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Natural Radio

Monitoring the Music of Mother Earth

Satellite Times

Cover Story

Cover Photo: *The earth and its dynamic electromagnetic relationship with the Sun is suggested by this digital composite image. The original Sun photo is the work of the SOHO-EIT Consortium satellite. The Earth photo came from the Apollo missions to the moon. Composite is the work of the* ST *art department. (Photos courtesy of NASA)*

Natural Radio—Monitoring the Music of Mother Earth

By Stephen P. McGreevy

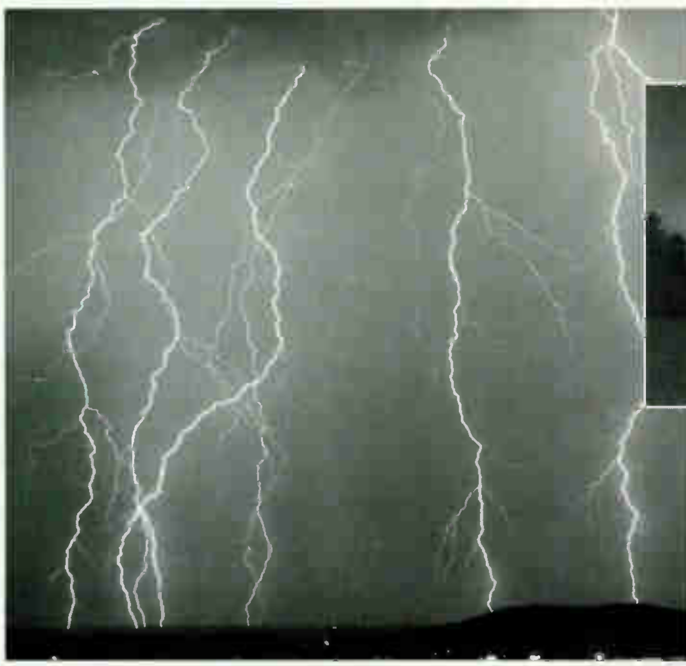
Few people know of (and even fewer have been fortunate enough to tune in) to the beautiful radio "music" produced by nature in the radio spectrum's basement. Lightning and aurora, aided by events on the Sun, can be heard on inexpensive VLF/ELF receivers. Read, beginning on page 10, one man's story of how he got started in natural radio monitoring.

Vol. 4, No. 2 CONTENTS November/December 1997

DXing Planet Earth

By Larry Van Horn

Have you ever heard a tweek? Curious what Dawn's Chorus sounds like? *ST's* managing editor has prepared a program guide to Mother Nature's radio show. Learn the basic principles and what equipment you need to get started listening to natural radio in the story starting on page 20.



Lightning and the "northern lights" are both manifestations of the earth's electromagnetic activity. This month, in two exclusive feature stories, **ST** *shows you how to monitor the background music.*

Radio hobbyists with special receivers here on Earth aren't the only set of ears listening to radio's basement. A whole army of satellites and a wide variety of orbits are also listening to Mother Nature. *ST* staffer Philip Chien gives us a tour of these satellites plus locations on the worldwide web where you can monitor their science in his *ST Special Report* starting on page 63.

DEPARTMENTS

ST

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DOWNLINK

By Larry Van Horn
Managing Editor
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HR 2369: Another Specter Looms for Radio Hobbyists

Congress is up to their old tricks again. They are trying to legislate what you will and won't be able to monitor with your radio equipment. In its present form this bill would affect the monitoring of both terrestrial and spaceborne communications.

Below is a letter we recently received from Robert Felton of Wake Forest, North Carolina, on the usage of the public airwaves as it applies to the current legislation being considered in the House.

"It hasn't been discussed much in newspapers, but access to America's largest National Park, one visited daily by tens of millions of Americans, may soon be sharply curtailed. It's the radio spectrum; and if a bill now before Congress becomes law you will soon be able to listen to only a very small part of what is broadcast.

"When Congress asserted control over the airwaves in the early 30s and created the forerunner of the modern Federal Communications Commission (FCC), 'just like a national park' was the phrase used to explain the new legislation. Basically, the law said that the radio spectrum belongs to everyone and is to be held in trust by the federal government for the use and benefit of all the American people.

"The provisions of the Communications Act of 1934 reflect this point of view. The government was given the authority to assign radio frequencies for broadcast and communications use, but no user could 'own' a frequency in the sense that one owns, say, an automobile. The assignment and usage of radio frequencies was, and was intended to be, precisely analogous to the assignment of a camping site; you had use of the site, but not ownership or exclusive control of the land underneath. You occupied it at the sufference of the owners—the American people.

"But a radio frequency isn't exactly the same as a national park campsite, is it? No, and the act recognized this as well. To enable visits to the park, while protecting the interests of those who use radio for business and public safety purposes, the act provided that no private transmission overheard by a radio monitor could be divulged to others or exploited for profit. Just as a camper owns his gear and is entitled to exercise exclusive control of it, but not the land underneath, a radio user owns the content of his transmission but not the frequency on which it is carried. It was a simple, easily understood formulation that worked well, and as intended, for more than 50 years. The law, no less than the frequency spectrum whose use is regulated, was a logical continuum.

"Then the cellular communications industry met the best Congress that money could buy, and this one-of-a-kind park has been hurting ever since. In 1986 Congress passed the Electronic Communications Privacy Act, legislation that makes it illegal to listen to cellular telephone communications. In 1994, the act was enlarged to make it illegal to manufacture receivers capable of receiving, or even being modified to receive, cellular communications. These laws, at a stroke, undermine the philosophical foundation that had supported radio communications in America for more than a half-century.

"Are cellular telephone users entitled to privacy? Sure ... but they should get their privacy the same way any other park user does—by pitching a tent. (By encrypting their transmissions, that is.) What could be more fair and reasonable than that? They *shouldn't* stroll around the park buck-naked while demanding that any passerby who sees them be slapped silly with criminal sanctions.

"Now, another huge chunk of park land is about to be placed off-limits. In fact, America is on the verge of adopting the most restrictive radio listening laws in the world. H.R. 2369, introduced by Rep. Billy Tauzin (R-LA) makes it illegal to listen to any broadcasts in the Commercial Mobile Radio Service. This doesn't mean only that you won't be able to listen to tow-trucks, it also means that you won't be able to take your scanner to the racetrack, that you won't be able to listen to some aeronautical transmissions, that actual police and fire communications will be illegal in some communities, that you may not be able to learn what those flashing lights under your bedroom at 2:00 a.m. are all about, that you won't be able to listen-in on space shuttle activities, or download a NOAA weather satellite image. As in the case of cellular reception, the manufacture of equipment capable of receiving the proscribed frequencies would be illegal.

"The law will operate with its majestic impartiality upon the news media, too. That 'film at 11:00' will probably be pretty bland stuff, because it will be unlawful for reporters to eavesdrop on the hometown goings-on.

"The language of the bill seems to indicate, further, that monitoring of the shortwave bands will be similiarly affected. As presently written, in fact, because the service sometimes transmits outside the frequencies set aside for international broadcasters, the law will make it illegal for Americans to own radios capable of receiving some U.S. Information Agency Voice of America broadcasts.

"Just like cold war-era Eastern Europe."

