2110	GOES-8 1945Z NH IR
2114	GOES-8 1945Z NH VS
2118	NOAA-14 POLAR DIR MER 070E-000E W021
2122	MET-5 2100Z D7 IR
2126	MET-5 2100Z D8 IR
2130	MET-5 2130Z D2 IR
2135	W050 24HR 850 HT ISOTACHS
2140	W051 24HR 850 HT ISOTACHS
2145	W052 24HR 700 HT ISOTACHS
2150	W053 24HR 700 HT ISOTACHS
2155	W150 00Z MSL PRES/1000-500TK
2200	W151 00Z MSL PRES/1000-500TK
2205	W152 24HR MSL PRES/1000-500TK
2210	W153 24HR MSL PRES/1000-500TK
2215	W154 48HR MSL PRES/1000-500TK
2220	W155 48HR MSL PRES/1000-500TK
2225	W156 24HR PRECIP ACCUM VT 12Z
2230	GOES-8 2045Z NH IR
2234	GOES-8 2045Z NE IR
2238	GOES-8 2045Z SE IR
2242	GOES-8 2045Z NW IR
2246	GOES-8 2045Z SW IR
2250	GOES-8 2045Z 4KM US IR
2254	GOES-8 2045Z 16KM FD IR
2258	GOES-8 2045Z NH VS
2302	GOES-8 2045Z NE VS
2306	GOES-8 2045Z SE VS
2310	GOES-8 2045Z NW VS
2314	GOES-8 2045Z SW VS
2320	W509 48 HR SLP/1000-500TK
2325	W510 48 HR 500MB HT/TMP/WND
2330	NOAA-14 POLAR VIS NH 010E-080W W022
2334	NOAA-14 POLAR VIS SH 010E-080W W023
2338	NOAA-14 POLAR NIR NH 170W-100E W024
2342	NOAA-14 POLAR NIR SH 170W-100E W025
2346	GOES-8 2145Z NH IR
2350	GOES-8 2145Z NH VS
2354	GOES-8 2245Z NH IR

ST

By Ken Reitz, KS4ZR

What's the Meaning of it All?

Those of you who are regular subscribers to *ST* are saying to yourselves: "Jeez, now he's going to lecture us on some kind of bogus treatise on philosophy." Save your venom, snake man! No, friends, we're going to try to make heads and tails of some of the actual terms commonly tossed around by real satellite authorities in the pages of this very magazine.

Don't know an ascending pass from a subsatellite path? Are you worried that your system has high resolution picture transmission (HRPT)? Is it OK for a satellite orbit to be eccentric? Is it possible to have ingress from a side lobe due to a parabolic anomaly? And, anyway, is that such a bad thing?

The answers to these and all your lexiconically perplexed dilemmas lie in the seldom read back pages of almost every satellite related book and periodical. Yes, even the back of this magazine has a nifty page of teensie type with the scoop on no fewer than 51 "...terms used in the satellite business and...described in layman's terms."

While the subject of satellites has a common treasury of words, like "apogee kick motor" and "over-budget," each satellite niche has its own special terms. For instance, weather satellites are all about imagery, a function totally lacking in a good communications satellite. Whereas spy satellites are primarily interested in spying, direct broadcast satellite (DBS) satellites are primarily interested in billing.

Let's Do Launch!

All satellites go from drawing board to production to launch, and, in some cases, back to the drawing board. But, for the most part, the launch record of the various parties involved in such endeavors is a good one. It turns out that the end of the cold war came just in time. The nuclear warheads are pounded into radioactive plowshares and the rockets get a 1.5 million dollar paint job featuring the Nike logo and *voila!* Is great capitalist launch vehicle!

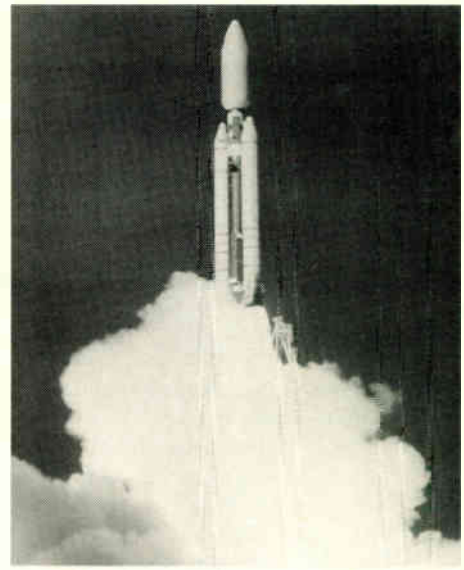
Now, in order to get this thing off the ground properly we'd better synchronize our watches. For this we'll use UTC, which is the abbreviation for Coordinated Universal Time. I know, you're thinking, "Hey, what happened to Greenwich Mean Time?" (Which was itself abbreviated as GMT because everyone knew what it stood for.)

So, here we are at the launch pad. Following a tedious photo opportunity session for visiting dignitaries and spies, our barely used ICBM is poised with its precious payload against a totally clear sky. The winds are light, the villages down range have been evacuated, and an expectant crowd waits at a nearby maternity ward. All the important officers are polled prior to "go for launch." The air inside the control room is tense and crackles with the sharp reports as each one checks in: Weather officer: Go! Communications: Go! Insurance Underwriters: Go! Defense Industry Lobbyists: Go!

Riding a tall, white plume of unnamable, ozone-depleting gases, our satellite rides a barely controlled explosion until the gas gauge reads "empty," by which time the cigars are lit and the air inside the control room looks like LA on a bad day.

Loused In Space

So much can go wrong between the launch pad and the vast void of space. But, if all goes well, the various stages of the launch vehicle will have fired properly and the payload will be delivered intact. Now that the rocket stages have burned up in the atmosphere or dropped harmlessly on unsuspecting fishing fleets, the object of our attention is safely in space. The satellite, launched with just enough energy to break the gravity of Earth but not enough to leave, hangs in a neat balance which is called an orbit.



With space vehicles, getting there is half the fun. Once in space, even more can go wrong. The satellite is forced to swim amid millions of bits of natural and unnatural debris. This debris is the result of forty years of launch successes and mishaps; old, brain dead satellites; brand new, unused satellites which failed for any number of reasons; spent booster rockets; payload shrouds; the odd tool from the space shuttle; and millions of meteors ranging in size from sand grains to baseballs, grapefruits, watermelons, and Yugos.

There are basically four types of orbits, give or take a couple thousand km: Low Earth Orbit (anything from pavement to 5,500 km up and known as LEO); Medium Earth Orbit (5,500 to 20,000 km and known as MEO); Geostationary orbit (roughly 36,000 km directly above the equator); and SNAFU Orbit (time to call the underwriters). In addition, calculations can be made to determine just how a satellite will orbit the planet. For instance, these new Personal Communications Satellites, which will be in constellations from 12 to 800 satellites, will fly Low Earth Orbits which cover mostly the first

60 degrees above and below the equator. That's where all the customers are. Geostationary satellites, like DBS 1, have to try to stay put in an assigned location so that we can receive all those 1960's sitcoms in digital clarity.

There is another type of orbit which is highly eccentric. These orbits take the satellite from LEO to MEO and trace an ellipse around the planet. These orbits were very popular in the 70's and 80's with Russia's Molnya satellites, which were broadcast satellites designed to be seen across its eleven time zones and from most of its satellite countries including Cuba. It was a very cost-effective idea and will actually be duplicated with AMSAT's next Phase 3D satellite.

Distinctions of the Species

Satellites are designed for different purposes. There's no such thing as an all-purpose satellite. Weather satellites, for example, come in two varieties: Polar Orbiting and Geostationary. The polar orbiters fly a LEO and transmit images as seen by the on-board devices which send the data back to Earth in various formats. Analog pictures (known as APT, Automatic Picture Transmission) are easily seen with modest receiving equipment. High Resolution Picture Transmissions (HRPT) are just that and require more sophisticated (read: expensive) receiving equipment. Geostationary weather satellites are so far away, they see the entire planet in their view. This makes it useful to track big storms and, I'm told, from there you can actually see the budget deficit.

Communications satellites are like repeaters. They relay ground transmissions, whether audio or video, to a broad area of Earth below. The area underneath the satellite where the signal can be received is known as the "footprint." With geostationary satellites, the footprint is huge and covers most of the continent. LEO satellite footprints are much smaller and they're moving! This means that LEO satellites have to be tracked. That is, unless we're talking about those Personal Communications Satellites, which will have the ability to "hand-off" your signal to the next satellite as it comes up over the horizon. This will be a seamless transition and, to the consumer, it will be just like a land-line call. (Sure. One minute you're talking to Grandma and the next you're talking to a Spanish speaking person trying to call a cab in Buenos Aires. Can't you just wait to get your first bill!)

Elements of Reception

Satellite reception techniques are the same, regardless of what mode or type of satellite you're trying to receive. You need a receiver, an antenna, and a feed line to connect the two. In the case of Personal Communications Devices, the whole thing is one small, expensive, hand-held unit which you can lose in a heartbeat.

The critical elements are: a decent antenna, high grade feed line and a quality receiver. Anything less and your reception will be marginal. Let's take the antenna first. It's really the most important element, and yet often the cheapest of the three. Most satellite transmissions take place on very high or ultra high frequencies (VHF/UHF) and so antennas tend to be small. This does not mean you can scrimp. In fact, the more money you put into your antenna the more noticeably your reception improves. However, you should also know that receiving and transmitting have different requirements altogether. For instance, trying to access an AMSAT with a basic quarter wave dipole will not give satisfactory results. But, for simply monitoring, it will suffice.

The feed line is usually a coaxial cable similar to ones used for TV. The difference for satellite applications is mostly the center conductor (it's usually thicker) and the braid (it's usually tighter). This makes for a lower loss, or more efficient, feed line. Just remember that the longer the feed line run, the more loss you'll encounter. Keep those feed lines short! And that's an order!

Finally, there's the receiver. This is where the boys are separated from their wallets. Having a quality receiver will pay big dividends in reception. Quiet and sensitive: it's what everybody wants in a receiver (and a spouse, for that matter). So find your dream receiver and wait for a sale (they all go on sale sooner or later) or consider settling for used. A properly cared for used receiver will usually be as good as a new one, without the high price tag.

Satellite communications is a miracle: Tiny little man-made moons circling the planet against the dark, cold, emptiness of space, relaying voice, video, and data from point to point on Earth with less power than most computers consume. It's enough to give you goose flesh. ST

If you have a question about satellites or how to hear satellites, send a letter to Beginner's Column-Satellite Times; c/o Ken Reitz; P.O. Box 98, Brasstown, NC 28902. If you need a personal reply be sure to include a self addressed stamped envelope.

By Steve Dye, gpsyes@aol.com

GPS Applications

One of the incredible facets of satellite navigation or GPS in general, is the broad applications base the technology serves. GPS in particular hosts numerous applications that we benefit from in every day life. Consider life in a typical day in the average American household, where does GPS come into it? To list a few, the 110V AC power supply we all take for granted was quite probably generated and distributed across the grid using GPS sourced timing references to synchronize the 50 Hz frequency at all stages between the power station and the home. Our digital cellular phone systems all use GPS timing references enabling the base stations, base station controllers, and exchanges to be perfectly synchronized with each other, ensuring a better signal quality and higher reliability. As we surf the web and cruise the net, it is highly conceivable that GPS timing ensured the data packets that form the text and graphical messages flowing through the many nodes and servers, arrive intact with no synchronization slippage.

The above three examples, applied to utilities and services we take for granted, all make use of the precise time dissemination feature of GPS, instead of the primary function for which GPS was designed: navigation.

In this edition of *Satellites Times*' we will look at two more applications of GPS, that illustrate the versatility and flexibility of this incredible technology.

Drivers in distress

The larger names in car rental as well as the top-of-the-range vehicle producers, are now incorporating GPS and terrestrial communications systems in their vehicles to offer some remarkable services to drivers who find themselves in a variety of unexpected and perhaps undesirable situations. In the event of an unexpected breakdown, a crime, or even being locked out, a subscriber to these services has less reason to worry—"help is just 11,000 miles away." Each service provider and vehicle manufacturer offers a variety of services and plans from which users can choose according to their particular needs.

The systems rely on a duplex communication channel utilizing either cellular phone technology or two-way paging networks to convey the messaging that will take place between the users and the service provider. This messaging is in the form of voice, data, or prerecorded user-defined data messages. Sensors in the vehicles relay information to an interface coupled to the cellular/paging equipment, which relays the status of the vehicle to the control center. A variety of messages can be sent on the up-link (vehicle to system) as follows:

- Engine fault alarms.
- Airbag activation.
- Entry and theft alarm
- Voice to a central control
- GPS information : location coordinates, time speed.
- Panic button (automatic 911 dialing)

Similarly, the downlink (system to vehicle) typically sends :

- Door lock control.
- Automatic engine cut.
- Power window control.

In the event of an emergency or a breakdown, the driver simply places a call to the control center using the vehicle's built-in cellular phone. Information gathered from the GPS receiver and other peripheral devices installed in the vehicle enables the call center to establish the location, the time, the vehicle's speed, and the status of the alarm and monitoring system. With this information, the control center, using a graphical information system (GIS), can easily determine the closest, most appropriate emergency response or breakdown unit to alert. As can be seen, GPS plays the most crucial role in this system, as precise coordinates enable the quickest response time, and it provides information concerning the estimated time of arrival of the rescue team or tow-truck.

Figure 1 illustrates a typical system architecture for this form of rescue service. GPS technology makes tracking a car's movements a simplified task, since GPS provides an accurate fix to within 100 meters or 15 meters if a differential system were employed. Locating a vehicle's whereabouts down to 100 meters quickly with no direction finding equipment is not possible using any other system, and gives GPS the edge in this kind of application. One other positive aspect of the system is its flexibility, since

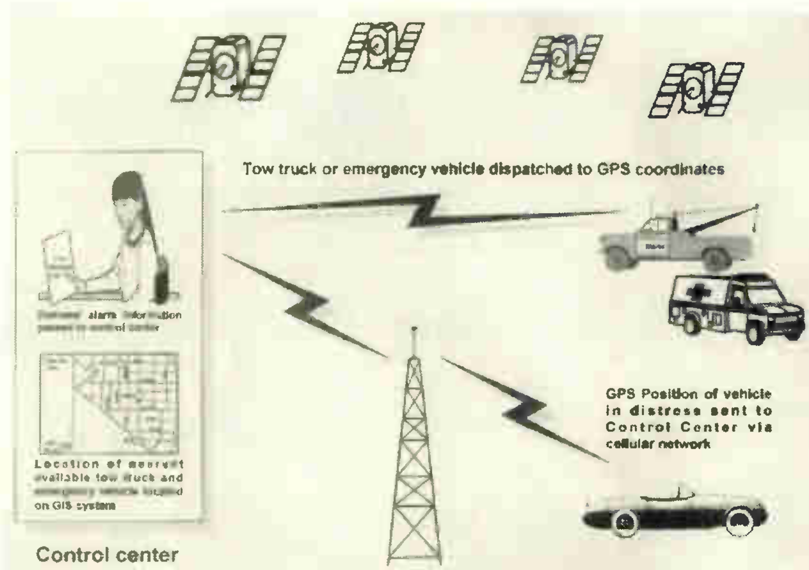


FIGURE 1: ***Using GPS to locate a driver in distress and dispatch the nearest break-down or emergency assistance***

existing infrastructures in terms of paging/ cellular networks. Couple this with GPS' global availability, and you have a system that can be easily deployed anywhere in the world.

The two-way data exchange between the vehicle and the control center enables a variety of useful functions to be performed. Since the vehicle is able to relay the status of its doors, alarms, and engine management system, it is not beyond comprehension that the control center uses the down-link to control some of the vehicle's functions remotely.

Consider a scenario where the driver locks him or herself out of a car. A call is simply placed to the control center, the identity of the vehicle and caller is authenticated by some appropriate means, and shortly thereafter an encoded signal is sent to the cellular or paging site closest to the vehicle's GPS coordinates. The signal, encoded with a signature for that particular car, unlocks the doors or opens a window—a feature which could benefit a lot of us!

Vehicle theft is a global problem. If a vehicle's engine is started without the user first disabling the alarm, a voice link can be activated between the vehicle and the control center, using the cellular phone to listen in on what conversation may ensue. This gives the operators an opportunity to ascertain the situation, and decide if the vehicle owner genuinely failed to deactivate the alarm, or if a theft is in progress. If the vehicle is stolen, the GPS unit continually sends location signals to the control center so that they in turn, can alert law enforcement agencies of the situation and supply regular updates of the vehicle's position, direction, and speed.

The above example is quite easy to visualize: GPS location and velocity information in conjunction with status alarms being sent over a duplex circuit. The following application of GPS is also security based, but is a little more abstract, and relies on one of the factors that we GPS users normally disfavor: ephemeral errors.

This particular application is certainly one very abstract use of GPS and is employed in the role of user authentication for the purpose of gaining access to computer systems. Currently, user authentication measures taken today use passwords, PIN's, and smart or magnetic cards. Higher security authentication systems use cryptographic cards, access tokens, or a person's biometry (personal characteristics). None of these methods are totally foolproof: PIN's and passwords can be stolen, guessed, or discovered, and encrypted security communications can be easily intercepted and decoded. One entity that can't be forged, however, is the unique combination of real-time, plus a use'rs GPS position, plus the real-time GPS space vehicles' ephemeral errors.