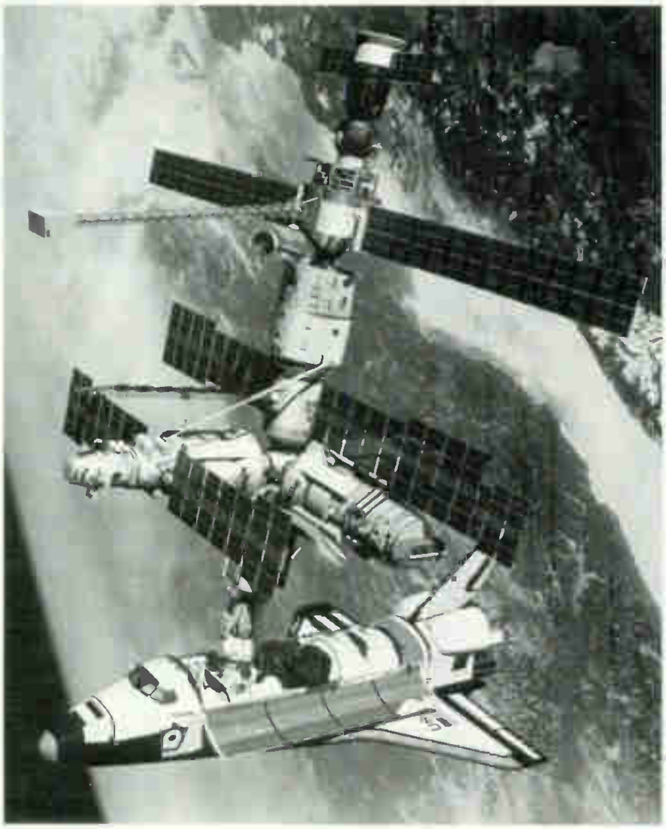
Bottom line has and continues to be the fact that the cellular telephone industry (the main supporters of H.R. 2369) have neglected to provide realistic privacy protections or information for its customers. Instead, the industry seeks to use legislation as a substititute for real privacy protection (encryption), because such protections cost money. In the face of widespread recognition that the only measure truly effective against the interception of radio communications is scrambling, reliance upon legislation to protect radio privacy is tantamount to hiding one's head in the sand.

ST

Satellite Monitor

By Wayne Mishler, KG5BI

Mir *is stepping stone to International Space Station*



Dismissing life-threatening breakdowns as "worth the risk," astronauts have consistently urged America to continue its space program aboard the aging Russian Space Station *Mir* even though construction of the new International Space Station (ISS) begins next year.

Senior lawmakers in September were recommending that NASA cancel its plans to send astronaut David Wolf to replace Michael Foale. Congress warned that "if an astronaut gets killed up there on *Mir*, that's going to set back the space program almost as badly as the *Challenger* disaster."

At about that same time an orbiting U. S. satellite zoomed to within 500 yards of *Mir* and sent its three occupants scrambling into an escape capsule to avoid a possible collision.

"This happens every month," the Associated Press quoted U. S. Space Agency spokesman John Lawrence, suggesting the incident was routine and nothing to be concerned about. But a spokesperson from Russia's Mission Control headquarters said the near miss was the closest in *Mir*'s 11 years in orbit.

With Foale on board, *Mir* previously experienced a serious fire, an orbital collision, life support breakdowns, and computer failures.

Tensions seemed to ease after the U.S. space shuttle *Atlantis* docked successfully with *Mir* September 27 delivering David Wolfe and a new computer to turn the station's solar panels toward the sun.

The shuttle's record-breaking cargo also included repair gear, scientific experiments, fresh drinking water, electrical batteries, tanks of air, and a special plug for a leak in *Mir*'s science module caused by the collision with a cargo ship in June.

It doesn't take a rocket scientist (although NASA has its share) to see that NASA is serious about supporting *Mir*. Their reasoning is not without reason.

"There was a lot of discussion about the risk (of this mission)," shuttle commander Jim Wetherbee radioed after a recent docking. "We are here to tell you, all 10 of us, the benefits far outweigh the risks."

The decision to proceed has far-reaching implications for both international diplomacy and space exploration. *Mir* is the world's only orbiting space station and the only operating laboratory providing NASA with information on human and plant life in space. Russia needs U. S. dollars to fund its space program. And continuation of *Mir* is important to both sides for assembly of the International Space Station beginning next year.

America's space program aboard the *Mir* is a prerequisite to more ambitious experiments planned for the Space Station.

One of the most important commodities of space flight is time in orbit. The total U.S. astronaut time aboard *Mir* at this writing is 22 months—with 18 months of continuous occupancy since March 1996. By contrast, it took the U.S. space shuttle fleet more than a dozen years and 60 flights to achieve an accumulated year in orbit. Many of the research programs planned for the ISS benefit from longer and longer stay times in space.

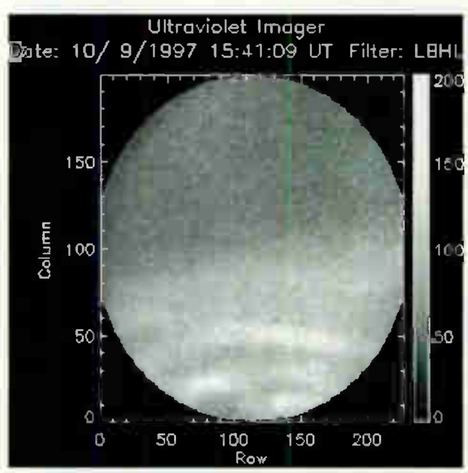
Astronauts argue that for less than two percent of the total cost of the ISS program, NASA is gaining knowledge and experience through Shuttle-*Mir* missions that could not be achieved in any other way.

When construction of the International Space Station begins next summer, it will be history's largest peacetime scientific and engineering project, with 14 international partners working together to prepare for a new era in space exploration.

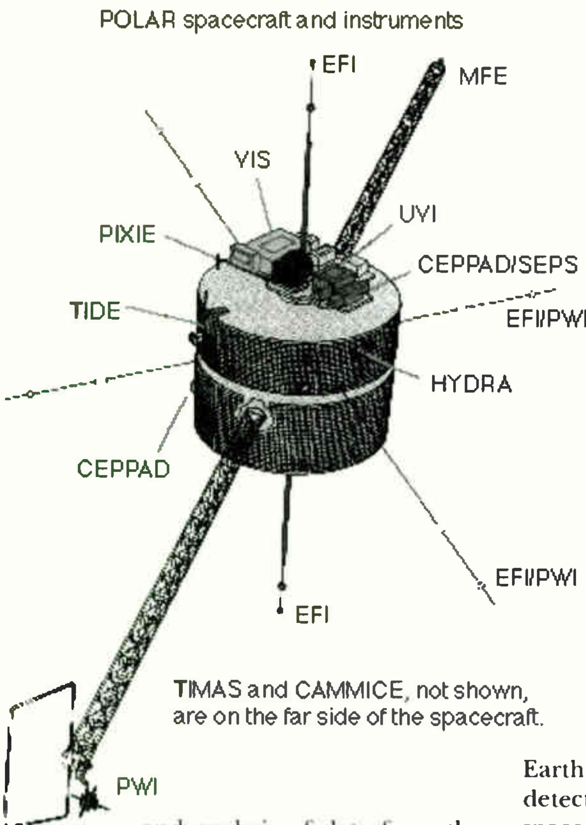
Earth's water steadily leaking into space

Now scientists warn that the Earth's water supply is slowly leaking into space.

Researchers from Los Alamos National Laboratory and other institutions explain in *Science* magazine how they discovered this phenomenon. Their measurements



SATELLITE MONITOR



and analysis of data from the POLAR satellite provide insight into one of the many byways through which water and other materials leave and enter Earth's atmosphere.

Of course they extrapolate this into models of how the atmospheres of planets evolve.

Using an instrument to reduce electrical interference from the satellite, the team took the first accurate high-altitude measurements of the so-called polar wind. This is the charged gas or plasma escaping from Earth and exiting the ionosphere through the poles. It is similar to the charged gases from the Sun's corona that make up the solar wind. Plasmas from Earth and the sun flow along Earth's magnetic field lines, or magnetosphere, and make up such spectacular electrical phenomena as auroras.

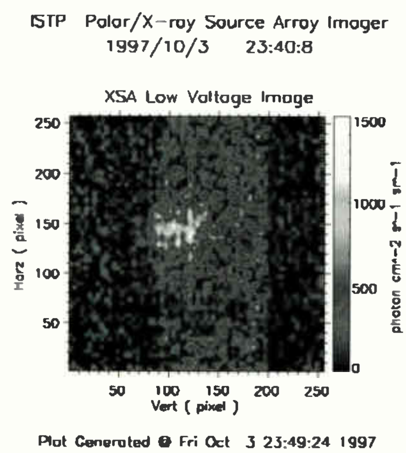
The team proved that the polar wind is one mechanism by which the atomic constituents of water vapor and other atmospheric gases are dragged outward from the ionosphere and spiral along the planet's magnetic field lines. Sunlight breaks the water into ionized hydrogen and oxygen gases in the upper atmosphere.