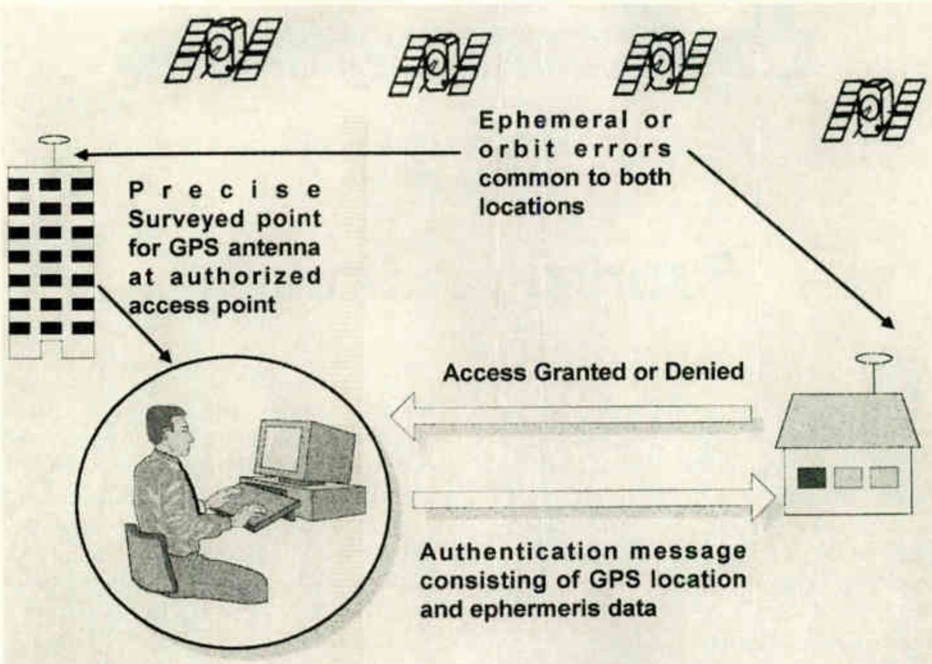


FIGURE 2: ***Using GPS and its navigation message data to authenticate a users location***

Systems have now been developed that incorporate the GPS time and the position of a user to be used as a signature to verify authorization for access a computer system. Using this system anywhere on the planet, a user who logs-in to a system also sends his latitude, longitude, elevation, and his version of the current GPS system time. The server accepting the log-in request assesses whether those GPS coordinates are valid or bogus. By way of example, if a system hacker in Baghdad tried to log into a bank in Germany, hoping to transfer funds and claiming he's in a London bank, the GPS information being sent would say otherwise, and system access would be denied. This form of location signature would alleviate the problems caused by the anonymity enjoyed by intruders who experience no problem in overcoming conventional authentication methods.

Suppose the intruder had developed a system to supply the GPS coordinates of an approved access point, spoofing the system. He would find, however, the system goes a little deeper than using typical navigation data. The system also exploits the continually changing orbital motion of the satellites—the orbit perturbations. This provide a unique location signature particular to that position and time. Since the satellite's ephemeral data is continually changing, the system is able to produce a new signature every five milliseconds. So, when a user logs on, the host requests the location signature, simultaneously processing both the remote location's GPS data as well as its own. It is imperative that the client and host be within 3000 kilometer of each other so that they use the same GPS satellites. Since both parties are using the same satellites, the same orbital perturbations are common to them, denying an illegal system-user the ability to intercept a signature and continually replay. Each signature is updated at a rate that makes each reading invalid after 5 milliseconds.

The apparent short range of the system can be extended on a global basis if the system employed a bridging location-verifying element between locations that would intercept the client and server, verifying the signature for onward transmission. Figure 2 illustrates the system's architecture and shows how the various elements interact with each other. ST

COMPUTERS & SATELLITES

By Dr. T.S. Kelso
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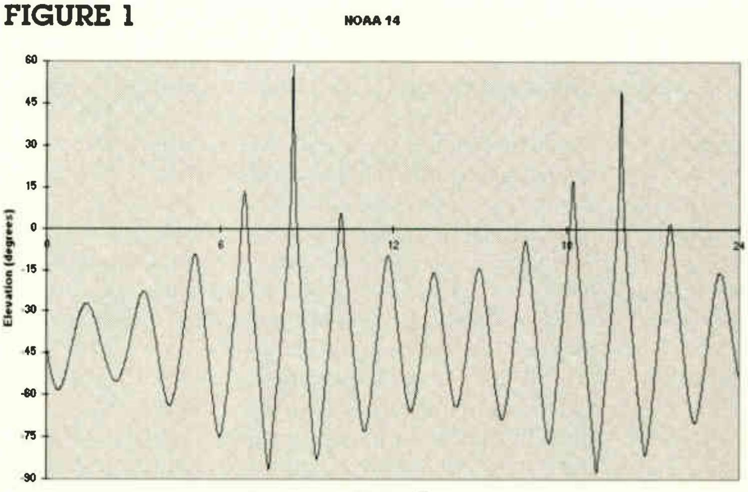
Sunrise . . . Sunset

Up until now, our investigations in this column have centered on making predictions about the coordinates—for example, the azimuth and elevation—of a satellite at a specific time of interest. While the process of making these calculations accurately and efficiently is not a trivial matter, it only addresses one facet of orbital analysis.

One of the biggest questions typically faced by an orbital analyst is the question of when (or even if) some particular event will happen. There are many such instances which might be of interest: the rise or set of a satellite, the time of an equator crossing, the time of culmination (the highest elevation during a satellite pass), the entry and exit times for an eclipse, or the time of closest approach to another satellite.

As such, two of the most important tools available to an orbital analyst are tools for efficiently determining the roots and extrema (the minima and maxima) of equations. Finding roots corresponds to finding crossing phenomena, such as rise or set times, while finding extrema corresponds to finding optimal circumstances, such as the closest approach of a satellite. This column will be devoted to selecting the best method for each tool and to developing an understanding for how to apply them—skills which will be absolutely essential in some of our upcoming investigations.

FIGURE 1



The Problem

For the sake of this column, let's assume our task is to find the rise times of the satellite *NOAA 14* on 19 January 1997 for an observer located in Montgomery, Alabama. This type of task is a typical requirement of any ground station wishing to download weather imagery during an overhead pass of any one of a number of polar-orbiting weather satellites. Of course, the computer used at most weather ground stations performs many tasks—often including capturing the imagery—and tracks more than a single weather satellite, so we'd like to develop an algorithm that is as efficient as possible.

A Simple Approach

Perhaps the simplest way to approach such a problem is to generate an ephemeris (or table) of look angles for *NOAA 14* for the period of interest. We could then read through the ephemeris to determine when the satellite's elevation went from negative to positive to find the rise time. A graph of this ephemeris is shown in figure 1.

The first problem that presents itself is just what size time step we should use for our ephemeris. Make it too large and we may completely miss a pass. Make it too small and we'll spend the majority of our time calculating ephemeris values which we won't even use. For example, if we use an interval of one minute, we'll calculate 1,440 satellite positions just to find six rise times. And, to double our accuracy requires doubling our computations.

An Improved Solution

A more effective way to find our rise times would be to start with large steps and then reduce our step size as we get close to a solution. The *bisection method* uses just such an approach. However, before we can apply the bisection method, we must know that the interval we want to search contains a root.

Mathematically, a root exists in the interval (a,b) if $f(a)$ and $f(b)$ (where the function f represents the satellite's elevation) have opposite signs. This conclusion, of course, depends upon the function f being continuous over the interval (a,b). Since *NOAA 14* (or any other existing satellite) does not have the ability to warp space, any function of its position will be continuous.

Before we tackle the issue of how to select the proper interval, let's do a quick comparison of the efficiency gain which results from using this approach. For an interval of one day, it could take as many as 1,440 evaluations to find our rise time to an accuracy of one minute. If we use the bisection method, however, we would start with an interval of 1,440 minutes and then halve it, repeating the process with the smaller interval that now contains our rise time. To achieve an accuracy of one minute would require only *eleven* calculations—an improvement of two orders of magnitude! And, doubling our accuracy now only requires one additional calculation rather than another 1,440! This property is known as *linear convergence*.

The bisection method has several advantages: speed and the guarantee of convergence (i.e., if the interval contains a root, it will find it). To apply it, however, we must determine the proper interval for our search.

Bracketing the Target

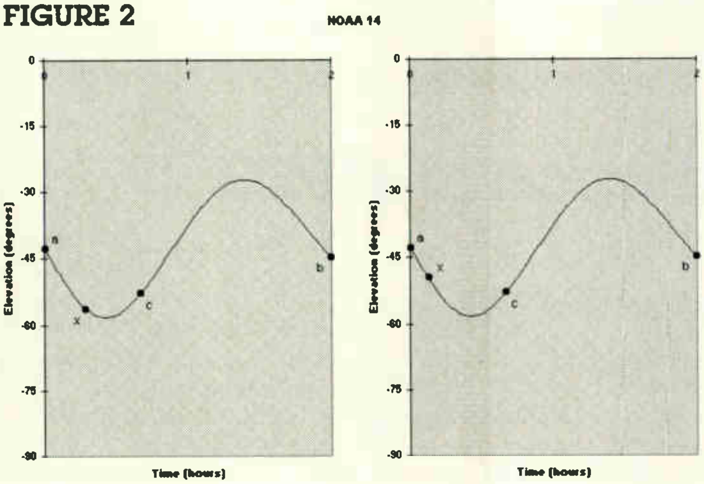
While we now have a much more efficient means to home in on our prey, we have actually just traded one problem for another. Instead of searching the entire time period of interest, we must first find a time period where one end of the interval corresponds to an elevation above the horizon and the other to one below the horizon. An examination of figure 1 shows this to be nearly as difficult as our original problem. And, if we're not careful, we can select an interval which has more than one rise time—the bisection method is only guaranteed to find one of them.

We can be much more effective in the hunt for our prey, however, if we first understand something about its characteristics. In developing an algorithm such as the one we're working on, it helps to first visualize our quarry, as we've done in figure 1. As with any satellite orbit (with the possible exception of a perfectly geostationary orbit), the first thing we notice is that our function is periodic. This result is completely expected since both the satellite's orbit and the earth's rotation are periodic. In fact, closer examination of figure 1 shows there are actually two periods—one which corresponds to the satellite's orbit and the other to when the observer rotates under the orbital plane (which happens roughly twice a day).

Since we know that a root is bracketed by a minimum on one side and a maximum on the other, let's turn our attention to first developing a tool to find extrema. As it turns out, the approach is similar but subtly different. In searching for a root, splitting the interval in half turns out to be the optimal approach since only two points are needed to determine whether an interval contains a root. To find a minimum, however, requires three points.

To bracket a minimum over the interval (a,b), there must be a point c such that $f(c)$ is less than $f(a)$ and $f(b)$ and c is our best guess at the minimum (see figure 2). To continue our search, we choose a point x, either in the interval (a,c) or (c,b). Let's say we choose the first interval. If $f(x) < f(c)$, then the minimum is in the interval (a,c) and x is our new best minimum value (see the left side of figure 2); otherwise, the minimum is in the interval (x,b) and c is still our best minimum value (see the right side of figure 2). It turns out that the most efficient means of searching for the minimum (without considering the shape of our function) is to use the *golden section search.*

FIGURE 2



It can be shown that the optimal choice for a new point within our bracketing interval is at approximately 38 percent (or 62 percent) of the interval. The name *golden section* or *golden mean* comes from the ancient Greeks who discovered this ratio. Using the golden section search will guarantee convergence and, like the bisection method, also converges linearly.

Tying It All Together

At first inspection, it would seem we've simply traded one problem for another. However, another look at figure 1 reveals that bracketing an extremum (minimum or maximum) should be much easier than bracketing a root. Each orbit of our target satellite produces a minimum and a maximum but does not necessarily produce a root. We make use of this information in the following approach.

To find the first pass of *NOAA 14* on 19 January 1997, let's examine the interval one orbital period *before* the beginning of the day (actually, we'll use slightly more than the orbital period since the interval between minima varies). The characteristics of our function assure us that there is at least one minimum in this interval. Finding the initial midpoint guess can be done using the golden section method—if the value at our new point is less than at the two endpoints, we search for a minimum; if it's greater, we search for a maximum; otherwise, we pick the other golden section value.

Once we know where a minimum is, we can find the next maximum by searching the interval from our minimum forward one orbital period. The same is true when finding a maximum—searching forward one orbital period brackets the next minimum. We can continue this process forward to find each successive minimum and maximum, finding them all very quickly. Each time we find a maximum, we would determine whether it is positive and for a minimum, whether it is negative. We would then only search for a root when one was properly bracketed. This method takes maximum advantage of the characteristics of our function to find what we're looking for.

Making It More Efficient

One limitation of the bisection and golden section methods is that they both ignore the shape of the function under investigation. While they both guarantee convergence and converge linearly, there are methods which can produce superlinear convergence by taking the derivative of the function into account. One such method which you may be aware of is the *Newton-Raphson method.* Unfortunately, this method only works when you can analytically determine the derivative of the function.

There are, however, adaptations of searches for roots and extrema—referred to as *Brent's methods*—which can provide superlinear convergence without the need for a derivative for well-behaved functions (such as the one we're working with). Our basic search strategy is the same except that the bisection and golden search methods are replaced by the more efficient Brent's methods. A detailed discussion of these methods—together with source code—can be found in chapters 9 and 10 of *Numerical Recipes in C: The Art of Scientific Computing* (Second Edition) by William H. Press, et al. I highly recommend this reference.

Whether we use these tools to generate pass schedules, as we have here, or in looking for satellite transits across the sun or the moon, the ability to quickly search for when a particular event occurs—or whether it even happens at all—will be a most useful skill. Once you've mastered their use, you'll wonder how you ever did without them!

If you have any questions or comments regarding this column, please feel free to contact me at **tkelso@grove.net**.

ST

By Steve Dye

An introduction to MPEG

If there's one application that demands transmission bandwidth, it's video. High speed data communications certainly occupy a sizable portion of the spectrum as well these days, but analog TV will always be known as the bandwidth-hog. As satellite TV programming grows in popularity, user expectations for an expanded range of programs will ultimately demand more spectrum—spectrum that is rapidly running out and costing more and more to license.

Including the aural carrier and its sidebands, a video channel occupies 6 MHz of bandwidth. In a bid to preserve picture quality, the nature of analog TV dictates a sizable guardband be placed between each assigned channel allocation to reduce interference from adjacent channel users. Clearly, a different approach to wireless delivery of video information is needed if a balance between user demand and efficient use of the RF spectrum is to be maintained.

The answer to this is MPEG, a digital video compression standard which is designed to provide real-time digital video efficiently using MPEG, up to six video channels occupy the same spectrum space required by just one 6 MHz wide analog channel.

Applications for MPEG are not limited to the transmission of real time video images for programming purposes. Despite the vast storage capacity of CD ROM, it would be extremely difficult to cram a full length digitized movie onto one CD. MPEG will allow a feature-length movie to be compressed and fitted onto a single disk. The Beatles' *Hard Days Night* was only the first feature-length movie you can now slip into your CD ROM drive's tray.

So, what is MPEG and how does it work? This article presents an overview of MPEG and explains how motion video images are digitized and compressed.

MPEG an overview

MPEG is an acronym derived from the Motion Picture Experts Group, and is a standard for real-time compression of digitized video information. MPEG encoders form a data stream, creating a spectrum-efficient utilization of any video system's available transmission bandwidth. The compression process employs three types of redundancy: spatial, time, and statistical. The redundancy process in MPEG exploits the fact that in motion video, a high level of correlation exists between not only the pixels in *successive* frames, but also those in the *same* frame.

Redundancy is a process by which repetition of the same data can be encoded by a single code representing that block. For instance, consider a scene where the upper twenty lines in a frame are all the same hue. Rather than using a quantum of data to describe the color of each individual line, one code could be used that describes the first block and the run length of all adjoining blocks of the same color. Of great importance in MPEG is the human eye's sensitivity to luminosity. This allows a lower sampling rate on certain video components, thus reducing the bit rate and, hence, the bandwidth occupied.

Temporal Redundancy

This form of redundancy utilizes the high levels of correlation between pixels in successive frames. Consider the previous scenario: MPEG has already described the contiguous pixels of one color with one code for one frame, MPEG will now code the next frame by using the same kind of method above, expressing that repetition.

Another area in which compression acts is by quantifying the differences in the subsequent frames. If it takes x amount of data to send a frame, then it will definitely take less data to describe the differences between the current and the following frame. So, when a scene changes, only the difference is encoded, as opposed to the entire frame.

Since this form of redundancy occurs between adjacent or successive framing, it is known as interframe compression. Figure 1, by way of example, illustrates temporal redundancy. The images in this example are very similar in content, with the only major difference being the change in angle of the aircraft as it climbs. The remainder of the image, the main section of the aircraft, remains unchanged. This is the essence of temporal redundancy: the differences in successive picture frames are calculated and encoded.

Here, a Discrete Cosine Transform (DCT) algorithm is applied that converts time domain components to the frequency domain. This is necessary to allow the frequency coefficients to be quantized in a manner that will further reduce the bit rate.

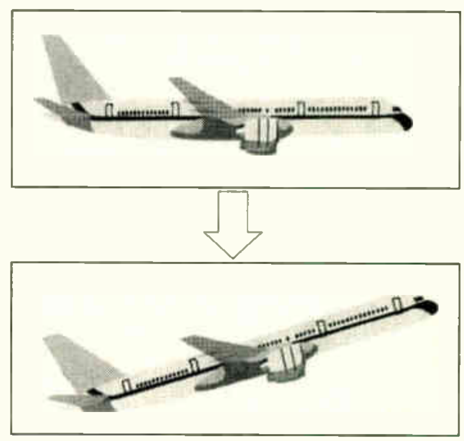


FIGURE 1. ***Intraframe compression using temporal redundancy.***

Spatial Redundancy

Spatial redundancy exploits the high levels of correlation that exist between neighboring pixels in a block or several contiguous blocks of pixels *within* a frame. In a picture that has large areas of the same color, such as a blue sky or a green field, there exists an extremely high probability that the pixels are the same color and intensity. Looking at a blue sky, for example, we can see that, if coding indicates the first pixels' particular information plus how many times it is repeated, redundant information has now been removed. This spatial compressing takes place within a single frame and is often known as Intraframe Compression. Figure 2 illus-

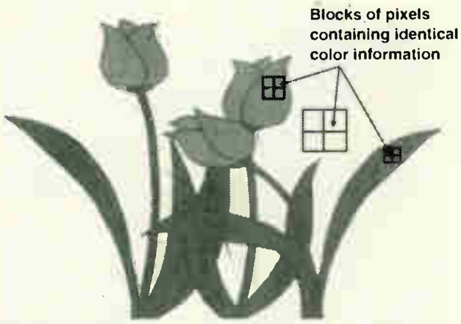


FIGURE 2. ***Spatial Redundancy (Intraframe).***

trates this. Notice the petals, leaves, and the background color all represent several contiguous blocks of information to be grouped together, granting redundancy.

Statistical Redundancy

By knowing, or being able to predict the position of a moving object in a picture, more redundant information can be removed. The regular line and frame synchronization signals necessary for each frame can be immediately made redundant. Consider the motion of an object such as a car traveling a highway or a football flying through the air: statistical redundancy algorithms track these objects in motion and predict their trajectory to a high degree of accuracy, allowing a further reduction in the bit rate. Since a picture is built up from 30 frames a second, it is possible to identify from the vector values (magnitude and direction of the object), where it will be 1/30 of a second later. This is known as motion compensation.

Reduced bit rate

MPEG has clearly addressed the needs of bit rate and spectrum economics. Since the compression has reduced the number of bits to represent a frame and all subsequent frames, then the bandwidth required to host MPEG video has now been drastically reduced. So far, the type of algorithm described is known as a lossless algorithm. Any algorithm that has been applied to the picture frames' content so far, is a reversible process. This, however, is not the limit of the compression process. The next stage, quantization, is where the compression really starts.

Quantization

Quantization is a familiar term used in the sampling of complex signals. Consider sampling a much less complex linear response as shown in figure 3. If we wanted to reproduce this response (having previously sampled it), we would, in theory, require an appreciably high bit resolution to represent or describe the signal.

If a lower bit rate were used, (lowering the resolution), the signal would not have been accurately sampled. The diagram in figure 3 shows, as an example, a linear response being sampled using 2 and 3 bit resolution. Clearly, the 4 bit sample offers a cleaner, more lucid analog reconstruction of the original.

The 2 bit resolution sample will feature more quantization noise, as it cannot determine what value should be placed in the gaps. One practical example of this is a simple comparison of a newspaper photo to a glossy photograph. The newspaper photo uses less information to describe the contents, and thus appears grainy.

Luminance

So far, color or hue has been discussed, but a picture has one other element of importance: luminance. This vital information has yet to be compressed. The levels of luminance in the analog pictures we view are virtually infinite, since they are an analog quantity. If we exploit the characteristics of the human eye, a high degree of redundancy can be achieved since the eye cannot discern between the minute differences of luminance that occur in video. This useful characteristic allows the compression algorithm to slim down the number of luminosity levels to a mere 256.

The DCT process applied outputs frequency coefficients proportional to the levels of luminance. These coefficients are digitally sampled using a lossy algorithm. The losses occur due to the sampling process and quantization as seen in figure 3.

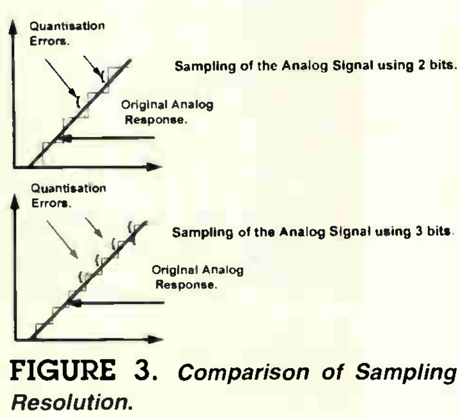


FIGURE 3. ***Comparison of Sampling Resolution.***

The lossy algorithm presents no real threat to the picture quality, since the human eye will perceive the changes in chrominance and luminance levels as gradual rather than jumpy.

The quantization process is carried out in a non-linear fashion and the degree of quantization varies according to the sample blocks' contents, relying on the human eye's perceptual sensitivity. The quantization resolution is determined by a feedback loop that assesses the level of (quantization) noise produced from using the lowest practical sample rate. This way, a balance between viewable picture quality and data output rate is maintained.

Variable and Run Length Coding

So far, the processes previously described present a data stream of 1's and 0's, at the output. These binary coded words could be grouped and further analyzed. Close examination of a picture will reveal that the smaller coefficient values and short runs of 0's occur far more frequently than the opposite case.

A coding scheme is introduced whereby the most frequent occurrence can be represented by short codes compressing the sample further. As for Run Length coding, special symbols are assigned to indicate the run lengths, or the number of zeros in the data stream. The final result from all these individual processes is a VHS-quality video picture, having undergone a compression ratio as high as 200:1. Figure 4 provides a block diagram of the entire MPEG compression process described here.

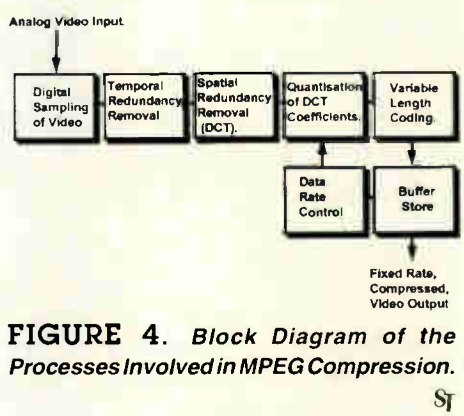


FIGURE 4. ***Block Diagram of the Processes Involved in MPEG Compression.***

ST

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ST ON THE AIR

By Steven J. Handler

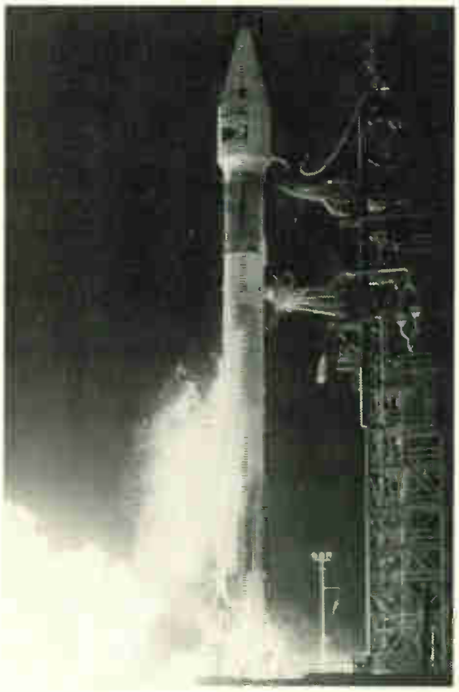
If You Don't Like the Movies You Can Always Start Your Own Channel!

It's raining so hard outside your neighbors are pitching in to build an ark. You glance out your window and see animals lined up two by two at the end of your block. Do you really want to go out to the video store to rent the latest movie? If you're a C-band dish owner and your receiver or IRD is equipped with a VC-II Plus descrambler, you're in luck. You can be spared braving the elements by tuning in one of TVN Satellite Theater's pay per view movies.

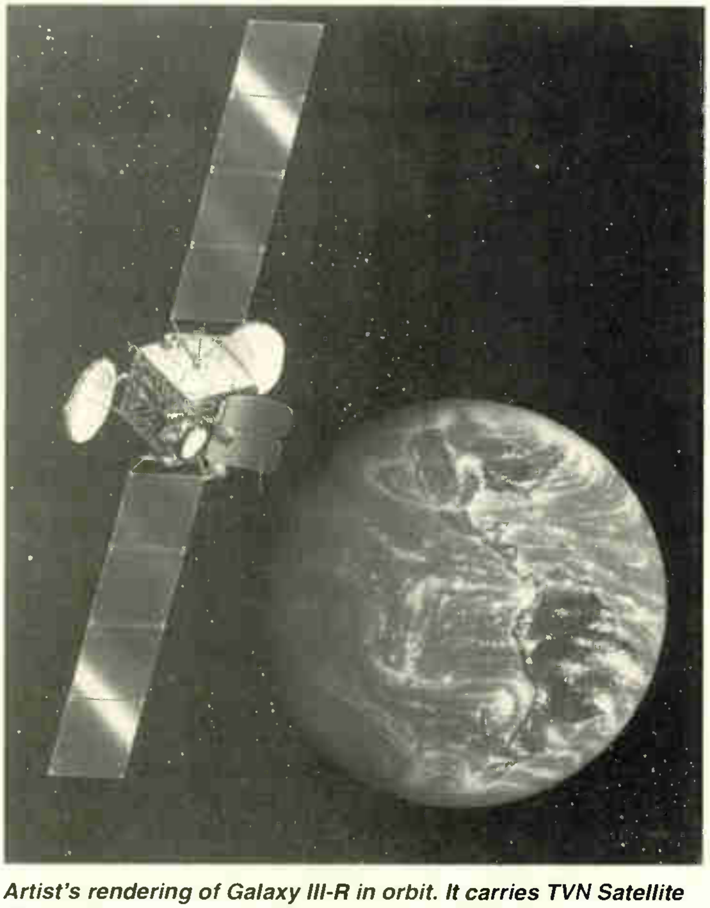
TVN Satellite Theater has transmitted nationally via satellite since 1991 and now serves over 750,000 customers. It was the world's first direct-to-home, multi-channel pay per view satellite television network. Their usual bill of fare includes a choice, 24 hours a day, of more than a half dozen of Hollywood's top box office films. Besides turning each of their customer's homes into a virtual cineplex movie theater, they also beam concerts, sporting events and specials on a pay per view basis.

Owned by TVN Entertainment Corporation headquartered in Burbank, California, TVN Satellite Theater broadcasts the movies almost continuously on channels 1 through 6, 8 and 9 of Galaxy III-R. A schedule is available in any of the popular programming guides such as *OnSat*. Galaxy III-R is a Hughes Model HS-601 geostationary satellite launched in 1995 and located at 95 degrees. It operates on both C- and Ku-band with 24 transponders each.

TVN charges $19.95 for the privilege of being able to use their service. This sign up fee is charged to a customer's credit card and includes one movie. Thereafter, for each movie viewed, there is a charge of $3.99. The customer can select between being sent a monthly bill or having the movie's cost automatically charged to a credit card. Those electing to be sent a bill incur an additional $1.10 per month billing fee.



Galaxy III-R, shown at launch, is home to TVN Satellite Theater. Photo courtesy of Hughes Communications, Inc



Artist's rendering of Galaxy III-R in orbit. It carries TVN Satellite Theater's programming. Photo courtesy of Hughes Communications, Inc.

It's simple to order a movie. Each of the TVN Satellite Theater channels is assigned its own special toll free telephone number. After deciding on a selection, the customer calls the telephone number assigned to the channel on which the movie is going to be broadcast. TVN uses an Automatic Number Identification System (ANI), which is similar but more sophisticated than caller ID, to automatically read the caller's telephone number. TVN's computers then match the caller's number to the master data base of home telephone numbers of its customers. Once matched, the caller hears an automated message confirming that their order has been accepted and reminding the customer of the channel number to view.

Ticketmaster serves as TVN Satellite Theater's live operator customer response facility. They handle the sales calls, orders, and customer service for TVN's C-band dish customers. Ticketmaster, which routinely processes over forty million inbound calls per year, can link up to fourteen of its regional phone centers together to handle high call volume TVN events.

For Your Viewing Pleasure...

In addition to pay per view movies, sporting events are also available. Some, such as boxing, are priced on a per event basis. Prices vary depending on the event. For example, last fall's Tyson vs. Seldon event cost $38.95 if ordered before fight da,y and $43.95 on the day of the fight.

TVN Satellite Theater also brings viewers college and NFL football. Each Sunday afternoon during the regular season, TVN's transponders on Galaxy III-R are used to transmit NFL games. Charging $147.95 to subscribe to the *NFL Sunday Ticket*, customers could choose among 13 NFL games each Sunday during the 17 week regular NFL season. For $69, customers could subscribe to the *ESPN Game Plan* which broadcasts up to 10 college games each Saturday for the 13 week season.

In December of 1995, TVN Satellite Theater became the first company to commercially deliver widescreen hit movies on a regular basis to home satellite viewers.

TVN SATELLITE THEATERS™

Most movies are shot in widescreen format, which is traditionally how they are shown in movie theaters. Movie theater screens tend to be rectangular, much longer than high. To accommodate the nearly square dimensions of the TV screen, movies are usually modified for home television viewing. TVN's widescreen satellite channel allows viewers to experience hit movies as they were originally shot.

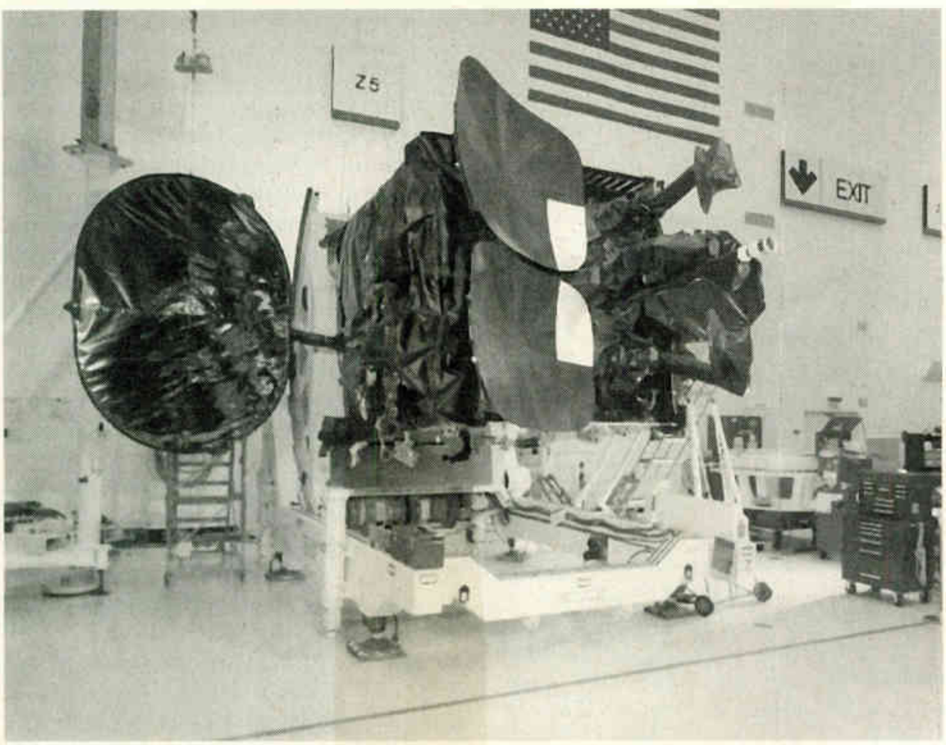
Coming Attractions

What's in TVN's future? Using five transponders leased on Hughes Galaxy 9 satellite, TVN is launching a revolutionary digital television delivery system for cable TV providers. Called "Digital Satellite TV Without the Dish," TVN will initially transmit 40 channels of digitally compressed movie programming using General Instrument Corporation's DigiCipher® II-MPEG 2 (DCII) digital compression and encryption transmission system. These signals, received by cable TV head-end sites across the country, will be made available to cable viewers. A uniquely featured special cable set-top box is scheduled to be manufactured by Grundig, a giant European consumer electronics manufacturer. Cable customers using the set-top box will be able to view the on-screen program guide and instantly order pay per view movies.

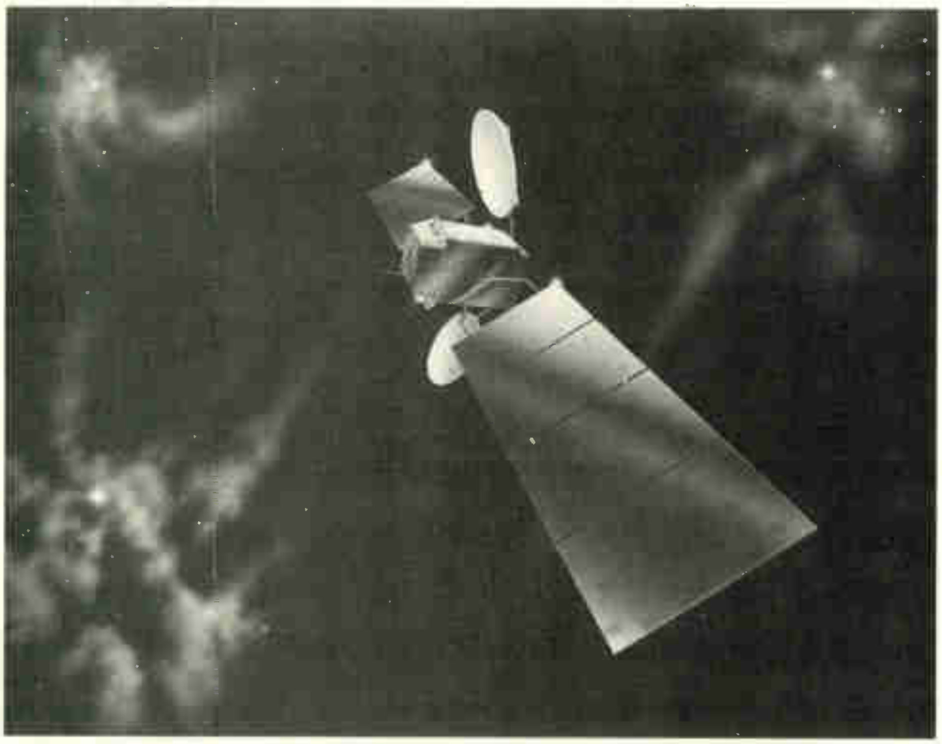
For more information about TVN, or to sign up, contact them at (800) 679-4TVN or (888) TVN-7378.

Space For Lease

C-band Transponder Capacity for Lease proclaimed the ID slide appearing on channel 22 of GE Americom's GE-1 satellite last November. The transponder was being offered for lease by Taurus Communications of Boston. Taurus, who is in the business of



Galaxy III-R under construction. Many of its C-Band transponders are used by TVN Satellite Theater. Photo courtesy of Hughes Communications, Inc.



Artists sketch of GE-1 in orbit. Taurus's transponder is on this bird. Photo courtesy of GE Americom.

corporate teleconferencing, has a fleet of seven Ku- and four C-band trucks. They bring these trucks to the site of a corporate conference and, using satellite, link two or more sites to the conference.

Launch of GE-1. Photo courtesy of GE Americom.

A spokesperson for Taurus said that they originally leased the GE-1 transponder to broadcast horse races. Unfortunately, before the satellite was available for use, they made a strategic business decision to exit the horse race broadcasting business. That left them with a slight problem, what to do with the transponder they had leased?

Transponder leasing is a complicated business. When a satellite manufacturer sets about to build a satellite, they offer some or all of the transponders for either sale or lease. Often, the earlier a buyer or lessee commits to a transponder, the better the price they can negotiate for the transponder. Those wishing to lease a transponder can usually pick their term, which typically ranges from several years to the lifetime of the satellite. This process results in a lessee committing to a transponder as much as several years before a bird is even launched. In Taurus's case, they committed to lease the transponder from GE about a year before the satellite's launch.

In the satellite business, transponders are sold or leased in several ways. "Transponder protected" means that, if during the term of the lease (or ownership) the transponder becomes inoperative, the satellite owner will switch the lessee's programs to another transponder on the same satellite. The move is usually either to a spare transponder which the satellite owner may have previously leased out for occasional use, or to a transponder being leased by another customer that is not "protected." Those leasing an unprotected transponder can find the satellite owner yanking it back if it's needed to replace a protected transponder that goes bad.