"We know that planetary atmospheres evolve, and we have models of that evolution, but this is the first time we've observed this particular evolutionary mechanism at high altitudes," says Los Alamos physicist Beth Nordholt. "This gives us a look at the cutting edge of atmospheric evolution and the dynamic way material flows from Earth into space, contributing significantly to Earth's space weather."

Their measurements of the hydrogen and oxygen plasmas along the POLAR satellite's orbit, ranging from 7,000 to 35,000 miles above the poles, imply that roughly 1,000 gallons of water leave Earth's atmosphere every day.

The flow of charged gases from Earth is extremely diffuse and hard to detect. To complicate matters, previous space instruments couldn't get accurate readings due to electrical interference from the spacecraft that carried them. That's why the team designed two instruments for the POLAR satellite: the Plasma Source Instrument and the Thermal Ion Dynamics experiment.

When photons from the sun strike spacecraft, they drive off electrons and give the entire craft a slight positive charge. This keeps positively charged gases from reaching the craft and its measuring instruments. The Plasma Source Instrument spews out low-energy ions of xenon gas that flood the outside of the POLAR spacecraft, effectively neutralizing it and allowing the TIDE instrument to detect the energies and masses of ions flowing into it.



The TIDE instrument has seven large apertures that give it high sensitivity in identifying and measuring charged hydrogen, helium, oxygen and other heavier ions from the ionosphere, along with helium from the solar wind.

"The contribution of ionospheric gases to the polar wind has been predicted for a long time, but since they hadn't been measured before, there was no way to incorporate them accurately into atmospheric evolution models," Nordholt explained.

Data collected by the team indicate that hydrogen plasmas are flowing faster than predicted by theory, and that oxygen plasmas are hotter and more plentiful than predicted. Additional research will be needed in order to understand why, but Nordholt said the success of the two instruments will help greatly in the design of future research missions.

Scientists find massive jet streams flowing inside the sun

Scientists have discovered "jet streams" or "rivers" of hot, electrically charged gas called plasma flowing beneath the surface of the Sun. They also found features similar to trade winds that transport gas beneath the Sun's fiery surface.

They say these new findings will help them understand the famous sunspot cycle and associated increases in solar activity that can affect the Earth with power and communications disruptions.

The observations are the latest made by the Solar Oscillations Investigation (SOI) group at Stanford University, California, and they build on discoveries by the SOHO science team over the past year.

"We have detected motion similar to the weather patterns in the Earth's atmosphere", says Dr. Jesper Schou of Stanford. "Moreover, in what is a completely new discovery, we have found a jet-like flow near the poles. This flow is totally inside the Sun. It is completely unexpected, and cannot be seen at the surface."

"These polar streams are on a small scale, compared to the whole Sun, but they are still immense compared to atmospheric jet streams on the Earth," adds Dr. Philip Scherrer, the SOI principal investigator at Stanford.

"Ringing the Sun at about 75 degrees latitude, they consist of flattened oval regions about 30,000 kilometres across where material moves about ten percent (about 130 km/h) faster than its surroundings. Although these are the smallest structures yet observed inside the Sun, each is still large enough to engulf two Earths."

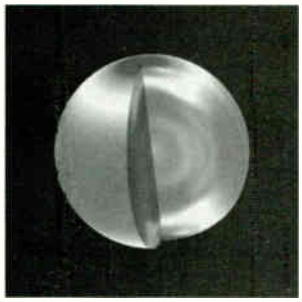
Additionally, there are features similar to the Earth's trade winds on the surface of the Sun. The Sun rotates much faster at the equator than at the poles.

However, Stanford researchers Schou and Dr. Alexander G. Kosovichev have found that there are belts in the northern and southern hemispheres where currents flow at different speeds relative to each other. Six of these gaseous bands move slightly faster than the material surrounding them. The solar belts are more than 65 thousand km across and they contain "winds" that move about 15 kilometres per hour relative to their surroundings.

The first evidence of these belts was found more than a decade ago by Dr. Robert Howard of the Mount Wilson Observatory. The Stanford researchers

"Jet streams" and rivers of plasma flow beneath the surface of the Sun, and their patterns are similar to weather patterns on Earth, scientists have learned.

have now shown that, rather than being superficial surface motion, the belts extend down to a depth of at least 20 thousand kilometres below the Sun's surface.



"In one way, the Sun's zonal belts behave more like the colorful banding found on Jupiter than the region of tradewinds on the Earth," says Stanford's Dr. Craig DeForest. "Somewhat like stripes on a barber pole, they start in the mid-latitudes and gradually move toward the equator during the eleven year solar cycle. They also appear to have a relationship to sunspot formation as sunspots tend to form at the edges of these zones."

"We speculate that the differences in speed of the plasma at the edge of these bands may be connected with the generation of the solar magnetic cycle, which generates periodic increases in solar activity, but we'll need more observations to see if this is correct," says DeForest.

Finally, the solar physicists have determined that the entire outer layer of the Sun, to a depth of at least 25 thousand kilometers, is slowly but steadily flowing from the equator to the poles. The polar flow rate is relatively slow, about 80 km per hour, compared to its rotation speed, about 6.000 km/h; however, this is fast enough to transport an object from the equator to the pole in a bit more than a year.

"Oddly enough, the polar flow moves in the opposite direction from that of the sunspots and the zonal belts, which are moving from higher to lower latitudes," says DeForest.

Evidence for polar flow had previously been observed at the Sun's surface, but scientists did not know how deep the motion extended. With a volume equal to about four percent of the total Sun, this feature probably has an important impact on the Sun's activity, argue Stanford researchers Scherrer, with Dr. Thomas L. Duvall Jr., Dr. Richard S. Bogart, and graduate student Peter M. Giles.

For the last year, the SOHO spacecraft has been aiming its battery of 12 scientific instruments at the Sun from a position 1.5 million kilometers sunward from the Earth. The Stanford research team has been viewing the Sun's surface with one of these instruments called a Michelson Doppler Imager that can measure the vertical motion of the Sun's surface at one million different points once per minute. The measurements show the effects of sound waves that permeate the interior. The researchers then apply techniques similar to Earth based seismology and computer aided tomography to infer and map the flow patterns and temperature beneath the Sun's roiling surface.

"These techniques allow us to peer inside the Sun using sound waves, much like a doctor can look inside a pregnant woman with a sonogram," says Dr. Schou.

Currently, the Stanford scientists have both identified new structures in the interior of the Sun and clarified the form of previously discovered ones. Understanding their relationship to solar activity will require more observations and time for analysis.

"At this point, we do not know whether the plasma streams snake around like the jet stream on Earth, or whether it is a less dynamic feature," says Dr. Douglas Gough, of Cambridge University, UK.

"It is intriguing to speculate that these streams may affect solar weather like the terrestrial jetstream impacts weather patterns on Earth, but this is completely unclear right now. The same speculation may apply to the other flows we've observed, or they may act in concert. It will be especially helpful to make observations as the Sun enters its next active cycle, expected to peak around the year 2001."

Digital camera to be used for space imaging

A satellite-borne digital camera will soon be photographing the Earth with one-meter resolution.

Space Imaging Eosat, working jointly with Eastman Kodak, has delivered key components of the system to be integrated into an imaging satellite payload.

According to Eosat, the satellite, Ikonos 1, will be the world's first commercial satellite to collect images of the Earth's surface with such high resolution.

"All of the components of Ikonos 1, including the imaging payload, spacecraft and ground operations centers, are coming together for a launch at the end of the year," says Robert Iwai, an Eosat vice president.