The *creme-de-la-creme* of transponder leasing (or ownership) is a "fully protected" transponder. This provides the ultimate in protection. If the transponder becomes unusable, another transponder on the same satellite will be provided. If the entire satellite becomes inoperative, the satellite owner will provide another transponder on a different satellite. Those with critical applications who can't afford to have their signals disrupted in the event of satellite problems, such as cable television programming providers, usually lease or purchase fully protected transponders. This brings us back to Taurus. Their transponder is fully protected, the top of the line for a company looking to lease a transponder.

The question now on everyone's mind is, how much will leasing this transponder set me back? In today's world of supply and demand, leasing a fully protected C band transponder in a cable neighborhood (a satellite whose tenants are mostly cable television programming providers) runs about $185,000 a month. If you're not planning to distribute your programming by cable television, a less fancy neighborhood will do, where you may find C-band transponders available for lease in the $140,000 to $150,000 per month price range, again depending on the length of your lease.

I asked Dudley Freeman, a representative of Taurus, what he thought about the current availability of C-band. "I don't think there's a scarcity of transponders in the C-band business. Two years ago there was a lack of capacity," said Freeman. And what about Ku, I inquired? "There are very, very few Ku-band occasional transponders," he noted. Lease rates for Ku transponders are typically well in excess of C-band rates.

As to the transponder being offered by Taurus, they quoted a very attractive price. I did toy with the idea of leasing a five minute slot to flash my mug around the U.S., Alaska, and Hawaii. However, this delusion quickly passed. Needless to say, those without deep pockets and a good idea won't being going *On The Air.* ST

By George Wood
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European Analog News

Having just spent five weeks at home in California, it was interesting to note again how the US and Europe can be so out-of-step in technological development. The US is almost always first in developing new consumer electronics, but *first* often doesn't mean *best*. TV is one example. By being in with broadcast television, the United States saddled itself with the horrible NTSC standard (known to many as "Never The Same Color"), while Europe had time to develop the better PAL and SECAM systems.

Cellular telephones are another example. As far as I could tell, the United States is covered with a crazy quilt of overlapping (and apparently incompatible) analog systems. Meanwhile, the digital GSM system has spread from Europe to the Middle East, South Africa, India, Australia, Hong Kong, and other regions. You can use the same pocket phone to make calls anywhere in those areas. (Somecould make a fortune by providing GSM service in major American cities. Even if they didn't have a single local subscriber, they'd make a mint just selling service to visitors from abroad!)

Being digital, you can easily hook up a GSM telephone to a computer. But the modems are expensive, and the speed is only 9600 bps, which makes for very slow Web surfing. And you have to pay per minute at the regular rip-off cellular rate. On the other hand, while I was in California, I saw and heard many advertisements for the wireless Web access, at prices that seemed little more than through ordinary telephone-based providers. Shortwave listeners often criticise satellite and Internet radio for not being portable. But with wireless Internet access on one of the new pocket computers, equipped with RealAudio, you can listen to hundreds of radio stations from anywhere in the coverage area!

Be that as it may, in satellite TVRO, the two continents have been taking turns in the forefront. North America developed C-band systems first. When TVRO arrived in Europe several years later, the satellites used the smaller dishes and higher-power used for the higher frequency Ku-band. On top of that, by putting several satellites into one orbital position, Astra gave viewers first 16, then successively 32, 48, and finally 64 analog channels at one spot in the Clarke Belt. It wasn't until DirecTV and USSB launched their joint DBS system that North America caught up.

But DirecTV/USSB surpassed Europe in being digital rather than analog. It's only been in the past six months that digital TVRO systems have been introduced in Europe. And one key market monopoly, Rupert Murdoch's British Sky Broadcasting in the British Isles, is still holding off, in no hurry to introduce expensive new technology when it dominates the analog TVRO scene in Britain.

However, what struck me most during my stay in America was that the competition between DirecTV, the DISH Network, and Primestar means that digital systems in the US, with discounts, are available with rebates for only around 150-200 dollars. Comparable European systems, in Scandinavia at least, cost at least *five* times as much. Market forces are supposed to bring price tags down, but Europe clearly has far to go to catch up with America in digital TVRO.

Analog

Analog satellite reception continues to dominate the European direct-to-home scene, and we'll begin with recent news from the analog world.

CMT Europe and JSTV have left Astra transponder 24 (CMT is now 24 hour on transponder 51, while JSTV's new home is transponder 53), and have been replaced by promos for British Sky Broadcasting. The (Horse) Racing Channel has moved to transponder 60.

The Auction Channel, with live broadcasts of at least two auctions a day, hopes to start in March, as part of Sky's Multichannels package.

QVC Germany has started on Astra transponder 52. Nickelodeon Germany and VH-1 Germany have started on Astra transponder 27 in clear PAL, replacing the D2-MAC Nickelodeon Sweden (which continues on Sirius).

Pro Sieben Schweiz has started on Astra transponder 61 in PAL. It is identical to the ordinary German Pro Sieben on transponder 14, with some special commercial windows for Switzerland.

CMT
COUNTRY MUSIC TELEVISION
EUROPE™

The German channel Sat1 will introduce a second channel, called Sat2, later this year. Eurosport will add Portuguese, Romanian, and Hebrew language soundtracks to the channel in 1997. (The channel can already be heard in English, German, and Dutch on Astra, Italian and Hungarian on Eutelsat II-F1, French on Telecom 2A, and Swedish and Finnish on Thor.)

The next Astra satellite, 1G, is scheduled to launch in June 1997.

HOT BIRD 13° EUTELSAT

Eutelsat

Eutelsat's Hot Bird 2 satellite was successfully launched on November 21 on an Atlas rocket from Cape Canaveral. It has joined Hot Bird 1 and Eutelsat II-F1 at 13 degrees East, as Eutelsat attempts to copy Astra's example. Hot Bird 2 is equipped with 20 transponders of which more than half are expected to be used for digital television broadcasts to small antennas. Two coverage zones are available on the satellite: the Widebeam, which reaches the entire European continent, North Africa, and the Middle East as far as the Gulf States; and the Superbeam, which reaches throughout western and central Europe.

Here are some of the channels operating on Hot Bird 2 satellite:

11.727 GHz	RTP Internacional (Portugal) (PAL)
11.747	Emirates Dubai TV (PAL) (moved from HB-1)
11.766	RAI (Italy) (clear MPEG-2)
11.785	Polonia 1 (PAL)
11.804	RAI (clear MPEG-2)
11.919	Italian Mediaset package (clear MPEG-2) (see below)
11.938	TPS (France) (MPEG-2)
11.958	DStv package (MPEG-2)
11.996	DStv package (MPEG-2)
12.015	ART Europe (Arabic) (PAL)
12.034	DStv package (MPEG-2)
12.073	DStv package (MPEG-2)
12.092	TPS (MPEG-2)

Other broadcasters booked on Hot Bird 2 include Germany's WDR (probably with a children's channel), and digital packages from Telepiu, Nethold, Sweden's Svenska Kabel, and NBC.

Before moving its final location at 13 degrees East, Hot Bird conducted some unusually well-publicized tests at 29 degrees East. Normally, satellite operators say little about the necessary testing before a new spacecraft is moved into final position. The high-profile stop at 29 degrees is seen as part of a campaign by Eutelsat to keep rival Astra away from that position, as Astra is planning to use 28.2 degrees East for its second generation digital satellites. (This is the position that is to be used later this year for the first digital services from British Sky Broadcasting, and probably the BBC as well, on the upcoming Astra 2A). The dispute between Astra and Eutelsat over 28-29 degrees East may delay the introduction of digital TVRO to Britain. Astra argues that Eutelsat already has five orbital positions above Europe, and doesn't need one more.

Hot Birds 3 and 4 are scheduled for launch in 1997, and Hot Bird 5 in 1998, all to be positioned at 13 degrees East.

Bloomberg INFORMATION TV

Bloomberg TV France has started broadcasts on Eutelsat II-F2, 11.575 GHz, 6.60 MHz. Bloomberg also hopes to launch its 24 hour business news service to the UK early this spring. That rules out digital, as BSkyB's system won't be available yet. Will Bloomberg be part of Sky Multichannels, or in clear PAL?

The Franco-German cultural channel Arte has begun on Eutelsat II-F1 on 11.055 GHz. German sound is on 7.02 MHz, and French is on 7.20 MHz. The German women's channel TM3 is no longer broadcasting on II-F1, 11.638 GHz.

The shopping channel QTTV, which specializes in offering bankrupt stock and end-of-line products at heavily discounted prices, has begun a weekly one hour service on Thursdays at 10:30 hrs UTC on Eutelsat II-F3, 11.554 GHz.

The Polish RTL 7 has started official service on Hot Bird 1 on 11.489 GHz. MCA Inc. has reached agreement to buy 50 percent of RTL 7 from Luxembourg's CLT. MCA says it will provide both first-run and library programming, and will create two Universal programming blocks, consisting of movie and action-adventure themes. Meanwhile, the rival Canal Plus Polska has replaced EDTV on Hot Bird 1 11.516 GHz.

ASTRA®

Radio Free Europe and Voice of America are no longer on Eutelsat II-F1, 11.095 GHz (the TV channel is RTL 2). But VOA Serbian TV has started on Eutelsat II-F3 (16 degrees East) on 11.556 GHz, with an hour of programming every night.

C-SPAN has been reported broadcasting to Europe for a few hours a day on Orion 1 on 12.585 GHz. Unfortunately, since Orion is so far over the Atlantic, at 37.5 degrees West, not too many European viewers outside of Britain and Ireland can tune directly into the satellite.

KinderNet and the Travel Channel have left Intelsat 601 (27.5 degrees West) 11.175 GHz (they're now available in digital form).

Aside from feeds, the only broadcasters remaining on what once was one of Europe's most important TV satellite positions, are CMT Europe (which is also on Astra) and BBC Prime (also available to Scandinavia on Intelsat 707).

The Italian private stations Canale 5, Italia 1, and Rete 4 have closed their analog services on Intelsat 602 (63 degrees East). The three channels are already being carried as clear digital channels on Hot Bird 2 on 11.919 GHz.

INTELSAT

Digital Marches On

Like the Italian stations, more and more European channels are appearing in digital MPEG-2, and in many cases also closing their analog transponders. Here are some more recent examples:

On Intelsat 707, at 1 degree West, Germany's Deutsche Welle TV is now digital on 3.911 GHz. Since Europe doesn't use C-band, this service is presumably aimed at Africa. Meanwhile, another C-band outlet on this satellite, AFRTS on 4.175 GHz, has split into several channels, switching from analog B-MAC to MPEG PowerVu.

Ireland's Tara TV has started on Intelsat 603 (34.5 degrees West) on 11.158 GHz.

The English version of VH-1 has started on Spain's Hispasat (30 degrees West), on 12.456 GHz, joining Discovery and five Spanish channels on that MPEG transponder. Meanwhile, Mexico's Grupo Televisa has signed a deal with a group of Spanish broadcasters, including Telefonica Espana, to offer digital television in Spain. The service will begin broadcasting in early 1997 and eventually number 70 channels. That dwarfs the current modest digital offerings on Hispasat.

As of March 1, 1997, all the Eastern-European versions of HBO and affiliated channels are being distributed in one 6-channel digital package, on either Germany's Kopernikus or Israel's Amos. Until now these channels have been distributed on S-VHS LP videotapes. The uplink is from Hungary. Satellite distribution improves the picture and sound quality, programs will start at the right time, and live transmissions, stereo sound, and teletext will now be possible.

HBO programming, however, will still only be available for cable networks. This could change in the future, but for now DTH viewers will remain HBO-less. The Polish version of HBO is already transmitted via a digital package, but will join the others.

Germany's major cable operator Deutsche Telekom has announced it expects to reach an agreement with cable network operators throughout Europe this year to create a common decoder standard for digital pay television. Torsten Kreindl, head of the German telecommunications group's cable TV activities, told a conference in Cologne the company had shortlisted seven manufacturers of the decoder technology necessary for pay TV.

Multi Thematiques (mTh), a digital TV venture set up by Canal Plus, Generale des Eaux, and TCI International—a unit of American cable giant TCI, will launch its long-awaited German six-channel package in March. The company has announced it will use Bavarian media mogul Leo Kirch's DF1 as distribution platform.

The agreement is good news for DF1, which won't be able to offer a full range of channels on cable networks owing to capacity bottlenecks. mTh, which mainly offers localised versions of niche channels developed for Canal Plus's Canalsatellite package, is also launching four channels for the Italian market.

They will probably be part of the Telepiu package where Leo Kirch has held a major stake. But according to the Italian daily *La Republica*, Kirch is planning to sell his 45 percent stake in Telepiu to Canal Plus, which already owns the 45 percent received from Nethold after the merger between the two companies. In exchange, Kirch would receive Canal Plus' 32.5 percent stake in the German pay-TV channel Premiere. Since Kirch already owns 25 percent of Premiere, he would be able to control Germany's only pay-TV network (and open the door to a previous deal giving a share of Premiere to Rupert Murdoch's News Corp, previously blocked by Canal Plus and the other owner, Bertelsmann).

Telepiu is increasing its existing DStv program on Hot Bird 1 with new transponders on Hot Bird 2. These include the introduction of pay-per-view services, for sports, movies, and music events. Around ten new foreign channels are being added to the package—among them Bloomberg Italy, Hallmark, and The Weather Channel. Talks are currently underway with the Disney company, which may result in an Italian version of the The Disney Channel. Telepiu's movie channel Tele +1 will be able to offer a near-video-on-demand service with movies starting at different hours.

Back in the German market, Kirch faces some new digital competition. German public broadcasters have outlined plans to offer digital television using open decoder technology. Germany's huge public TV networks, ARD and ZDF, fighting back against media giants Bertelsmann and Kirch, will offer viewers digital TV, but at no extra charge for subscriptions.

Officials from both networks told the conference on digital television in Cologne that a group of companies, including Sony, Grundig, and Panasonic, plan to market open decoders that would make free digital television possible. The main difference between the open decoders and the ones used by Kirch's DF1 will be that open decoders would not include the conditional access system that restricts access to programming for paying customers only.

The open boxes would cost no more than $330 and could even be included as part of TV sets to be unveiled by the industry at the Berlin broadcasting exhibition in August. The new decoder is a blow to Kirch's DF1. But it could be a major breakthrough for Germany's advertising-financed networks like RTL, SAT1, and Pro7, who could now consider adding digital features to their programming.

Middle East

TRT International has started on Turkey's latest satellite, Turksat 1C, at 42 degrees East, on the Eastern beam, on 10.975 GHz, bringing to nine the active transponders on that beam.

There are also six European transponders carrying programming to the Turkish immigrants in Germany and Scandinavia. But, while apparently stronger than predeccesor Turksat 1B in signals to Turkey, the new satellite is even weaker than the older satellite to Europe. (And Turksat 1B barely showed up in Scandinavia.)

The Arab world's newest satellite is Arabsat 2B, which has replaced Arabsat 1C at 31 degrees East. It is identical to Arabsat 2A (26 degrees East), with 22 C-band and 12 Ku-band transponders. Arabsat 1C will be relocated to 20 degrees East, the former location of Arabsat 1DR.

New on Arabsat 2A are Kuwait TV, which has started on 12.646 GHz, and Abu Dhabi TV on 4.075 GHz.

The Orbit Satellite Television and Radio Network has been broadcasting 31 digital TV channels and 11 Musicam radio channels to 23 countries across the Arab World. There's a promotional channel in PAL on Arabsat 2A in the C-band. The programming itself uses two Intelsats at opposite ends of the Arab world: Intelsat 703 at 57 degrees East aimed at the Middle East (on 11.075, 11.555, and 11.600 GHz) and Intelsat 705 at 18 degrees West beaming to North Africa and Europe (on 11.500 and 11.658 GHz), using something called MPEG-1.5. The line-up of each service is supposed to be specifically tailored for the geographical area targeted.

The 31 channel line-up on Intelsat 703 was augmented at the beginning of the year as Rupert Murdoch's Star-TV's Middle East unit launched a package for Orbit on that satellite. The new channels include Star Plus International, Star Movies, Star Sports, NBC, CNBC, and the Fox Kids Network. Three more channels—Sky News, Channel [V] International, and Viva Cinema—will be added in April. The Star package is being offered as a separate subscription, called Sky Select, alongside the basic Orbit package. Before the Sky Select launch, Star Sports from Murdoch's British Sky Broadcasting was reported on Arabsat 1C for a few days at the beginning of December, in PAL on 3.811 GHz.

Intelsat 703 will also be used when Orbit introduces Pay-Per-View services to the Arab world, possibly as early as the first half of 1997.

Orbit and Walt Disney Television International have announced that the Disney Channel will be launching on the Orbit service on April 2, 1997. According to the press release: "The Disney Channel will be specifically tailored to the region's tastes and interests." Presumably this means that *Aladdin* and the (oh so bare) *Little Mermaid* will not be included.

The Disney Channel will be offered on an *a-la-carte* basis to Orbit's subscribers, either in Arabic or with subtitles. (This is unlike Europe, where the Disney Channel is only available to viewers in Britain and Ireland, and then as a freebie extra to those who subscribe to British Sky Broadcasting's complete movie package. Disney *a-la-carte* would probably be very popular in Europe, but it doesn't fit in with Rupert Murdoch's monopoly.)

Asia/Pacific

Malaysia's recently launched Measat 2 is now located at 148 degrees East. It has six C-band and eight to nine Ku-band transponders, which will be used to carry 128 digital TV channels, as part of the existing system with Measat 1 (at 91.5 degrees East).

According to the *Sydney Morning Herald*, the Australian Broadcasting Corporation is considering a plan to sell its Asian satellite television service. The newspaper says the proposed sale of Australian Television is supported by the new Conservative government of Prime Minister John Howard. Australian Television broadcasts Australian news and other ABC programming to Asia, using a transponder on one of Indonesia's Palapa satellites. The *Herald* said that under the plan the ABC would sell Australian Television's satellite capacity and its contracts with Asian pay TV operators. In return, the ABC would retain eight to 12 hours of daily time of service for its programming. Australian Television was set up under the previous Labour Party government. Howard's new right wing regime apparently prefers private alternatives.

NBC plans to distribute its programs in Japan. The president of NBC Asia, S.K. Fung, says NBC programs will be seen in Japan this year, although it remains to be decided whether they will be shown on conventional commercial TV, cable TV, or by satellite. NBC has been airing its CNBC business channel in parts of Asia for 1-1/2 years, and last year started an NBC Asia general channel. But the network doesn't have any programming available in Japan yet.

Japan is being inundated with digital satellite television. A service called Sky-D, will put four digital programmers into two competing camps. Sky-D will launch on the Superbird-C satellite, which is also being used by DirecTV Japan, and will also use the transmission and encryption system as DirecTV, so viewers can choose to receive one or both of the packages with the same equipment, apparently similar to the DirecTV/USSB combination in the US.

The Sky-D package will consist of around 20 to 25 digital channels, including many of the company's current channels. These include CNN International, the Golf Channel, and MTV Japan.

Competing against the alliance is PerfecTV and Rupert Murdoch's Japan Sky Broadcasting (JSkyB) on JCSat-3. PerfecTV began broadcasting in October, and JSkyB has announced plans for an initial launch this Spring. Both systems are using the same encryption system.

Yet another group has announced a planned start date for digital satellite broadcasting in Japan. SkyPort, which currently carries a seven channel analog package, says it will begin a multi-channel digital package in October 1997.

Japan's Direct Internet Corp. will use the PAS-2 satellite to provide its subscribers with Hughes' DirecPC Internet service, offering Internet access at speeds more than 20 times faster than conventional telephone lines. The DirecPC service will deliver Internet data directly to subscribers with small rooftop dishes.

Direct Internet will use one-half of a transponder on the PAS-2 Ku-band Northeast Asia beam, which provides coverage of Japan and neighboring countries.

That's all for this time. Thanks to James Robinson, *SATCO DX Chart Update*, *Telesatellit News*, Richard Karlsson, *What Satellite TV*, and Curt Swinehart for their many contributions.

ST

By Doug Jessop

Death of a Satellite

In the movie *Independence Day* when aliens came to invade Earth, the first thing they did was to knock out the communications satellites. While visiting the master control center of the television station that I call my "day job," I couldn't help but remember the movie as we saw the daily syndication feeds on Telstar 401 vanish into thin air.

INDEPENDENCE DAY

As you have probably already heard by now, AT&T's prime satellite, Telstar 401, has been declared a complete loss. According to sources at AT&T's operation center, Telstar 401 had a massive power discharge, most likely from a solar flare. Working with the International Solar Terrestrial Physics (ISTP) Program, they managed to track a so-called "magnetic cloud event" that originated from the sun's surface on January 6 (More information: **http://www-istp.gsfc.nasa.gov/istp/cloud_jan97/event.html**).

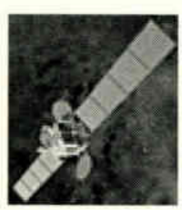
It is interesting to note that after the initial failure, AT&T staff were able to get the satellite to recognize telemetry commands for a short while. With the temperature being -280 degrees Celsius (almost absolute zero), sources indicated that the fuel would become frozen solid fairly rapidly.

The bigger story here is not that AT&T lost the crown jewel of its satellite fleet, but why didn't other satellites have the same problem from this increase in solar radiation? The easiest answer seems to be that the satellite bus in question may to have a major design flaw. Case in point: this at least the fourth time in the last couple of years that the Martin Marietta series 7000 bus has had major problems.

A History of Problems

Back in March of 1996, Canadian satellite communications were sent to their knees with the temporary loss of Anik E1. In that case, the momentum gyro went haywire until they were able to come up with a scheme to use telemetry controls through two of the transponders. At the time, solar activity was also considered the culprit. In a little publicized "coincidence," INTELSAT K had nearly the same problem on the same week that Anik E1 spun out of control. The difference was that the INTELSAT folks were able to regain control within a short time. To add insult to injury, while the Canadians were grappling with Anik E1, the sister bird Anik E2 even had a quick telemetry scare. What model was the bus in these cases? Series 7000.

Of course, let's not forget that the failed T401's little sister, AT&T's Telstar 402, is not the original 402. It is actually Telstar 402R. At the time of the original launch of Telstar 402, I was the Director of Marketing for Keystone Communications who happened to have a number of full-time leases on Telstar 401. The launch was broadcast in the clear so all the clients could see the long-awaited event. Everything went well on the launch, but of course that was not the full story. The next morning it became obvious that something was terribly wrong. When a satellite is launched it goes through a series of maneuvers to get it into the proper orbit. A critical



stage is when the apogee kick motor is activated to boost the satellite into its final orbit. The original T402 never made it into final orbit. After doing a little digging, it seems that NORAD sighted a hydrazine vapor trail. Word in the industry seemed to indicate that a fuel line had been damaged when the lid of the pyrotechnic canister that jump starts the apogee kick motor had nicked the fuel line. What model satellite was the original (and subsequent backup bird) Telstar 402? Series 7000. Coincidence?

AT&T's Telstar 401 is a total loss, so what now? That depends who you are. When the transponder inventory is sold, the clients have a choice of "protected service"—the highest of which is called "Platinum Service Protection." Only two clients, FOX and ABC, had this service level on C-band, which gives them first shot at any other unprotected service on another AT&T bird. Both FOX and ABC were fairly quickly moved over to Telstar 402. Some of the ABC feeds are on Telstar 303, which is currently operating in an inclined orbit.

The switch has not been without a couple of problems. Two of the full time transponders for ABC are now on inclined Ku satellite. These are being used for full time news gathering, which understandably is a big revenue source for them. The problem is that not all affiliates have tracking ability on Ku which should also be of interest to you wild feed fans. ABC has been turning off the LEICH encryption while they try to get all the bugs out of their new home. Fox had just bought a Ku transponder for news but the Ku transponder contract was apparently not platinum and AT&T had to take it back. Platinum service contract is akin to earthquake insurance—it may seem like a waste of money until your place starts shaking.

What about the services that did not have "Platinum Service?"

Keystone had been doing all of the feeds for Paramount, UPN, and Buena Vista on Telstar 401. In a lucky twist of fate, the folks at Keystone had just picked up three transponders on Galaxy 3 on January 1st (talk about dodging the bul-

The live broadcasts of Regis & Kathy Lee from NATPE became a satellite nightmare with the loss of Telstar 401

let). Other high profile users on the crippled satellite include PBS and Georgia PTV. They bring in another wrinkle, considering the fact that they use some pretty heavy duty compression to allow a number of signals on one transponder. In some cases, instead of just one full time signal per transponder, we are talking in the neighborhood of 8:1 digital compression.

Another major effect of the loss of Telstar 401 is in the area of Business Television. People with regular feeds to their various offices nationwide are pretty much left in the dark for a while until other arrangements can be made. Finding occasional satellite inventory on a stable satellite (not inclined orbit) just became equivalent to winning the lottery.

The Telstar 401 failure has already prompted response from other satellite users. For example, the big boy of news gathering, Conus Communications, has implemented the following satellite booking policy despite unusually high demand:

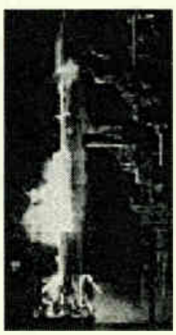
Conus will NOT accept ANY bookings in key news times from non-Conus stations through January 31 or until the current satellite transponder situation clarifies itself. This includes the time periods 1600-1830 EMT and 2200-2330 EMT.

"This new Conus policy is in response to a continuing demand on limited satellite space segments as well as the recent loss of nearly 40 percent of occasional use transponder capacity, a consequence of the loss of Telstar 401.

Conus has taken other measures on behalf of local stations to capitalize on existing satellite space. Due to a renovation completed in May 1996, the Conus Washington Direct facility is fully capable of digital broadcast, as well as analog. The result: a single half transponder carries four separate, yet simultaneous, paths of high quality video. The theory became practice on Election Night, Nov. 5, 1996, and a repeat performance occured when Conus Washington Direct covered inaugural events."

AT&T Skynet, the satellite division of AT&T, is being sold to Space Systems/Loral. They obviously will be renegotiating the sales price now that a big portion of their inventory is now a space popsicle. On the good news side, Space Systems/Loral is building two new replacement satellites which will have a payload of 24 Ku-band transponders with a power of 110W and 24 C-band transponders with 20W each. The first of the new series 5000 TELSTAR 5 satellites is scheduled to be launched May 21-25, 1997, and be in service about 60 days later. It is probably a safe bet to say that the satellite design team people will be burning the midnight oil to make sure they don't get an encore performance of recent failures.

LORAL
Space & Communications



AT&T will petition the FCC to move Telstar 302 to Telstar 401's orbital slot at 97 degrees West Longitude to provide temporary transponder capacity for customers. Telstar 5 will be the permanent replacement for Telstar 302 at 97 degrees WL, subject to FCC approval.

On Telstar 5, C-band transponders will be used by commercial broadcasters and syndicators while Ku-band transponders will be used for direct-to-home broadcasting. AT&T plans to re-establish public broadcasting, distance learning and satellite news gathering services on Telstar 402R Ku-band as soon as possible in conjunction with the start of service on Telstar 5."Loral fully supports AT&T's swift and dedicated efforts to make out-of-service Telstar 401 customers its top priority," said Bernard L. Schwartz, chairman and chief executive officer of Loral. "We have every intention of proceeding with the transaction to purchase Skynet and will continue to work constructively with AT&T to resolve all issues."

For the latest new transponder sightings check the *Satellite Services Guide* in this issue of *Satellite Times.*

Domestic News

NBC and National Geographic Television have formed a joint venture to launch National Geographic channels throughout the world in 1997. The channels will carry documentary, drama and children's shows, using National Geographic's library of nature programming as well as shows that will be acquired. NBC's US network and its European channel already carry programming produced by National Geographic. To start, the venture will launch cable- and satellite delivered channels in Latin America, Europe, and Asia, in cooperation with local partners in each territory. Financial contributions from the partners were not disclosed.

Although not set in stone, CBS announced an early programming sched-

BET on Jazz
THE CABLE JAZZ CHANNEL™

ule for its new cable channel, Eye on People. The lineup will be a mix of interviews, investigative pieces and other shows-all made up of clips from the CBS archives. The channel, targeted to launch in the spring, will include *Today's People*, a daily program about the lives of ordinary folks and celebrities; *Eyewitness*, a weekly hour that will go behind the scenes at places like firehouses and emergency room and animal hospitals; *The Public Eye*, a consumer-affairs program and *60 Minutes: The Second Time Around*, a show that will feature archival pieces from CBS' popular newsmagazine.

Spike Lee has signed on as a spokesman for BET Movies/STARZ!3, the movie channel started by Black Entertainment Television. In addition, he will host the cable network's premiere week which will feature Lee's films *Do the Right Thing*, *Clockers*, *Crooklyn*, and *She's Gotta Have It*. BET movies is scheduled to launch February 1 with free previews each Saturday in February on parent channel BET.

In its first attempt to steal viewers from Viacom Inc.'s Nickelodeon network, the Walt Disney Co. is finishing up plans to launch a cable/satellite nework devoted solely to educational shows for children. With the network, tentatively called "ABZ," Disney will target young children and preschoolers during the day and teens and young adults at night. The project marks one of Disney's first attempts at combining its reputable family entertainment business with television since purchasing Capital Cities/ABC Inc. last year. Disney/ABC Cable Networks President Geraldine Laybourne, credited in the industry for making Nickelodeon the powerhouse it is, is spearheading the project.

DIRECTV™

Legal Stuff

Personalized Media Communications says the US International Trade Commission (ITC) has commenced an investigation of DirecTV, United States Satellite Broadcasting, Thomson Consumer Electronics, Hughes Network Systems, Hitachi Home Electronics, Toshiba America Consumer Products, and Matsushita Electric Corporation of America, for violation of section 337 of the Tariff Act of 1930, in the importation, sale for importation, and sale in the United States after importation, of DSS receivers that infringe a U.S. patent owned by PMC.

The company said its patent, No. 5,335,277, covers "new technology that allows end-users to customize the processing of a broadcast signal to exert greater control over programming content displayed on a television. This is achieved by the viewer directing the transmission of broadcast communications signals, data and processing instructions with private data resident in the user's personal computer or receiver, thereby turning the broadcast signal into a 'personalized media' stream."

Let's go hypothetical for a moment with this legal mumbo jumbo. Let's say that I use DirectPC satellite services for my Internet connection. I can certainly exert control over the content displayed on my computer using my web browser (Netscape in my case). Does this then mean that my web browser also violated dear old number 5,335,277?

If the courts decide in favor of PMC, DSS systems sales could become frozen. With presumed automatic appeals, this case could take forever and make DSS systems hard to come by. In the reality check department, my guess is that all the high-paid lawyers will take a good hard look at this, and if they think PMC has a chance they will bring out the checkbook pretty fast to make this annoyance go away. ST

Doug Jessop has been in the broadcasting industry since 1979 and was the creator of the Keystone Communications North American Satellite Guide. He can be reached at http://www.searcher.com/STcomments.html

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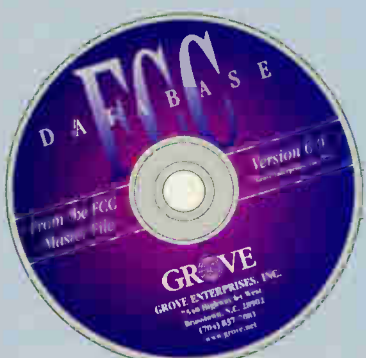

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ST FINAL FRONTIER

By Philip Chien

The Biggest Space Program Myth

One of the biggest myths about the space program is the Great Wall of China. Is it visible from space? The short answer—no, but not for the reasons you'd think.

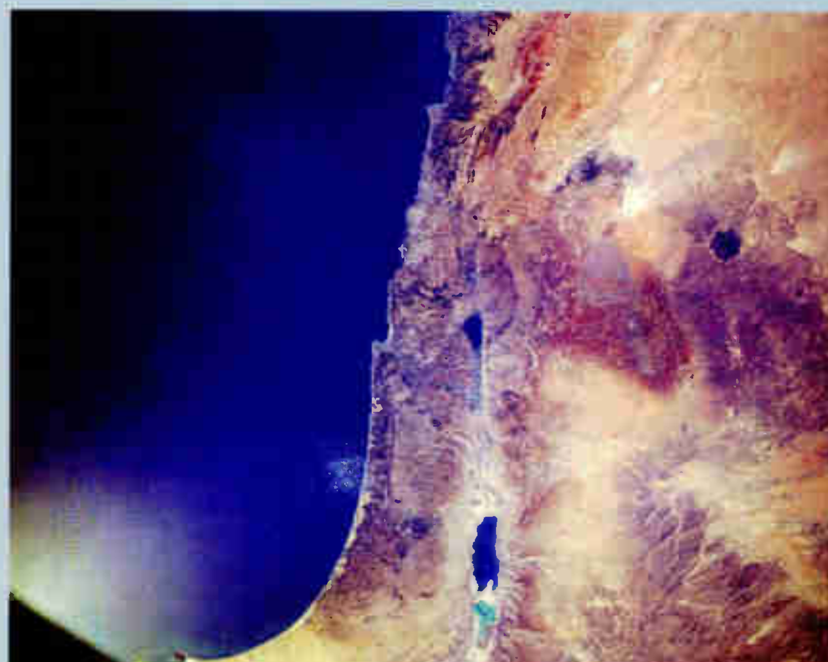
Our story starts with the Mercury program, America's first astronauts. If you believe the media hype, at the time these were the seven top test pilots in the country—the cream of the crop selected by the Air Force, Navy, and Marines. Or if you believe the 1983 movie *The Right Stuff*, seven individuals who happened to meet the requirements, happened to catch the eye of a recruiter who saw them on a television show, or happened to be in the right place at the right time. The truth was somewhere in between—military test pilots with the right credentials who happened to make the cut. Most had graduated from test pilot schools, but only Deke Slayton was actually based at Edwards. They all had perfect eyesight—but they were not supermen.

On the last Mercury mission, MA-9 astronaut L. Gordon 'Gordo' Cooper reported seeing trucks on highways, ships, aircraft, and railroad trains—with his naked eye. This shocked doctors and other specialists who couldn't believe that a set of eye—no matter how perfect—could see items that small from space. Somehow the myth developed that the only artificial object which could be viewed from space was the Great Wall of China. The problem with this statement is, none of the Mercury missions traveled far enough north to go over Northern China—the Great Wall was always beneath the horizon!

It turned out that Gordo wasn't crazy, and there was an extremely reasonable explanation. Highways, wakes generated by ships, contrails generated by aircraft, and tracks are all extremely long straight lines. And straight lines rarely occur in nature. So they stand out. While Gordo never did see a truck, ship, aircraft, or train, he saw their evidence by a cloud of smoke moving down a highway, a wake in the ocean, a contrail in the upper atmosphere, or tracks.

During the Gemini program the military was interested in testing how well a person's vision could be used in space. The upcoming Manned Orbiting Laboratory (MOL) program would involve observations of targets of military importance, and it was important to evaluating the role of men in space. The Gemini 5 mission (not coincidentally Gordon Cooper's second flight), featured a Conerex camera with a 1000 mm lens. It was mounted in one of the spacecraft's windows, and while Cooper or pilot Pete Conrad maneuvered the spacecraft, the other one would try to follow predesignated targets with the camera. Large natural and artificial objects under the spacecraft's flight path, like the Great Pyramids, were used for the test.

Was the experiment successful? The Department of Defense confiscated the film after the mission landed, and eventually released several purposely blurred prints. When questioned about the original film many years later, the military "claimed" that it had been accidentally destroyed.



A photograph taken by the Shuttle of the Eastern Mediterranean and Israel. Prominent features include the Red Sea, the Dead Sea, and the Israel/Egypt border (demarked by the change of earth tones at bottom).

By this point it was obvious that many artificial objects could be viewed from low Earth orbit. Large artificial structures like runways and dams are especially obvious from space—both to the human eye and on photographs.

By the Apollo program, the myth had evolved to claim that the Great Wall could be viewed from the moon. A quick look at any Apollo moon mission photograph of the Earth clearly shows that this is rather preposterous. And Apollo 11 astronaut Mike Collins reported that not only could he not see the Great Wall, but all of Asia was just a brown smudge at the moon's distance.

Skylab was the first U.S. crewed spacecraft in a high inclination (50 degree) orbit. It traveled over 90% of the Earth's populated areas, including all of China. Many of Skylab's experiments were specifically designed for Earth observations, including a suite of six cameras with multispectral films. However, NASA was sensitive to claims that Skylab was going to be used for military purposes, after the cancellation of the Manned Orbiting Laboratory program. (In fact, the actual reasons for

MOL's cancellation were the high cost of the Vietnam war and the development of the unmanned Keyhole satellites). So, the Department of State had written agreements with each country which was involved with Skylab's Earth observation projects. While Skylab's orbit took it over hundreds of countries, politics would choose which countries would cooperate with the Earth observation experiments.