And finally . . .

Saddle your space burros, podnas. Get ready for the rush of 98. Gold rush, that is. There's gold in them asteroids. And other precious medals, too.

How precious?

Maybe $4 trillion just waiting to be picked up on your average, everyday asteroid, says John Lewis of the University of Arizona.

Of course you can't zoom around the asteroids on an empty gas tank. So entrepreneur James Benson has formed a new company, SpacDev, which, among other things, plans to put in rocket fuel stations for ships rushing to the asteroid gold, according to the *Miami Herald.*

Lewis, a SpaceDev consultant, says there are thousands of asteroids and comets within easy rocketing distance of Earth. And comets, he points out, are sources of rocket fuel.

Really. Comets are balls of dusty ice. Break the ice down into hydrogen and oxygen, and presto—rocket fuel. The cost: about $6,000 a pint if made on Earth and transported into space. Much less if made and sold in space.

So, prospectors, rest easy. When low on fuel, you just zoom into your local SpaceDev station on a nearby asteroid and say "fill 'er up." ST

Sources: European Space Agency, Los Alamos National Laboratory, *Miami Herald*, NASA, Space Imaging Eosat

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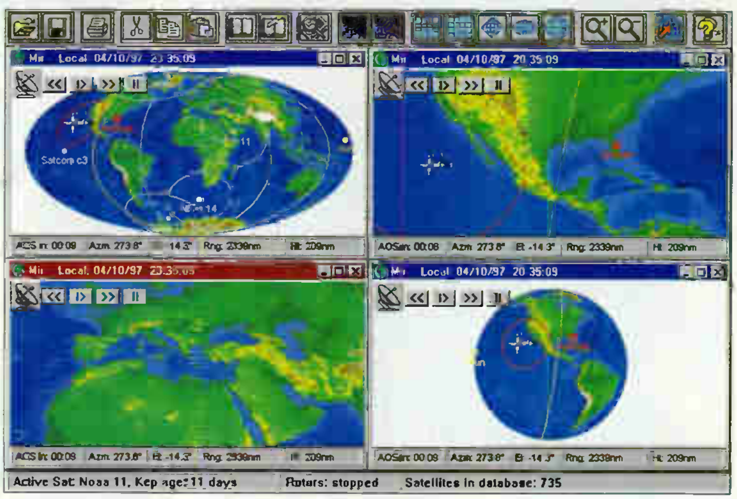

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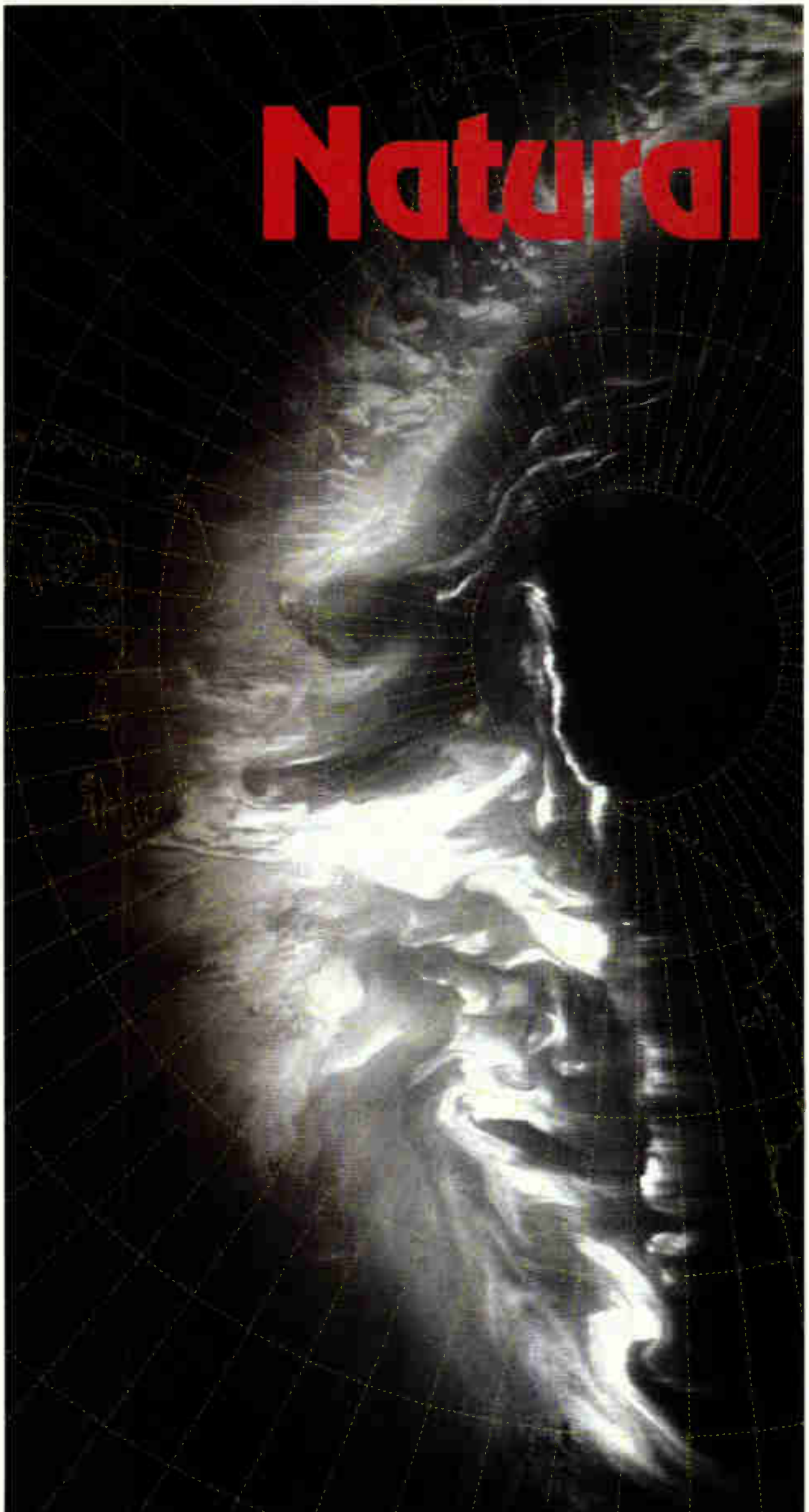
Natural Radio

Monitoring the Music of Mother Earth



The earth is an electromagnetic (and radio frequency) hot spot, as evidenced by DMSP satellite image of the Aurora Austrealis taken on 21 July 1993 over the South Pole. The yellow lines denote the latitude/longitude grid and land masses.

By Stephen P. McGreevy
spmcgrvy@ix.netcom.com

ew people know of (and even fewer have been fortunate enough to tune in) to the beautiful radio "music" produced naturally by several processes of nature including lightning storms and aurora, aided by events occurring on the Sun. I have been fascinated with listening to naturally-occurring radio signals since about the middle of 1989, when I heard my first whistlers almost immediately after first trying out a rudimentary receiving apparatus I had put together for the occasion.

Whistlers, one of the more frequent types of natural radio emissions to be heard, are just one example of many natural radio sounds the Earth constantly produces. These signals have caught the interest and fascination of a small, but growing number of hobby listeners and professional researchers for the past four decades.

What is Natural Radio?

Natural Radio, a term coined in the late 1980's by California amateur listener and researcher Michael Mideke, describes naturally-occurring electromagnetic (radio) signals emanating from lightning storms, aurora (the Northern and Southern lights), and Earth's magnetic-field (the magnetosphere). The majority of Earth's natural radio emissions occur in the extremely-low-frequency and very-low-frequency (ELF/VLF) radio spectrum—specifically, at audio frequencies between approximately 100 to 10,000 hertz-per second (0.1-10 kHz).

Unlike sound waves which are vibrations of air molecules to which our ears are sensitive, natural radio waves are vibrations of electric and magnetic energy (radio waves) which—though occurring at the same frequencies as sound—cannot be listened to without a fairly simple radio receiver to convert the natural radio signals directly into audio.

Whistlers are magnificent bursts of ELF/VLF radio energy initiated by lightning strikes. A whistler, as heard in the audio output from a VLF "whistler receiver," generally falls lower in pitch, from as high as the middle-to-upper frequency range of our hearing, downward to a low pitch of a couple hundred Hertz-per-second (Hz). Measured in frequency terms, a whistler can begin at over 10,000 Hz and fall to less than 200 Hz, though the majority are heard from 6,000 Hz down to 500 Hz. Whistlers can tell scientists a great deal of the space environment between the Sun and the Earth and also about Earth's magnetosphere.

The causes of whistlers are generally well known today, though not yet completely understood. What is clear is that whistlers owe their existence to lightning storms.

Lightning stroke energy happens at all electromagnetic frequencies simultaneously, that is, from "DC to light." Indeed, the Earth is literally bathed in lightning-stroke radio energy from an estimated 1,500 to 2,000 lightning storms in progress at any given time, triggering over a million lightning strikes daily. The total energy output of lightning storms far exceeds the combined power output of all man-made radio signals and electric power generated from power plants. Whistlers also owe their existence to Earth's magnetic field (magnetosphere), which surrounds the planet like an enormous glove, and also to the Sun.

Streaming from the Sun is the solar wind, which consists of energy and charged particles called ions. And so, the combination of the Sun's solar wind, the Earth's magnetic field surrounding the entire planet (magnetosphere), and lightning storms all interact to create the intriguing sounds of whistlers.

The Mechanics of What Causes Whistlers

How whistlers happen from this combination of natural solar-terrestrial forces is (briefly) as follows: Some of the radio energy bursts from lightning strokes travel into space beyond Earth's ionosphere layers and into the magnetosphere, where they follow approximately the lines-of-force of the Earth's magnetic field to the opposite polar hemisphere along "ducts" formed by ions streaming toward Earth from the Sun's solar wind. Solar wind ions get trapped in and aligned with Earth's magnetic field. As the lightning energy travels along a field-aligned duct, its radio frequencies become spread out (dispersed) in a similar fashion to light shining into a glass prism. The higher radio frequencies arrive before the lower frequencies, resulting in a downward falling tone of varying purity.

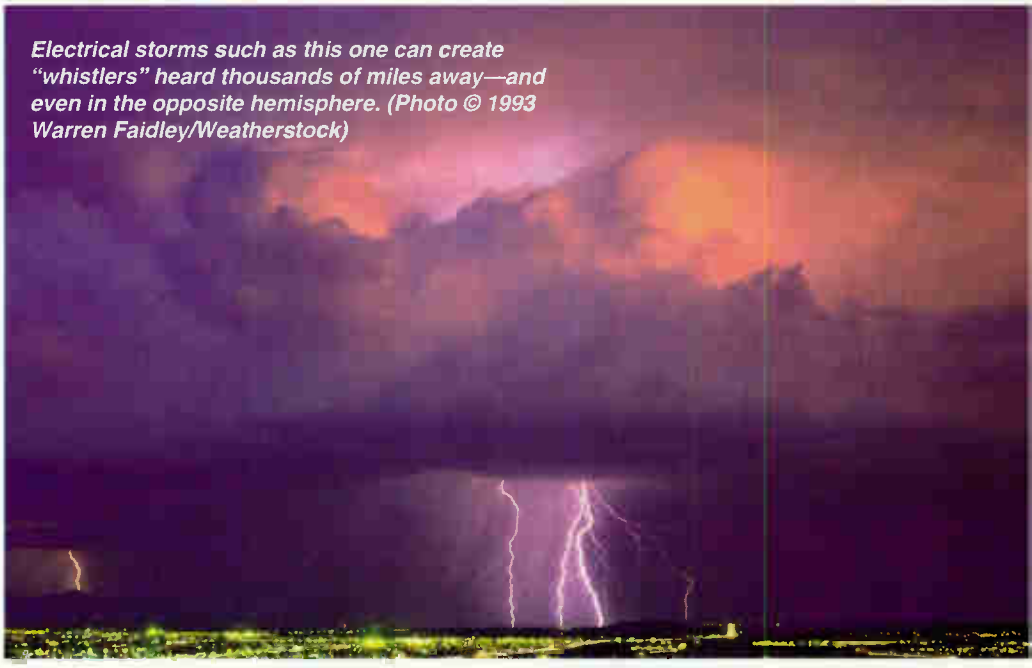
In this manner, a whistler will be heard many thousands of miles from its initiating lightning stroke—and in the opposite polar hemisphere! Lightning storms in British Columbia and Alaska may produce whistlers that are heard in New Zealand. Likewise, lightning storms in eastern North America may produce whistlers that are heard in southern Argentina or even Antarctica. Even more remarkably, whistler energy can also be bounced back through the magnetosphere near—or not-so-near—the lightning storm from which it was born!

Whistler History

Considered by many listeners to be the "Music of Earth," whistlers are amongst the accidental discoveries of science. In the late 19th century, European long-distance telegraph and telephone operators were the first people to hear whistlers. The long telegraph wires often picked up the snapping and crackling of lightning storms, which was mixed with the Morse code or voice audio from the sending station. Sometimes, the telephone operators also heard strange whistling tones in the background. They were attributed to problems in the wires and connections of the telegraph system and disregarded.

The first written report of this phenomenon dates back to 1886 in Austria, when whistlers were heard on a 22-km (14 mile) telephone wire without amplification. A paper by W.H. Preece (1894) appearing in *Nature Magazine* describes operators at the British Government Post Office who listened to telephone receivers connected to telegraph wires during a display of aurora borealis on March 30 and 31, 1894. Their descriptions suggest they heard whistlers and the "bubbling/murmuring" sounds of the "chorus" from aurora.

During World War I, the Germans and Allied forces both employed sensitive audio-amplifiers to eavesdrop on the enemy's telephone communications. Metal stakes were driven into the ground next to enemy telephone wires and were connected to tube-type high-gain amplifiers, whereby



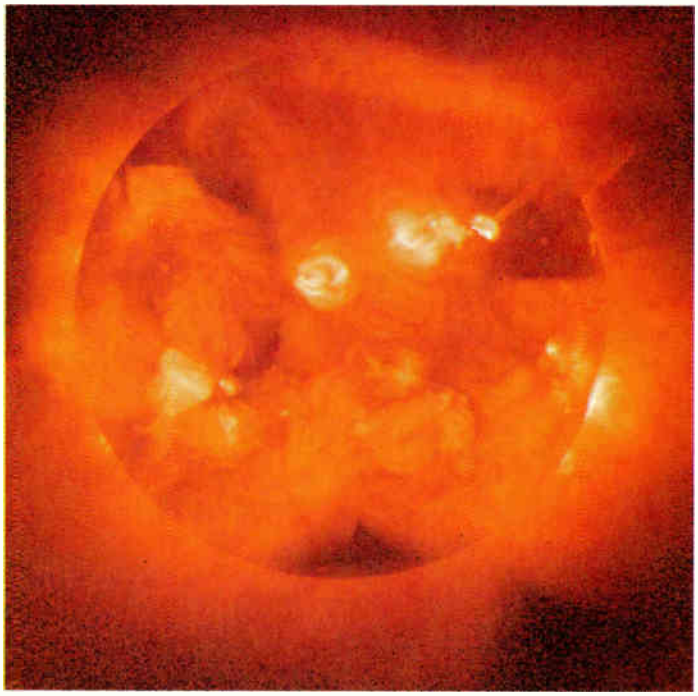
Electrical storms such as this one can create "whistlers" heard thousands of miles away—and even in the opposite hemisphere. (Photo © 1993 Warren Faidley/Weatherstock) the audio signal in the telephone wires could be eavesdropped. This early form of electronic espionage worked fairly well most of the time, despite the bubbling and crackling background noise made by lightning—but not always. On some days, the telephone conversations they were eavesdropping on were partially or wholly drowned out by strange whistling sounds. Soldiers at the front would say, "you can hear the grenades fly."