Enter the space shuttle. It's flown over 80 missions with a wide variety of orbits, including many which go over China. Many countries participate in cooperative observations, and national borders are no longer a consideration when pictures are taken. There was a minor incident when the STS-9 astronauts innocently took photos of the then top-secret Soviet launch site at Bakinor: subsequently and the Department of Defense reserved the right to view all shuttle Earth observation photography and limit the release of sensitive photos.

Cairo and the Nile. The Great Pyramids of Giza can actually be seen (see circle) in the sandy area outside of the dark green river plain.

So why hasn't any photo been taken of the Great Wall from orbit? Or why hasn't any astronaut reported spotting the Great Wall?

It turns out that the Great Wall isn't very visible, not because of its size, but because of its construction materials. It was built from native materials close to the Wall's site. So it's a fairly low contrast target, blending in well with the background. In addition, the Western view of the Great Wall is of the massive structure President Nixon visited and David Copperfield walked through while performing an illusion. This image is only true for a small portion of the wall; much of it is just native rocks piled up high. Only a small section of the wall near Beijing is maintained for the tourists. For the most part the Great Wall isn't so great!

Still, this hasn't stopped shuttle astronauts from trying to view and take pictures of the Great Wall. The STS-62 crew was especially interested in trying, and wanted to use sun glint to try to get a picture of the wall at sunrise with long shadows showing the wall's structure. While they didn't succeed in returning photos of the Great Wall, they did return photos of the Great Pyramids in Egypt, incredibly clear photos of Mexico City, and many other interesting targets.

The second greatest myth of Earth observation and the space program is that you can't see national borders from space. And it is true that many astronauts have commented about how the Earth seems to be a much smaller place, with wars and internal conflicts invisible from space. But occasionally you do see a national border. The Israel/Egypt border is especially distinct—straight as a razor, as one astronaut commented. The reason it is visible is because of different approaches to land use. On the Israeli side the land is artificially irrigated and used for crop production while the Egyptian side has much less vegetation.

And one final space program myth. It *is* possible to see animals from space. Not elephants or whales, but some of the smallest animals—coral. Australia's Great Barrier Reef consists of millions of coral. Astronauts have described the sight as incredible when viewed from space.

Austrailia's Great Barrier Reef seen from space.

For a fascinating look at the Earth from space check out *Orbit: NASA Astronauts Photograph the Earth* (Random House, ISBN 0-7922-3714-5, $40 retail). Its a hardcover coffee table book, printed from images computer scanned from the original flight film. The vast majority of the 175 photos are from the shuttle program, but some are from previous U.S. manned spaceflights.

The authors, Jay Apt, Michael Helfert, and Justin Wilkinson are all scientists with Earth observation experience at the Johnson Space Center. Author Jay Apt was a planetary scientist with the Pioneer Venus program and is an active astronaut, having flown on four shuttle missions. Many of the photos in the book were taken during his first three shuttle flights. Jay also holds the amateur radio license N5QWL and has flown with amateur radio on all four of his shuttle missions. ST

WHAT'S NEW

by Wayne Mishler, KG5BI
email: mishler@ipa.net

New service breaks cellular-phone barrier

A new service offered by Inmarsat enables anyone anywhere the ability to send and receive telephone calls, faxes, and computer data via satellite.

Based on the Inmarsat-B mobile satellite communications system, the new service does not require a computer modem or special landline connections. It transmits data at 9,600 bits per second. A data rate of 64,000 bits per second is possible through special Inmarsat-B high-speed data terminals for ISDN subscribers or for corporate customers with leased lines.

"Now that the global service is available, thousands of government officials, journalists, oil and gas industry workers, peacekeeping forces, and others who need immediate and reliable remote mobile data communications can benefit from 9.6 kb per second services," says Inmarsat manager Jonathan Elder.

An Inmarsat-B transportable terminal weighs about 40 pounds (18 kilograms) and offers access to the World Wide Web, computer bulletin boards, and on-line services such as Compuserve and America Online. Software compatible with Microsoft Windows 95 is available on the Web at **http://www.inmarsat.org/inmarsat/html/toolbox.** A maritime version of the terminal is also available.

Inmarsat

You can request additional information from Inmarsat via their Web site: **http://www.inmarsat.org/inmarsat/low_band/html/about/ask.html.**

Transportation industry gets new PCS service

Qualcomm, Inc., has introduced a new PCS service for the transportation industry. The service is called CabCARD Personal Communications, and it enables users of the OmniTRACS mobile communications system to send and receive Internet e-mail messages anywhere in the world from their vehicles via their OmniTRACS mobile terminal. It also offers drivers and fleet owners voicemail and prepaid telephone service from any touch-tone telephone. The service is ideal for drivers who want to manage their telecommunications costs and stay in contact with family and friends while on the road.

Here's how the system works. A user sends an e-mail or voice message to a central computer which routes it to the fleet computer. The fleet computer converts and sends the message to Qualcomm's OmniTRACS Network Management Center in San Diego. The Center transmits the message to a satellite, which downloads it to the target vehicle's on-board mobile communications terminal. Responses from drivers follow a reverse route.

The CabCARD is exactly that — a prepaid telephone card which authorizes users to access the service.

E-mail is available only to OmniTRACS mobile communications customers operating on certain dispatch computer platforms, but the prepaid phone services are available for any OmniTRACS customer. E-mail can be sent and received through any on-line service or any appliance capable of linking to the Internet. There is an 800 number for voicemail. And, says OmniTRACS, the service costs less than a cellular phone.

By pre-paying, drivers can budget their telecommunications costs. You can add prepaid time to the card by telephoning or sending a pre-formatted message to OmniTRACS via the mobile terminal. Everything is password protected, and messaging is private.

You can get more information from Qualcomm's Web site: **http://www.qualcomm.com/**, or by telephoning them at 800-34-TRACS.

Quality audio satellite receiver tunes-in hundreds of free services

Universal Electronics, Inc., has introduced a new subcarrier receiver that turns your satellite system into an ultra-high quality audio system featuring music, sports, talk shows, religious programming, major radio stations, variety, public radio, and many other services — with no subscriber fees.

Audio subcarriers are the additional signals attached to the main satellite video carrier — not the audio that accompanies your video program. These signals are located above video from 5.0 MHz to 9.0 MHz typically. Hundreds of audio services are available. Music, news, talk shows, and sports are all offered by this audio subcarrier group.

Universal's new SC-50 receiver opens a new world of audio for your satellite system, bringing you the FM² audio channels located from 100 kHz to 5.0 MHz as well as the new channels in the 5.0 MHz to 9.0 MHz range. It works with C-band and Ku-band home satellite systems. It installs in minutes, and is simple and quick to tune with a 16-character display and direct frequency readout. There are 50 channels of memory for storing your favorite radio services for immediate recall. With the SC-50 you won't have to change your present satellite receiver to tune in audio subcarrier and FM^2 services.

"This unit is in demand and ideal for the home dish owner, C- and Ku-band. The SC-50 is simple to hook up, takes only one connection to the regular home satellite receiver, which can be accomplished in about three minutes," says Universal President Tom Harrington.

While your present satellite receiver will receive some of the standard audio subcarriers, mainly 6.20 MHz and 6.80 MHz (which carry the audio for your video), you must reprogram your receiver's audio section to receive the other audio channels that are available. Later, when you want to restore your video's audio, you must reprogram the receiver again. This can be a time-consuming and difficult procedure. And many satellite receivers cannot be tuned to the new audio subcarriers.

The SC-50 ends the hassle: you simply punch in your frequency. It takes only seconds to be enjoying super-quality audio. And, as you develop a list of favorite channels, you can enter them into the receiver's memory for instant recall. Selection is as easy as scrolling through the channels with a touch of the up or down button.

To install the SC-50, you simply run a cable from its Baseband-in jack to the Baseband-out jack on your present receiver. You run another cable from the SC-50's Line-out jack to the Aux-in jack on your stereo audio system. To receive stereo you will need a "Y" connector to branch the cable to your system's left and right channels. Plug in the power cord and you're in business.

Universal offers a satellite radio guide booklet to help you find the audio services that are available, and has released a new book entitled *Satellite Radio* covering the non-video services carried on many domestic C- and Ku-bands. The guide and the book were published separately, allowing the guide to be updated every three months. The book contains eight chapters covering satellite audio services. It sells for $16.95 plus $3 shipping.

The book, guide, and additional information on the SC-50 is available from Grove Enterprises or from Universal; 4555 Groves Road, Suite 12; Columbus, OH 43232-4135. Their phone number is (614) 866-4605.

Protect your satellite equipment against lightning

A new lightning arrestor which provides protection from lightning without sacrificing RF performance has been announced by the Andrew Corporation.

This new T-shaped Arrestor Plus T-Series surge arrestor is weatherproof and suitable for a variety of outdoor applications. Its advanced technology, says the Andrew Corporation, ensures superior multi-strike protection.

Advertised features include compact size, durability and reliability, and superior RF performance. It is available in Type N or DIN interfaces.

For information, visit the company's web site, **http://www.andrew.com,** or call 800-255-1479, ext. 12, and ask for bulletin 3970.

Wall-mounted satellite dish simplifies installation

Can't get on the roof to mount your satellite dish? No problem. Mount it on an outside wall. A special antenna for this specific purpose is now available from Kaul-Tronics Inc. (KTI) in Wisconsin.

The KTI 60 cm offset antenna comes with a universal mount that attaches to a wall, or sloped or flat roof. It is designed for strength and offers some relief from that annoying "rain fade" problem common in dish antennas. It has a unique, vented, D-channel feed support arm that reduces moisture condensation on the inside. And its domed top reduces snow accumulation which can block signals from the feed horn.

KTI's phone number is 608-647-8902. You can fax them at 647-7394.

Satellite TV now available to apartment dwellers

Apartment complexes can now be equipped with a small antenna capable of providing direct-to-home programming to all units in the complex.

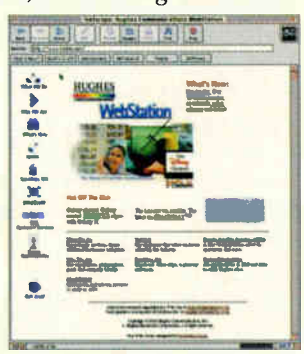
In response to growing demand from residents and owners of apartments, SkyView (a division of Ethnic-American Broadcasting Company) is now offering DIRECTV programming and Sony DSS hardware systems for apartment buildings and condominiums throughout the United States.

"For the first time ever, the most advanced multichannel television product on the market today will be made available to multiple-dwelling units in a full-service, customer-friendly mode," says EABC president David Moro. "SkyView's alliance with DIRECTV and Sony opens the door to a previously untapped market of 27 million units nationwide."

Property owners and management companies can get more information about SkyView's new service by calling 800-207-0306.

Hughes Web site is valuable resource for satellite customers

Hughes Communications Inc. (HCI) has upgraded its Web site, **http://www.hcisat.com,** introducing several new customer services and information resources, including data on bi-annual sun outages that can affect every satellite customer.



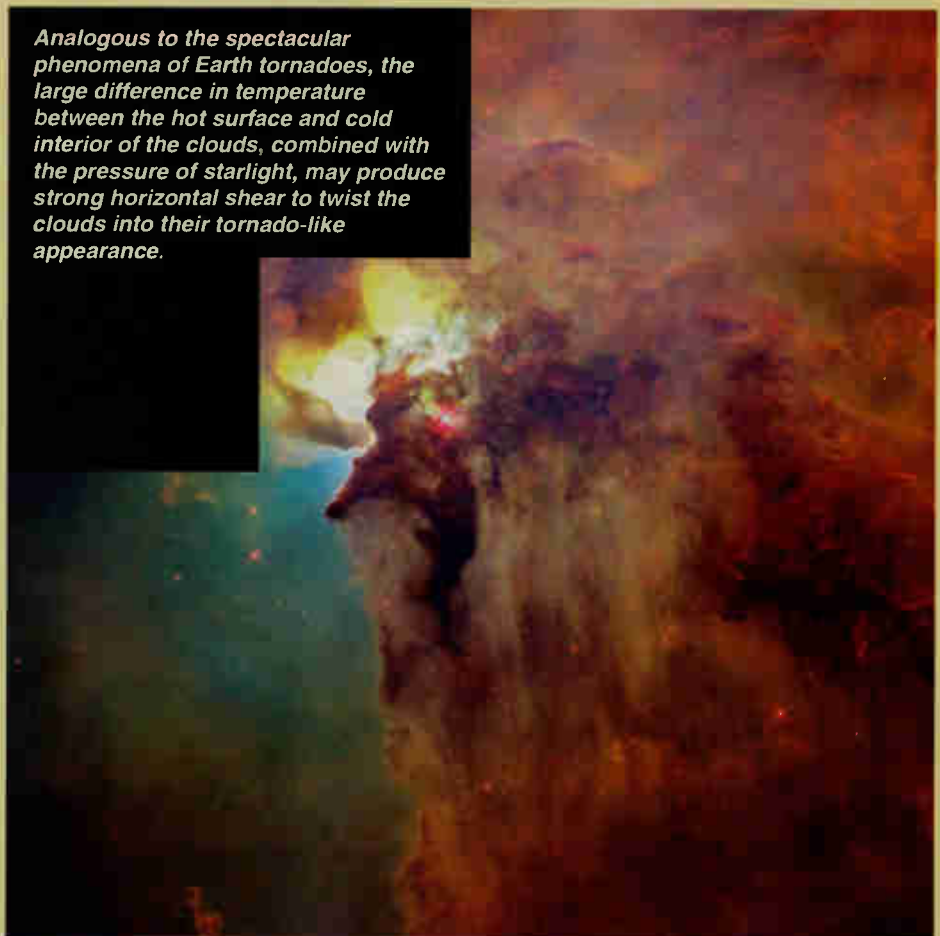
The "Sun Outages" section explains and demonstrates the cause of sun outages and their effect on satellite operations, and tells customers when their satellite signals are most likely to be affected. High resolution maps, which can be downloaded and printed, show when and were sun outages will peak and how long they will last.

The Web site offers numerous other attractions as well. It has an improved interface, and is easier and more fun to use. ST

By Larry Van Horn

Giant "Twisters" and Star Wisps in the Lagoon Nebula

These NASA Hubble Space Telescope (HST) images reveals a pair of one-half light-year long interstellar "twisters"—eerie funnels and twisted-rope structures (upper left)—in the heart of the Lagoon Nebula (Messier 8) which lies 5,000 light-years away in the direction of the constellation Sagittarius.



Analogous to the spectacular phenomena of Earth tornadoes, the large difference in temperature between the hot surface and cold interior of the clouds, combined with the pressure of starlight, may produce strong horizontal shear to twist the clouds into their tornado-like appearance.

The central hot O type star, Herschel 36 (upper left in photo at right), is the primary source of the ionizing radiation for the brightest region in the nebula, called the Hourglass. Other hot stars, also present in the nebula, are ionizing the extended optical nebulosity. The ionizing radiation induces photo-evaporation of the surfaces of the clouds (seen as a blue "mist" at the right of the images), and drives away violent stellar winds tearing into the cool clouds.

Analogous to the spectacular phenomena of Earth tornadoes, the large difference in temperature between the hot surface and cold interior of the clouds, combined with the pressure of starlight, may produce strong horizontal shear to twist the clouds into their tornado-like appearance. Though the spiral shapes suggest the clouds are "twisting", future observations will be needed, perhaps with Hubble's next generation instruments, with the spectroscopic capabilities of the Space Telescope Imaging Spectrograph (STIS) or the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), to actually measure velocities.

This Hubble picture reveals a variety of small scale structures in the interstellar medium, small dark clouds called Bok globules, bow shocks around stars, ionized wisps, rings, knots and jets.

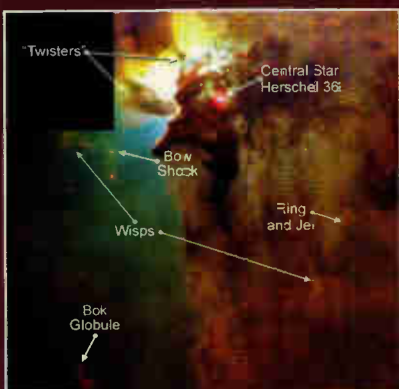
The Lagoon Nebula and nebulae in other galaxies are sites where new stars are being born from dusty molecular clouds. These regions are the "space laboratories" for the astronomers to study how stars form and the interactions between the winds from stars and the gas nearby. By studying the wealth of data revealed by HST, astronomers will understand better how stars form in the nebulae.

These color-coded images are the combination of individual exposures taken in July and September 1995, with Hubble's Wide Field and Planetary Camera 2 (WFPC2) through three narrow-band filters (red light—ionized sulphur atoms, blue light—double ionized oxygen atoms, green light—ionized hydrogen).

This work is based on public data retrieved from the HST Archive, cosmic-ray cleaned, calibrated and combined by Adeline Caulet (Space Telescope European Coordinating Facility, European Space Agency). ST

Photos Courtesy: A. Caulet (ST-ECF, ESA) and NASA

A close-up of the tornado-like structures in the heart of the Lagoon nebula. These color-coded images are the combination of individual exposures taken in July and September 1995, with Hubble's Wide Field and Planetary Camera 2 (WFPC2) through three narrow-band filters (red light—ionized sulphur atoms, blue light—double ionized oxygen atoms; green light—ionized hydrogen).



New York City, Resolved

By Larry Van Horn

This is a radar image of the New York City metropolitan area. The island of Manhattan appears in the center of the image. The green-colored rectangle on Manhattan is Central Park. This image was acquired by the Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR) aboard the space shuttle Endeavour on October 10, 1994. North is toward the upper right.