These whistling sounds were at first attributed to the audio amplifiers' circuitry reacting adversely to strong lightning discharge noises. When laboratory tests on the high-gain audio amplifiers failed to recreate the whistling sounds, the phenomena was then considered "unexplainable" at that time. (H. Barkhausen, 1919).

In 1925, T. S. Eckersly of the Marconi Wireless Telegraph Company in England, described disturbances of a musical nature that had been known to radio engineers for many years. They were heard when a telephone or any other audio-recorder system was connected to a large aerial. What they were hearing are now known as "tweeks," the common ringing and pinging sound that lightning discharge radio energy (sferics) atmospherics sound like at night over a VLF receiver or audio amplifier. Several people began to observe how lightning and auroral displays coincided with many of the strange sounds they were hearing with their audio apparatus (Barkhausen, Burton, Boardman, Eckersly, et al.).

In the 1930s, the relationship of whistlers and lightning discharges was hypothesized, and in 1935, Eckersly arrived at the commonly accepted explanation that lightning initiated radio waves traveling into Earth's ionosphere caused these tweek sounds. They were getting close.

Interest in whistlers waned during World War II, but was renewed with the development of sound spectrographs and spectrum analyzers, which could trace the time-versus-frequency component of audio sounds. This technology was developed mainly for the study of the sound characteristics of speech and other sounds, but these also were fine tools for the exploration of whistlers, as well (R. K. Potter, 1951).



It all begins here, in disturbances on the Sun and the resulting disruptions in the solar wind. This is an X-ray image of the sun taken at 07:33 UT on 12 November 1991. Variation in brightness reflect variations in plasma temperature and density. (Yohkoh Mission for High-Energy Solar Physics, SOHO-EIT Consortium, an ESA-NASA program of international cooperation).

It was during this time that L.R.O. Story in Cambridge, England, had begun an in-depth investigation into the nature and origin of whistlers. Armed with information presented by Barkhausen, Boardman, et al., a homemade spectrum analyzer, and other audio frequency radio equipment, Storey studied whistlers in earnest, discovering several types of whistlers that were or were not audibly associated with lightning discharge clicks in the receiver. He was able to make graphs of many kinds of whistlers, forming the basis of the modern magneto-ionic theory of their origin, and also the effects of Earth's magnetic storms on whistlers.

Storey's conclusion that whistlers were formed by lightning discharge energy echoing back and forth along the lines-of-force of earth's magnetic field suggested that there was a much higher than expected ion density in the outer ionosphere and beyond, and that the source of this extra ionization was linked to the sun. He also (correctly) presumed these ions from the sun also were responsible for magnetic storms and auroral displays.

Storey, while mainly concentrating on whistlers, was able to hear and categorize a number of other audio-frequency emissions that he heard, including the Dawn Chorus, steady hiss, and certain "rising whistlers," also known as "risers."

Story's studies throughout the early-to-mid 1950s made an important contribution to whistler theory by showing that whistlers travel very nearly in the direction of Earth's magnetic field. In 1952, the results of Storey's work were presented by J. A. Radcliffe to the Tenth General Assembly of the URSI held in Sydney, Australia, exciting considerable interest among the delegates in attendance. Radcliffe's report greatly stimulated whistler research at Stanford University, headed by the "Father of Whistler Research," R. A. Helliwell.

In 1954 at the next URSI General Assembly held in the Hague (Netherlands), whistler theory was discussed in depth, and plans were devised to study whistlers at opposite conjugate points of Earth's magnetic field. Lightning storm atmospherics observed in one hemisphere were heard as "short whistlers" (one hop whistlers) in the opposite hemisphere.

This notable observation was conducted by Helliwell at Stanford in California and aboard the *U.S.S. Atka* located in the South Pacific near the opposite magnetic conjugate point. Lightning storms generating atmospheric static pops as heard in the ship's onboard VLF receivers were heard nearly simultaneously in Stanford as short whistlers. Additional verification of Storey's whistler was confirmed by the observation of whistler "echo trains" simultaneously heard in Alaska and in Wellington, New Zealand, which lies at the opposite magnetic conjugate from Alaska.

Whistler Theory in Detail

With this generalized history of whistler discovery and research in mind, I should pause this history lesson and now explain whistler theory in somewhat greater detail. The generally accepted theory of whistlers (Storey, Morgan, Helliwell) follows.

The Earth's outer magnetic field (the magnetosphere) envelopes the Earth in an elongated doughnut shape with its hole at the north and south magnetic poles. The magnetosphere is compressed on the side facing the Sun and trails into a comet-like tail on the side away from the Sun because of the solar wind which consists of energy and particles emitted from the Sun and blown toward Earth and the other planets.

Earth's magnetosphere catches harmful electrically charged particles and cosmic rays from the Sun and protects life on Earth's surface from this lethal radiation. Among the charged particles caught in the magnetosphere are ions (electrically charged particles), which collect and align along the magnetic field lines stretching between the north and south magnetic poles.

These magnetic-field-aligned ions bombarding Earth's magnetosphere, form ducts which can channel lightning-stroke electromagnetic impulse energy. Whistlers result when an electromagnetic impulse (sferic) from a lightning-stroke enters into one of these ion ducts formed along the magnetic lines of force, and is arced out into space and then to the far end of the magneto-ionic duct channel in the opposite hemisphere (called the opposite magnetic conjugate), where it is heard as a quick falling/descending emission of pure note tone or maybe as a brief swish sound.

Whistlers sound the way they do because the higher frequencies of the lightning stroke radio energy travel faster in the duct and thus arrive before the lower frequencies in a process researchers call dispersion. A person listening with a VLF receiver like the WR-3 in the opposite hemisphere to the lightning stroke (at the far end of the magnetospheric duct path) will hear this short or one hop falling note whistler. One hop whistlers are generally about one-third of a second to one second in duration.

If the energy of the initial short one hop whistler gets reflected back into the magneto-ionic duct to return near the point of the originating lightning impulse, a listener there with a VLF receiver will hear a pop from the lighting stroke impulse, then roughly one to two seconds later, the falling note sound of a whistler, now called a long or two hop whistler. Two hop whistlers are generally about one to four seconds in duration depending on the distance the whistler energy has traveled within the magnetosphere. One hop whistlers are usually higher pitched than two hop whistlers.

The energy of the originating lightning stroke may make several hops back and forth between the northern and southern hemispheres during its travel along the Earth's magnetic field lines-of-force in the magnetosphere. Researchers of whistlers have also observed that the magnetosphere seems to amplify and sustain the initial lightning impulse energy, enabling such multi-hop whistlers to occur, creating long echo trains in the receiver output which sound spectacular. Each echo is proportionally longer and slower in its downward sweeping pitch and is also progressively weaker.

Conditions in the magnetosphere must be favorable for multi-hop whistler echoes to be heard. Using special receiving equipment and spectrographs, whistler researchers have documented over 100 echoes from particularly strong whistlers—imagine how much distance the energy from the 100th echo has travelled—certainly millions of miles! Generally, only one to two echoes are heard if they are occurring, but under exceptional conditions, long "trains" of echoes will blend into a collage of slowly descending notes and can even merge into coherent tones on a single frequency, hard to describe here, but quite unlike any familiar sounds usually heard outside of a science-fiction movie.

A Little More History

Back to the history of whistler research. Plans for studying whistlers, chorus and other audio frequency natural radio phenomena were formulated by Dr. J. G. Morgan of the University of New Hampshire in Hanover, as well as Dr. Helliwell at Stanford, for the International Geophysical Year (IGY) which began in 1957.

Over 50 receiving stations were set up at many locations all over the globe, including remote locations in northern Canada, Alaska, Europe including Scandinavia, and even Antarctica. This period was the beginning of the most intensive professional study of whistlers ever.

In the early 1960s, a couple of satellites (*IEEE-1, Injun, Allouette*) destined for low Earth orbit were outfitted with VLF receivers. These satellite-based VLF radio receivers successfully recorded whistlers, and greatly enhanced scientific knowledge of natural VLF radio emissions.

During the 1970s, space probes such as *Pioneer* and *Voyager* discovered whistlers occuring on other planets of our solar system, especially Jupiter and Saturn, which both have enormous and powerful magnetospheres. These gas giants also have huge magnetospheres and their own polar aurora as well.

The 1980s saw increasing hobbyist and amateur observations of whistlers, thanks to the increasingly easy availability of solid-state electronic parts and VLF receiver construction articles and notes. By 1985, whistler articles and receiver designs would appear in several electronic and radio hobbyist magazines, and also radio club bulletins—most notably the Longwave Club of America's (LWCA) monthly bulletin, *The Lowdown* (LWCA, Bill Oliver, 45 Wildflower Road, Levittown, PA 19057).

Several LWCA members including Mideke, Mitchell Lee, Ev Pascal, Ken Cornell and others, would publish and/or design and use their own successful whistler receiver versions. These hobbyist whistler receivers tended to use small loop or wire antennas, unlike the professional VLF receivers used during the late 50s and early 1960s, which used very large loop and/or tall vertical pole antennas.

Mike Mideke—the Dean of Natural Radio Listeners

Mike Mideke was my radio mentor who sparked my fascination with whistlers and natural radio. He has been an avid enthusiast involved in various esoteric radio (and non-radio) pursuits since the early 1970s. Mike taught me a lot about longwave radio receiving and transmitting experimentation at radio frequencies much higher than natural radio. He began regularly monitoring natural radio about the middle of 1988, more than a year before I would hear my first whistler in the Oregon desert.

For the past 25 years, Mike, his wife Elea, and two sons have lived as caretakers on a large ranch in a remote central California canyon, far from electric powerlines. At that location Mike was able to string out antenna wires over thousands of feet in length, running in several different compass directions, and connect them to his plethora of radio receivers. His remote, electrically-quiet location was also ideal for listening to whistlers.

Over the years, Mike has also made many hundreds of hours of recordings of

Away from the madding crowd—and from AC current in particular—author seeks remote locations to park his specially equipped van (only partially visible in this twilight shot).

Inside the van, author's mobile equipment includes WR-4B VLF receiver and tape recorder.

amazing radio sounds of the Earth. He was particularly fortunate to be able to monitor 24 hours a day during the height of the sunspot cycle—from 1989 to 1991—when solar activity, geomagnetic disturbances and whistlers were most numerous. Mike also passed along the results of his own receiver experiments, thus positively influencing my own receiver experimentation.

Once I had heard whistlers on my own, I became hooked on this very esoteric aspect of radio listening. I had been enjoying shortwave listening to stations around the world and amateur radio for the past dozen years, but this was something very new and fascinating—something that played well into my other casual and hobby interests in geophysics, meteorology and radio wave propagation studies.

Over the next few years, I would learn a great deal about natural radio phenomena and how to build excellent receiving equipment to listen for natural radio sounds. One of the main goals was to build a whistler receiver that would not require a whole roll of antenna wire, but only a small whip antenna—a desire which came to fruition in the spring of 1990, when I accidentally heard a loud whistler while rolling up the final few meters of antenna wire.

I knew it was possible to hear whistlers with small antennas, and as I've already mentioned, a prototype to my portable hand-held WR-3 receiver was devised in the spring of 1991 with the help of another radio friend, Frank Cathell of Conversion Research.

In addition to all of my whistler receiver tinkering, trials, and successes mentioned above, I began serious and regular natural radio listening (and quality recordings) in February 1991. Nearly every Sunday morning well before sunrise (the prime time to listen for whistlers), I would pack my favorite whistler receiver, a small reel-to-reel tape recorder, and lunch into a knapsack and bicycle to the nearby hills.

At the base of the hills, I would walk the bike via a fire access-road up to my favorite listening spot—a flat ridgeline overlooking much of Marin County, San Francisco, and San Pablo Bay at an elevation of about 600 feet above sea-level that I call "Whistler Hill." At this location I would listen for whistlers and run the tape recorder if I heard any. I was rewarded by many beautiful sunrises and nice whistlers on my weekly visits, and I was quite happy with my MC-1 receiver, a unit which used a 66-inch whip antenna.

Get Away from the AC

Why didn't I stay home and listen to whistlers from the comfort of my bed, as is generally possible with more conventional broadcast radio? The problem lies with the electric-mains grid which has spread nearly every place man has settled. Alternating-current electric power lines emit hum at 60 Hertz (Hz) in the Americas, and 50 Hz in Europe and Asia. In addition to these fundamental AC power frequencies, harmonic energy is also radiated (i.e., 120, 180, 240, 300, 360 Hz, etc in the Americas, or in Europe and Asia: 100, 150, 200, 250, 300 Hz, etc.)—often to well above 1 or 2 kHz. Since whistler receivers are sensitive to these electric power frequencies, any natural radio events which might be occurring get masked by this terribly annoying humming sound, should one try to listen anywhere near AC powerlines.

The only solution to AC power-line hum is to locate a listening spot away from AC power poles and wires—often as far as several miles before the hum levels are reduced to low or nil levels.

This necessitates walking, hiking, bicycling or driving to remote locations where there are few or no AC power lines—easy to do in many parts of California and the West, but often very difficult in flat land or urban locales. Sometimes—and with good filters in the whistler receiver—one can listen as close as a couple-hundred feet (or maybe even closer) to residential AC electric wires.

On a few fortunate and astounding occasions, whistlers can get so loud as to even be heard through the loud power-line hum levels encountered in a suburban backyard, demanding the whistler listener to immediately relocate to their favorite quiet listening spot in order to hear and tape record such magnificent giant whistlers, and at the same time praying that the monster whistlers are still going when the whistler receiver is again turned on. Murphy's Law and my experiences generally suggest they will be gone, not to return until another inopportune time.

Most whistlers are heard in a 500 to 1000 mile radius from the exit point region of its duct, though its sound characteristics may be different from one place to another within this whistler reception area. Whistlers also tend to cluster in the middle and upper-middle latitudes of the globe—between 25 and 60 degrees north/south, and are rarely heard at the geomagnetic equator—a wandering latitudinal line on the globe at the half way point of any great-circle line drawn from Earth's magnetic north pole to the magnetic south pole.

Most of the continental United States and southern Canada are between these latitudes and can hear not only splendid whistlers but also the beautiful VLF radio chorus of the auroral displays. The same goes for most of Europe, especially the British Isles and Scandinavia. In the Southern hemisphere, southern Argentina and Chile; the southern parts of Australia, particularly Tasmania; New Zealand; and

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perhaps, the Cape Horn region of South Africa, are similarly at the right latitudes to hear whistlers and chorus. The South Island of New Zealand and the Tierra del Fuego region of South America, plus the Antarctic Peninsula, are where the good displays of aurora and auroral chorus can be seen and heard.

Conversely, there are days when there seem to be whistlers happening nearly everywhere, as though a giant switch was turned on somewhere in Earth's magnetosphere to issue forth a barrage of weak and strong whistlers too frequent to count. Like weather fronts and hurricanes, it would appear that, given a day when things are ripe for strong whistler production, the locations where strong whistlers are heard constantly changes, depending on such factors as the locations of lightning storms; the magnetospheric whistler ducts beginning and end points, and the solar terminator (which moves westward 15 degrees an hour). We are particularly interested in the midnight to 6 a.m. local period.

Thanks to simultaneous whistler monitoring and tape recording efforts—first by 1950s and 60s whistler researchers such as Storey, Morgan, Helliwell, etc, and later by coordinated amateur and student study groups—hundreds of individual whistlers have been documented. Their findings have determined that the average whistler is heard in an area of about 500 miles radius, though the "big whoppers" may be heard as far as 2000 to 3000 miles from this loudest arrival points.