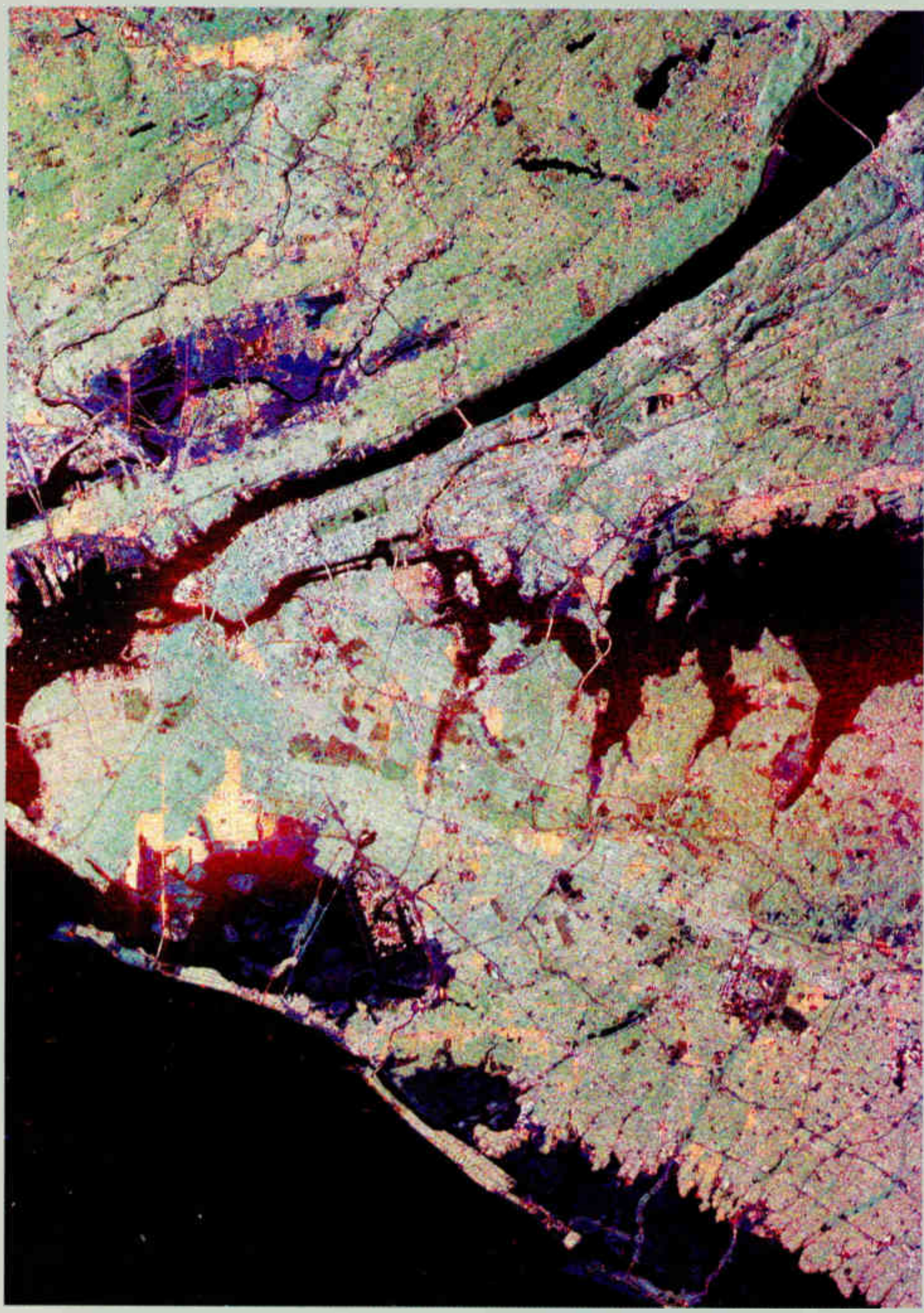
The area shown is 75.0 kilometers by 48.8 kilometers (46.5 miles by 30.2 miles). The image is centered at 40.7 degrees north latitude and 73.8 degrees west longitude.

In general, light blue areas correspond to dense urban development, green areas to moderately vegetated zones and black areas to bodies of water. The Hudson River is the black strip that runs from the left edge to the upper right corner of the image. It separates New Jersey, in the upper left of the image, from New York. The Atlantic Ocean is at the bottom of the image where two barrier islands along the southern shore of Long Island are also visible. John F. Kennedy International Airport is visible above these islands. Long Island Sound, separating Long Island from Connecticut, is the dark area right of the center of the image. Many bridges are visible in the image, including the Verrazano Narrows, George Washington and Brooklyn bridges. The radar illumination is from the left of the image; this causes some urban zones to appear red because the streets are at a perpendicular angle to the radar pulse.

The colors in this image were obtained using the following radar channels: red represents the L-band (horizontally transmitted and received); green represents the L-band (horizontally transmitted, vertically received); blue represents the C-band (horizontally transmitted, vertically received).

Radar images like this one could be used as a tool for city planners and resource managers to map and monitor land use patterns. The radar imaging systems can clearly detect the variety of landscapes in the area, as well as the density of urban development.

Spaceborne Imaging Radar-C and X-Band Synthetic Aperture Radar (SIR-C/X-SAR) is part of NASA's Mission to Planet Earth. The radars illuminate Earth with microwaves allowing detailed observations at any time, regardless of weather or sunlight conditions. SIR-C/X-SAR uses three microwave wavelengths: L-band (24 cm), C-band (6 cm) and X-band (3 cm). ST



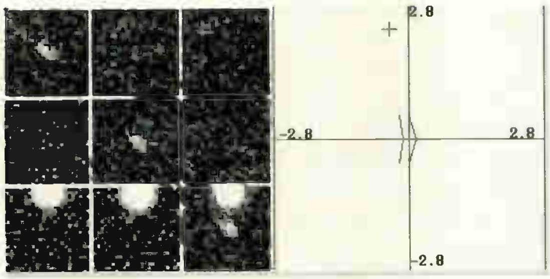
Solar System Census Count Increases by Two

Two newly detected members of the Solar System—a rare asteroid orbiting close to Earth and a distant comet making its only appearance—mark the first discoveries of the year for a team of astronomers at NASA's Jet Propulsion Laboratory (JPL), Pasadena, CA.

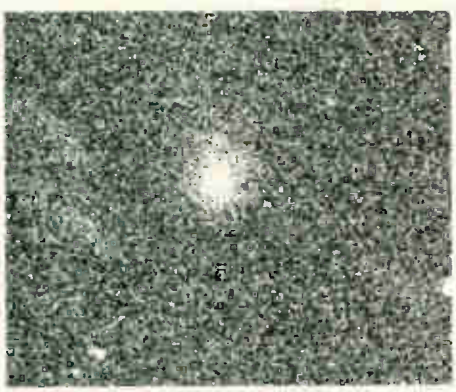
The discoveries, reported Jan. 10 by JPL planetary scientists Eleanor Helin, Steve Pravdo, David Rabinowitz and Ken Lawrence, were made possible with a few nights of clear observing weather and use of a sensitive, harge-coupled device (CCD) camera called the Near-Earth Asteroid Tracking (NEAT) system at Mt. Haleakala, Maui, HI. Since their initial sightings, both objects have become the focus of worldwide observations by astronomers in Japan, China, Australia, Canada, Italy and the Czech Republic.

"This asteroid is a member of a rare class of asteroids, called Atens, which stay within Earth's orbit most of their lifetimes," said Helin, principal investigator of the NEAT project. "The object has a higher inclination to the plane of Earth's orbit than most Atens: in fact, at 31 degrees, it has the second highest inclination of all the Atens we've discovered."

The highly inclined orbit, which is unusual, may result from long-range interactions with the planets, or may be the outcome of previous orbits passing near the Earth. With the discovery of more Atens, the relative importance of these competing influences may be better understood.



Newly discovered asteroid, dubbed 1997 AC11, crosses earth's orbit periodically.



The new comet, "1997 A1."

Dubbed 1997 AC11, the asteroid is a faint object with an absolute magnitude of 21, and probably measures about 600 feet in diameter. It is only the 24th Aten to be discovered in 21 years, since Helin found and named the first Aten in January 1976. With orbits that are smaller than Earth's, and short periods, Atens are in the vicinity of Earth frequently. This closeness to Earth makes them more likely to impact the planet than other types of asteroids.

"Atens never wander far from the orbit of Earth and can cross Earth's orbit as many as four times a year," Helin said. "1997 AC11, for instance, has a period of 8/10ths of a year, or roughly 9.5 months. As we continue to observe it in coming months, we will be able to characterize its orbital path with more precision. With more precise data, we will be able to examine its potential for collision with Earth at some time in the future."

Along with the newest Aten, astronomers also discovered a new comet, still distant but moving toward the Earth and Sun, as it passed through the constellation of Leo. Designated Comet 1997 A1, the celestial snowball is expected to make its closest approach to Earth on Feb. 6, passing at a distance of about 230 million miles, but remaining visible in the night sky for several months thereafter.

"This comet has traveled a long distance, originating in the Oort Cloud, a region far beyond Pluto's orbit which is believed to house trillions of incipient comets," Helin said. "It has a parabolic orbit, which means it will travel through our Solar System once and probably never be seen again. Parabolic comets do not present their calling cards before arriving in the inner Solar System. They appear without warning."

At discovery, 1997 A1 was fairly dim at magnitude 19, and showed a weakly condensed nucleus with a diffuse halo and short tail, Helin said. The Minor Planet Center at the Smithsonian Astrophysical Observatory in Cambridge, MA, announced the discovery, reporting it as a parabolic comet, with an orbital inclination of 145 degrees from the ecliptic plane, and indicated that it would not pass any closer than 3.17 astronomical units (295 million miles) from the Sun.

JPL's NEAT team, in conjunction with another observing effort under way at the Laboratory's Table Mountain Observatory in San Bernardino, CA, will continue to track and characterize the comet over the next several months until it is no longer visible.

During its closest approach on Feb. 6, the newly discovered comet will be visible in the constellation of Cancer and brighten to a magnitude of about 18. Moderate-sized telescopes with CCD chips will be able to observe the comet, Helin said. Astronomers report that the comet is continuing to outgas, or warm up and boil off some of its ices, as it moves toward the Sun.

Discoveries of very faint or distant objects, and those surprisingly close by, are increasing due to the introduction of technologically advanced, fully autonomous CCD telescopes. The NEAT camera, for example, employs a very large, very sensitive 4,096-by-4,096-pixel CCD. The camera is installed on a 39-inch telescope operated at the summit of Mt. Haleakala by the U.S. Air Force.

Using this powerful, fully automated system, astronomers are discovering many more objects than was possible in the past. The January observing run, for instance, produced more than 700 asteroid sightings, including high-inclination inner-belt asteroids and a number of potential Mars-crossers, which will be confirmed after more observations become available. Total detections since NEAT began operations in late 1995 have climbed to more than 9,000 objects, of which more than 50 percent are new objects and more than 800 of those have received new designations.

NEAT was built and is being managed by the Jet Propulsion Laboratory for NASA's Office of Space Science, Washington, DC. ST

RADIO ASTRONOMY

Jeff Lichtman

Arecibo Upgrade (Part 2)

In 1974, the first upgrade of the Arecibo antenna was completed. The first part of this project involved a major improvement in the reflecting surface, achieved by replacing the wire mesh surface with aluminum panels. This permitted operation, in principle, to much higher frequencies, still limited by the loss and bandwidth restrictions of the line feeds discussed in Part 1. The first upgrade did allow the possibility of the very important 1420 MHz (21 cm wavelength) spectral line of atomic hydrogen in the Milky Way and other galaxies. Many projects using the unequaled sensitivity of Arecibo have been carried out with this important tracer of structure of matter in the Universe.

The second part of the upgrade was the addition of a powerful transmitter at the frequency of 2380 MHz, designed for radar studies of the solar system. This instrument has been used for the studies of Mercury and Venus mentioned earlier, as well as for a variety of other projects including a number of asteroids which approach relatively close to the earth.

After the first upgrade, the surface of the first spherical reflector at Arecibo had a surface roughness of approximately 2.5 mm r.m.s. This would allow operation to frequencies as high as 8 GHz with reasonable efficiency. The panels themselves have a surface error of approximately 1 mm. The remainder of the error is contributed by the inaccuracy with which the panel positions and final adjustments were determined.

It is thus evident that there exists an enormous untapped potential at the Arecibo observatory. The world's largest single antenna has, in fact, been used only over a fraction of the frequency range over which it could operate, and over only a handful of narrow frequency bands. The second upgrade project has been designed to rectify this situation and allow the full potential of the Arecibo telescope to be realized.

Other Aspects of the Upgrade

As part of the Second Arecibo Upgrade, a new solar system S-Band radar transmitter has been designed and constructed. It has one megawatt of continuous wave power output at a center frequency of 2380 MHz, with a bandwidth of approximately 25 MHz. The power is over twice that of the previous transmitter, which together with the improved sensitivity afforded by the Gregorian system, will improve the radar sensitivity by approximately a factor of 20. The increased bandwidth will allow for more precise and rapid modulation of the klystron transmitter, improving the ability to image solar system objects including planets, their satellites, and asteroids.

View of Arecibo

Another part of the Second Arecibo Upgrade is the ground screen, which is a 50-ft. high fence surrounding the periphery of the primary antenna.

The ground screen is about 1 km in length and has an area of about 16,000 M² This is equal to five football fields (the 305-m antenna's collecting area is equivalent to that of 26 football fields). The purpose of the ground screen is not to collect radiation from a source, but to prevent the receiver feed horns from picking up any of the radiation emitted by the ground outside the antenna. The flat metal panels of the ground screen reflect radiation from the cold sky into the feed horn, and reduce the total system noise by more than a factor of 2 when the feed is at its maximum 200 angle from zenith.

Current Upgrade Status

The ground screen, the first part of the upgrade to be completed—was finished during the summer of 1993, major decrease in system noise temperatures at large zenith angles. The contract for the structural upgrade was awarded to COMSAT/RSI, and construction started in the summer of 1993. Additional contracts were given to the same company for fabrication of the secondary and tertiary reflectors. The drive system is being fabricated by Vertex Communications Corp. and the S-band transmitter by Continental Electronics.

At the time this article is being written, the new anchors have been built and the new cables have been installed and adjusted to an intermediate tension. Most of the steel reinforcement and additions on the platform and the feed arm have been completed, and the enclosure itself is being assembled on a platform at the bottom of the antenna's spherical primary reflector.

The form of the enclosure is beginning to take shape, and the radial supports for the secondary reflector are also visible. After the construction itself is completed, there will be a period of equipment installation and preliminary tests, and a more extensive period during which all of the new systems are fully calibrated and are integrated into the NAIC-developed control system. They also readjusted the primary surface, and extended the upper frequency limit to 10 GHz and beyond.

The Promise of the Upgraded Instrument

The Second Arecibo Upgrade has posed major technical challenges but they will result in significant changes in the functioning of the telescope.

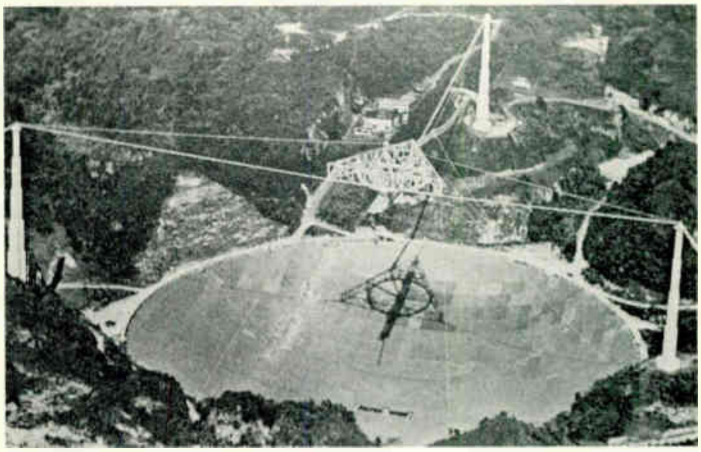
Broadly speaking, these can be grouped into three categories:

- Dramatic increase (by a factor - 4) in sensitivity due to higher antenna efficiency and reduced noise.
- Greatly expanded frequency coverage (to ≥ 10 GHz) and augmented bandwidth (1-2GHz compared to 10-40 MHz).
- Improved radar performance from doubled radar transmitter power combined with enhanced sensitivity.

This improved capability will be reflected in a wide range of new scientific projects that can be undertaken in almost every area in which Arecibo has previously been engaged, and will open up some entirely new areas of research. We give here just a few examples of the exciting science that will be enabled.

New stars form out of cold clouds of gas and dust in interstellar space. The very low temperature of interstellar clouds—only about 10 K—means that they emit essentially no visible or infrared radiation. However, the molecular material in these clouds does emit efficiently at radio wavelengths. A general characteristic of molecules is that the heavier they are—that is, the more atoms they include—the lower is the frequency at which they radiate. The high sensitivity and broad frequency coverage of the upgraded Arecibo telescope will allow detection and study of a range of very heavy molecules in these coldest regions of the galaxy. By studying these emissions, astronomers will gain an understanding of chemistry and physical conditions in the regions out of which new stars their planetary systems form.

Extragalactic astronomy will benefit from the Second Arecibo Upgrade as well. Astronomers studying the large-scale structure of the universe will gain a much-improved ability to measure the velocities and masses of galaxies in our "corner" of the universe. We can hope to learn about the distribution and quantity of "missing matter" that may be affecting the expansion of the universe, and thus get a better idea of both the past and future of the universe.



Aerial view of Arecibo

One of the many areas of study that will be dramatically enhanced by the increase in transmitter power as well as the improved sensitivity is the observation of asteroids. Objects in the main belt (between Mars and Jupiter) as well as near-Earth asteroids will be observed in much greater detail and many more objects will be available for study. Astronomers are particularly interested in learning more about the shapes of these asteroids, whether they are composed of single or multiple bodies, and what their surfaces are like. All of these questions will be pursued with the upgraded radar facility in the years ahead.

Acknowledgments

Many individuals have worked for up to a decade on the second Arecibo upgrade. Dr. Goldsmith at Arecibo recently acknowledged publicly the following individuals for their contributions during the upgrade project:

Don Campbell (Associate Director, NAIC), Mike Davis (Upgrade Project Scientist), Kurt Sarnuelson (Upgrading Project Manager), Lynn Baker (Gregorian Reflector Engineer), and Jose Maldonado (Assistant Director for Facilities, Arecibo Observatory).

Dr. Goldsmith said that many other NAIC staff have devoted enormous amounts of time to ensure a successful project, and their efforts were appreciated. As upgrading project manager, Ben Hooghoudt contributed many important ideas until his unfortunate death in 1994. A number of outside experts and consultants also made important contributions to the project.

The Arecibo Observatory is part of the National Astronomy and Ionosphere Center which is operated by Cornell University under a cooperative agreement with the National Science Foundation (NSF). Support for research efforts is provided by the NSF Division of Astronomical Sciences, the Division of Atmospheric Sciences, and the National Aeronautics and Space Administration (NASA).

I would like to thank Dr. Paul Goldsmith for the background material used to prepare this edition of the Radio Astronomy column in *Satellite Times*. Some of the material used in preparing this column came from Dr. Goldsmith's presentation at the Society of Amateur Radio Astronomers Conference at NRAO, Greenbank, WV in July 1996.

If you plan a trip to Puerto Rico, stop by and visit. It will be an experience you will remember.

Additional Reading

The Upgraded Arecibo Observatory, L.M. LaLonde, *Science*, 186, 213-218, 18 October 1994.

The Arecibo 5 GHz Mini-Gregorian Feed System, L. Magnani, *Pub. Asir. Soc. Pacific*, *105*, 894901, August 1993.

Development of a Dual-Reflector Feed for the Arecibo Radio Telescope: An Overview, P.-S. Kildal, L. Baker, and T. Hagfors, *IEEE Antennas and Propagation*, 33, 12-17, October 199 1. ST

World Radio Network Schedules

WRN 2- N. American Multi-lingual Service

Galaxy Five (125 deg West) transponder 6-3.820 GHz (TBS) vertical polarization, audio subcarrier 6.2 MHz. Please note that programs listed below with an asterisk (*) are subject to pre-emption without notice. All times Eastern (UTC +5 hours)

0030 - *WRN Announcements, until....
0255 - *YLE, Church Service (Sunday only)
0400 - *WRN Announcements, until....
0600 - [YLE Radio Finland], News in Finnish
0625 - YLE, News in Swedish
0630 - YLE, News in English
0700 - *WRN Announcements, until....
0800 - RTE News in Irish
0900 - Radio Prague in Czech
0927 - *WRN Announcements, until....
1000 - YLE, Radio Finland, News in Finnish
1005 - YLE, Regional News
1030 - YLE, News in Finnish
1100 - YLE, News in Swedish
1130 - YLE, Easy Listening Music and Chat in Finnish
1200 - *Vatican Radio, news in French, English, Albanian, Slovene, Croatian, Hungarian, Czech, and Slovak
1400 - *WRN Announcements, until....
1500 - *Radio Vlaanderen International in Dutch
1530 - *Radio Netherlands in Dutch
1625 - *WRN Announcements, until....
1645 - *YLE, News in French
1700 - *Polish Radio Warsaw in Polish
1800 - Radio Budapest in Hungarian
1830 - YLE Radio Finland, Devotional Music
1855 - YLE, News in Swedish
1900 - YLE, News in Finnish
1930 - YLE, Easy Listening Music and Chat in Finnish
2010 - YLE, Current Affairs in Finnish
2030 - YLE, Documentaries in Finnish
2030 - YLE, New Classical releases in Finnish (Sun)
2130 - YLE, Easy Listening Music in Finnish
2230 - YLE, News in Finnish
2300 - YLE, News in Finnish
2310 - YLE, Devotional Programming in Finnish
2320 - YLE, News in Swedish
2323 - YLE, Programme Information in Finnish
2330 - ORF Radio Austria International in German

WRN1- European English Service

Astra 1B (19 deg East) transponder 22-11.538 GHz (VH-1) vertical polarization, audio subcarrier 7.38 MHz. WRN is also available on cable and local radio stations. WRN program information can be heard daily at 0125 and 1025 BST. It is also available on VH-1 text pages 222, 223, 224. All times UTC (Central European Time +1 hour)

0000 - Radio Budapest
0030 - Radio Netherlands
0127 - *Earth and Sky* (Daily Science Series)
0130 - ORF Radio Austria International
0200 - NPR *All Things Considered* (repeat)
0300 - CBC *As It Happens* (Tue-Sat)
RCI News, and Features (Sun and Mon)
0400 - Polish Radio Warsaw
0430 - *BBC Europe Today* (Mon-Fri)
Glenn Hauser's *World of Radio* (Sat)
UN Radio From New York (Sun)
0500 - PRI *Market Place* (Tue-Sat)
Radio Romania International (Sun)
SABC Channel Africa-Johannesburg (Mon)
0530 - YLE Radio Finland
0600 - Voice of America World Wide (Mon-Fri)
VoA Saturday (Sat)
VoA Sunday (Sun)
0700 - NPR *All Things Considered* (repeat)
0800 - ABC Radio Australia
0900 - Polish Radio Warsaw (Mon-Sat)
C-Span Weekly Radio Journal (Sunday)
0930 - Radio Canada International (Mon-Fri)
UN Radio (Sat)
1000 - Radio Prague
1030 - Radio Netherlands
1127 - *Earth and Sky* (Daily Science Series)
1130 - SABC Channel Africa-Johannesburg (Mon-Sat)
Glenn Hauser's *World of Radio* (Sun)
1200 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekly Edition* (Sat)
NPR *Weekly Edition* (rpt) (Sun)
1300 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekend Edition* (Saturday and Sunday)
1400 - Radio France International
1500 - Voice of Russia (Mon-Fri)
Radio Romania International (Sat)
Voice of America-*Communications World* (Sun)
1530 - KBS Radio Korea International
1600 - ABC Radio Australia
1700 - ORF Blue Danube Radio (Monday-Friday)
Glenn Hauser's *World of Radio* (Sat)
SABC Network Africa (Sun)
1730 - Radio Austria International
1800 - RTE *News at Six*
1830 - Radio Netherlands
1925 - News in Esperanto from Polish Radio Warsaw
1930 - YLE Radio Finland
2000 - RTHK-News from Hong Kong (Mon-Fri)
UN Radio from New York or Radio Denmark (alternate Sat)
2015 - Health Watch (Sat)
Radio Romania International (Sun)
2030 - Radio Vlaanderen International
2100 - Radio Sweden
2130 - Polish Radio Warsaw
2200 - Voice of America *World Report* (Mon-Fri)
VoA *Today* (Sat and Sun)
2300 - PRI *The World* (Mon-Fri)
NPR *All Things Considered* (Sat and Sun)

WRN2- European Multi-lingual Service

Eutelsat II-F1 (13 deg East) transponder 25-10.987 GHz (NBC) vertical polarization, audio subcarrier 7.38 MHz. Please note that programs listed below with an asterisk (*) are subject to pre-emption without notice. All times UTC (Central European Time +1 hour)

0309 - Vatican Radio
0745 - *WRN1 (NPR and ABC Radio Australia)
0830 - Vatican Radio (Sun) until 1130
0930 - Vatican Radio (Mon-Sat) until 1130, except Wed to 1200
1130 - *WRN1 (SABC Channel Africa) except Wed
1200 - Radio Studio Delta (Mon-Fri) until 1300
1200 - *WRN1 (NPR Sat and Sun)
1300 - Vatican Radio
1530 - Radio Studio Delta (Mon-Fri)
1530 - *WRN1 (Sat and Sun Radio Vlaanderen-Brussels and ABC Radio Australia)
1630 - Vatican Radio
2230 - Radio Studio Delta (Mon-Fri)
2230 - *WRN1 (Sat and Sun)
2330 - *WRN1 (Mon-Fri)

WRN- Asia-Pacific English Service

AsiaSat-2 (100.5 deg East) 4.000 GHz, vertical polarization, MPEG2 DVB, Symbol Rate 28.125 Mbaud, FEC 3/4, Select WRN1 from audio menu. AET-Australian Eastern Time (UTC +11 hours and for Hong Kong +8 hours to UTC).

UTC... AET
0000...1100 - YLE Radio Finland (Mon-Fri)
UN Radio (Sat)
Radio Romania (Sun)
0030...1130 - ORF Radio Austria International (Mon-Fri)
Radio Sweden (Sat)
Polish Radio Warsaw (Sun)
0100...1200 - PRI *The World* (Tue-Sat)
NPR *Weekend All Things Considered* (Sun and Mon)
0200...1300 - RTE Dublin
0300...1400 - CBC *As It happens* (Tue-Sat)
0300...1400 - Radio Canada International (Sun and Mon)
0400...1500 - Polish Radio Warsaw
0430...1530 - Radio Budapest
0500...1600 - PRI *Market Place* (Tue-Sat)
UN Radio from New York (Sun)
UN Radio Romania (Mon)
0530...1630 - ORF Radio Austria International
0600...1700 - NPR *All Things Considered* (repeat)
0730...1830 - Radio Canda International
0800...1900 - RTE Dublin
1000...2100 - Radio Prague
1030...2130 - SABC Channel Africa (Mon-Fri)
SABC Network Africa (Sat)
Radio Romania International (Sun)
1100...2200 - RTHK Hong Kong
United Nations Radio (Sat)
Glenn Hauser's *World of Radio* (Sun)
1130...2230 - KBS Radio Korea International
1200...2300 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekly Edition* (Sat)
NPR *Weekly Edition* (repeat) (Sun)
1300...0000 - Radio Canada International
1400...0100 - RTE Dublin
1500...0200 - Voice of Russia
1530...0230 - ORF Radio Austria International
1600...0300 - Radio France International
1700...0400 - ORF Blue Danube Radio (Tue-Sat)
Glenn Hauser's *World of Radio* (Sun)
SABC Network Africa (Mon)
1730...0430 - KBS Radio Korea International
1800...0500 - RTE Dublin
1830...0530 - Radio Netherlands
1927...0627 - *Earth and Sky*
1930...0630 - YLE Radio Finland
2000...0700 - RTHK Hong Kong (Tue-Sat)
Radio Romania International (Sun)
UN Radio and *Health Watch* (Mon)
2030...0730 - Radio Vlaanderen International
2100...0800 - RTE Dublin
2230...0930 - ORF Radio Austria International
2300...1000 - Radio Netherlands
2357...1057 - *Earth and Sky* (Daily Science Series)

WRN- Middle East and Africa English Service

Intelsat 707 (1 deg West) 3.9115 GHz, right-hand circular-polarization, Symbol Rate 8.022 Mbaud, FEC 3/4, MPEG2 Audio Stream. CAT-Central African Time (UTC +2 hours).

UTC... CAT
Next four hours can be heard in South Africa on SAfm 104-107
2300...0100 - Radio Netherlands
2357...0157 - *Earth and Sky* (Daily Science Series)
0000...0200 - YLE Radio Finland (Mon-Fri)
UN Radio (Sat)
Radio Romania (Sun)
0030...0230 - ORF Radio Austria International (Mon-Fri)
Radio Sweden (Sat)
Polish Radio Warsaw (Sun)
0100...0300 - PRI The World (Tue-Sat)
NPR *Weekend All Things Considered* (Sun and Mon)
0200...0400 - RTE Dublin
0300...0500 - CBC *As It Happens* (Tue-Sat)
Radio Canada International (Sun and Mon)
0400...0600 - Polish Radio Warsaw
0430...0630 - Radio Budapest
0500...0700 - PRI *Market Place* (Tue-Sat)
UN Radio from New York (Sun)
UN Radio Romania (Mon)
0530...0730 - ORF Radio Austria International
0600...0800 - NPR *All Things Considered* (repeat)
0730...0930 - Radio Canada International
0800...1000 - RTE Dublin
1000...1200 - Radio Prague
1030...1230 - SABC Channel Africa (Mon-Fri)
SABC Network Africa (Sat)
Radio Romania International (Sun)
1100...1300 - RTHK Hong Kong (Mon-Fri)
United Nations Radio (Sat)
Glenn Hauser's *World of Radio* (Sun)
1130...1330 - KBS Radio Korea International
1200...1400 - NPR *Morning Edition* (Monday-Friday)
NPR *Weekly Edition* (Sat)
NPR *Weekly Edition* (repeat) (Sun)
1300...1500 - Radio Canada International
1400...1600 - RTE Dublin
1500...1700 - Voice of Russia
1530...1730 - ORF Radio Austria International
1600...1800 - Radio France International
1700...1900 - ORF Blue Danube Radio (Tue-Sat)
Glenn Hauser's *World of Radio* (Sun)
SABC Network Africa (Mon)
1730...1930 - KBS Radio Korea International
1800...2000 - RTE Dublin
1830...2030 - Radio Netherlands
1927...2127 - *Earth and Sky*
1930...2130 - YLE Radio Finland
2000...2200 - RTHK Hong Kong (Mon-Fri)
Radio Romania International (Sat)
UN Radio and *Health Watch* (Sun)
2030...2230 - Radio Vlaanderen International
2100...2300 - RTE Dublin
2230...0030 - ORF Radio Austria International

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Space Glossary

The following are some terms used in the satellite business and are described in layman's terms.

ALTITUOE (ALT): The distance between a satellite and the point on the earth directly below it, same as height.

AQUISITION DF 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 NDDE: 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.

CDORDINATED UNIVERSAL TIME (UTC): Also known as Greenwich Mean Time (GMT). Local time at zero degrees longitude at the Greenwich Observatory, England. Uses 24 hour clock, ie. 3:00 pm is 1500 hrs.

CULMINATION: The point at which a satellite reaches its highest position or elevation in the sky relative to an observer. (Known as the Closest Point of Approach)

DECAY RATE: This is the rate of decay of the orbital period (time it takes to complete one revolution) due to atmospheric friction and other factors. It is a real number measured in terms of Revolutions per Day (REV/DAY).

DECLINATION (DEC): The angular distance from the equator to the satellite measured positive north and negative south.

DIRECT BROADCAST SATELLITE (DBS): Commerical satellite designed to transmit TV programming directly to the home.

DOPPLER 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.

DDWNLINK: 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.

EURDPEAN SPACE AGENCY (ESA): A consortium of European governmental groups polling resources for space exploration and development.

FOOTPRINT: A set of signal-level contours, drawn on a map or globe, showing the performance of a high-gain satellite antenna. Usually applied to geostationary satellites.

GROUND STATION: A radio station, on or near the surface of the earth, designed to receive signals from, or transmit signals to, a spacecraft.

INCLINATION (INC): The angle between the orbit plane and the Earth's equatorial plane, measured counter-clockwise. 0 (zero) degrees inclination would describe a satellite orbiting in the same direction as the Earth's rotation directly above the equator (orbit plane = equatorial plane). 90 degrees inclination would have the satellite orbiting directly over both poles of the earth (orbit plane displaced 90 degrees from the equatorial plane). An inclination of 180 degrees would have the satellite orbiting again directly over the equator, but in the opposite direction of the Earth's rotation. Inclination is given as a real number of degrees between 0.0 and 180.0 degrees.

INTERNATIONAL DESIGNATOR: An internationally agreed upon naming convention for satellites. Contains the last two digits of the launch year, the launch number of the year and the piece of the launch, ie. A-indicates payload, B-the rocket booster, or second payload, etc.

LATITUDE (LAT): Also called the geodetic latitude. the angle between the perpendicular to the Earth's surface (plane of the horizon) at a location and the equatorial plane of the earth.

LONGITUDE (LONG): The angular distance from the Greenwich (zero degree) meridian, along the equator. This can is measured either east or west to the 180th meridian (180 degrees) or 0 to 360 degrees west. For example, Ohio includes 85 degrees west longitude, while India includes 85 degrees east longitude. But 85 degrees east longitude could also be measured as 275 degrees west longitude.

LOSS OF SIGNAL (LoS): The time at which a particular ground station loses radio signals from a satellite.

MEAN ANDMALY (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.

PERIOD DECAY RATE: Also known as Decay. This is the tendency of a satellite to lose orbital velocity due to the influence of atmospheric drag and gravitational forces. A decaying object eventually impacts with the surface of the Earth or burns up in the atmosphere. This parameter directly affects the satellite's MEAN MOTION. This is measured in various ways. The NASA Two Line Orbital Elements use revolutions per day.

PERIGEE: The point in the satellite's orbit where it is closest to the surface of the earth.

PDSIGRADE ORBIT: Satellite motion which is in the same direction as the rotation of the Earth.

RETRDGRADE ORBIT: Satellite motion which is opposite in direction to the rotation of the Earth.

REVDLUTIDN 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.

TELEVISIDN 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.

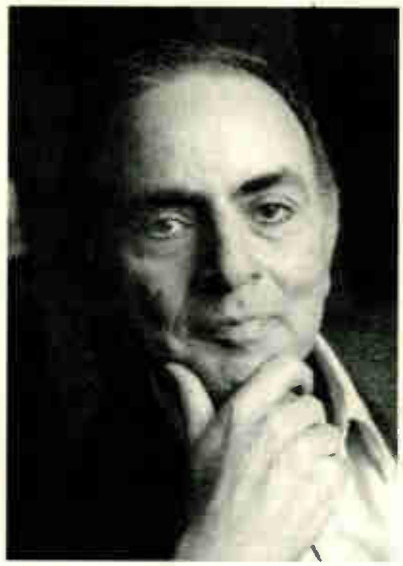
UPLINK: A radio link originating at a ground station and directed to a spacecraft.

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
E-mail address: st@grove.net

Homage to a Genius



All of us have our superheroes. As a child, I wondered at the rocket wizadry of Wehrner von Braun; the visionary penmanship of Arthur C. Clarke, Robert A. Heinlein, and Jules Verne; and the singular assault on traditional science by Albert Einstein.

But Carl Sagan transcended the boundary between theoretical science and the common man. His affability and admiration drew 22 honorary degrees from universities across the nation. He had a rare charisma that led people to *want* to understand, to *want* to feel closer to their universe. Nowhere did that become more evident than in his *Cosmos* television series.

Sagan was comfortable in many disciplines, but felt most at home doing research. He helped solve many of nature's puzzles—the high temperatures produced by Venus's greenhouse effect, seasonal changes on Mars resulting from windblown dust, Titan's characteristic red aura from complex organic molecules, and others as well.

But it was a special gift that enabled him to relate complex theories in simple terms to his students, readers, and viewers. For the past three decades he was a Professor of Astronomy and Space Sciences at Cornell University. He also had a leading role in preparing NASA astronauts for their Mercury, Gemini, and Apollo missions, just as he prepared scientists for Galileo, Voyager, Viking, and Mariner excursions into deep space.

Some scientists disapproved of Sagan's popularization of science, but this limited attitude on the part of his peers did not recognize the enormous benefits to the scientific establishment which their brilliant colleague brought. Sagan was an ambassador for science and, as such, was undoubtedly responsible for continued funding for important scientific research.

There was another reason Sagan was occasionally rebuffed by the scientific establishment: he rejected the concept of absolute authority, believing that science must be open to revision, a chilling concept to stuffy laboratory types who feel insecure under the scrutiny of review.

Even his own advocacy was renegade in some respects: his outspoken promotion of exobiology troubled some of his colleagues. But this openness to new ideas, new concepts, was what made Carl Sagan. He, too, was a visionary, unfettered by the shackles of classical reasoning and traditional science. His kind is rare, and his presence will be missed.

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