Project Inspire

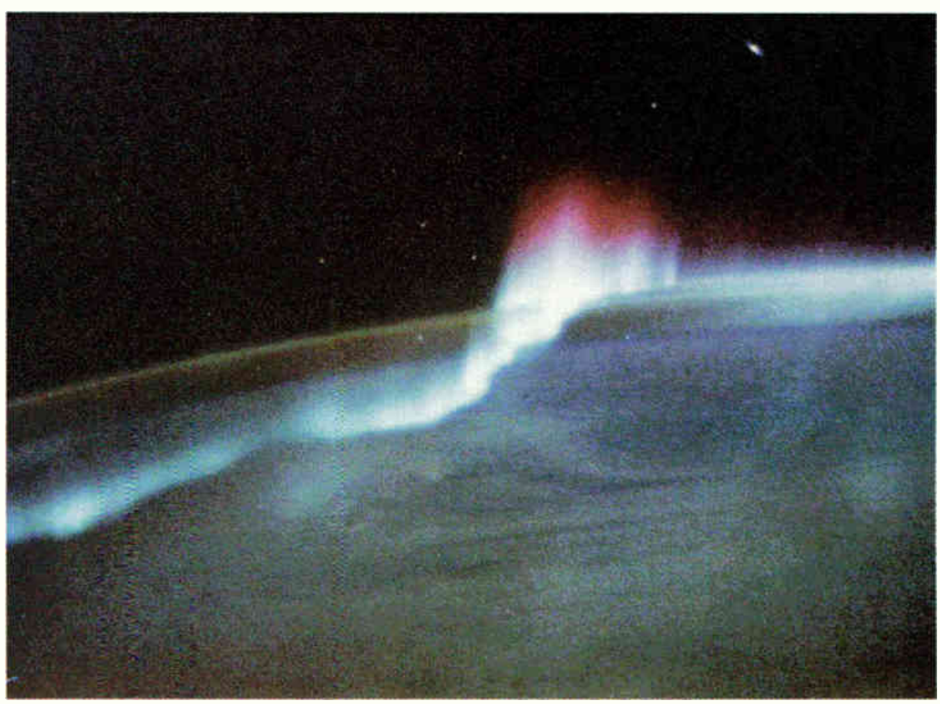
One of my favorite examples of intense scrutiny of individual whistlers (by at least 25-30 listening groups or single monitors), was of two "giant Whistlers" occuring on the morning of March 28, 1992, about an hour apart. These two huge whistlers were not really different from other strong whistlers which occur in the hundreds or thousands throughout any season, but they were remarkable in that they were serendipitously caught on tape by many listeners who were participating in a high school student monitoring effort called "Project Inspire," coordinated by a team of scientists and high school professors.

The Inpsire effort was sanctioned by NASA to study the ground reception pattern of radio wave emissions from a special modulated electron-beam generator (called ATLAS) aboard the space shuttle (STS-45), which flew in late March 1992.

A schedule of ATLAS transmissions was established in hopes that the ground-based VLF radio receivers set up by the student groups would hear its emissions. Unfortunately, the shuttle-based ATLAS unit failed after only two (unheard) transmissions. Fortunately, it was decided that student groups and other individuals should adhere to their listening schedule arranged for the mornings of March 26-30, 1992.

It was during many of these scheduled listening periods that many interesting natural radio events were captured, including several strong and powerful whistlers. A very detailed report (the *Project Inspire Data Report*) was produced in August 1992 by Michael Mideke, who was the project's data analyst. It is from this report that the following interesting scenarios of whistler reception has been interpreted.

"Back to the two Giant Whistlers of March 28, 1992. Bill Hooper, shivering at 4 a.m. Pacific time in his camper near



Space Shuttle photo of red tipped arcs of the Aurora Australis over the South Pole.

California's Death Valley, started his tape recorders running once again. Bill was one of many experienced whistler enthusiasts who was monitoring individually, but part of the larger Inspire student effort. He had set up one of the most sensitive whistler receiving stations—by far—of the entire group participating in the Inspire listening sessions, thanks in part to his remote desert locations great distance from any electric power lines combined with plenty of room for a large antenna and very sensitive whistler receivers of his own original design.

"At precisely 4:02:38 a.m. PST, or 1202:38 Universal Time Coordinated (UTC), an extremely strong (long, two hop) whistler was recorded by Bill at his Death Valley listening site. So very strong was this whistler that it briefly overloaded Bill's receiving system. It also produced a four hop echo which was also clearly recorded on his tape. This whistler was also heard and recorded as far away as the U.S. midwestern region and eastern seaboard, but much weaker and truncated; that is, only a fairly narrow spectrum of this huge whistler, in the 3-6 kHz range, propagated eastward. This whistler was also heard weakly to moderately in south-central Texas, but again, was somewhat truncated there like farther east.

"Interestingly, a large part of Texas was experiencing heavy rains and lightning storms—whistler receivers in southeastern Texas were picking up very strong, local-like lightning stroke sferics. If the source lightning of this whistler was in Texas, one wonders how it arrived so loud in the California desert. Perhaps it was generated by lightning strikes somewhere else, perhaps to the north or northeast of California, and far enough as to not really make much of an obvious sferic pop in the whistler receiver.

"An hour later, a nearly identical strong whistler to the one at 1202 UTC occurred at 1303:03 UTC, this time heard by myself as well as Mike Mideke and others listening in Arizona New Mexico and even Minnesota. Unlike the earlier big whistler, this particular whistler as heard in Minnesota was stronger. It also was not as truncated as was the earlier strong whistler."

Interestingly, the sferic generated from the causative lightning stroke was rather weak in California, unlike its whistler. Clearly, on this morning the big whistlers were concentrated in the western United States even though the lightning storms weren't. It should be noted there were days when the whistlers were stronger in the eastern United States and were weaker out West, which points out how the locations of strong whistler activity change day-by-day and can't easily be tied to where lightning is happening. More on this in a bit.

What I can explain about those great big eastern Nevada whistlers of September 17, 1993, is as follows: They were coming from rather weak, but distinct and clean tweeking pops, the kind which are produced by fairly distant ground strikes. Now, I've listened to a lot of lightning sferics while watching the lightning strikes making them, and the sounds of lightning static can be as varied as the visual strikes. I've noticed that the big, bright, single cloud to ground lightning strikes can deliver a very loud, but clean pop in the whistler receiver's output. Cloud-to-cloud lightning, sometimes tripping other nearby in-cloud lightning, sounds more crackly or like the crushing of a walnut in a nutcracker.

Anyway, interspersed amongst the numerous weak sferics and occasional, huge whistler generating popping tweek were occasional strong and semi-local lightning sferics—dry sounding and not tweeking—that were generating very weak and quite diffuse (hissy) whistlers. These strong sferics were coming from lightning within about 50-100 miles of my listening location. Seems they just weren't generating big whistlers—or if they were, the whistlers were arriving strongly somewhere else but distant enough to explain their rather weak strengths near their source lightning.

So, this idea of lightning stroke energy entering a duct or ducts to travel to the magnetic conjugate and then back again to the general area of their origination is a fairly simplistic explanation and not entirely satisfactory. And, as simplistic explanations tend to do, it fails to consider more complex events taking place.

Whistlers Jumping Rail?

It is my supposition that, somewhere, as they merrily arch along the magnetic field lines, whistler ducts can cross, combine, and/or excite each other. In my mind this helps explain why two hop whistlers don't always land near where their originating lightning stroke occurred, but can wind up a thousand or more miles away. Whistlers can "jump rail," if you will, and enter adjacent ducts, winding up curiously far from where they should arrive—whistler wanderlust.

I think conjugate points (and their associated impact zones), caused by variations in the exact position of Earth's magnetic field, can vary daily and even hourly—call it conjugate end-point drift.

If the solar wind is pushing against the magnetosphere, either gently—or as can be the case after solar flares and coronal mass ejections from the Sun—rather violently, then the motion of Earth's magnetic field lines and any whistler ducts present within them must also get tugged and pulled to various degrees from their normal positions.

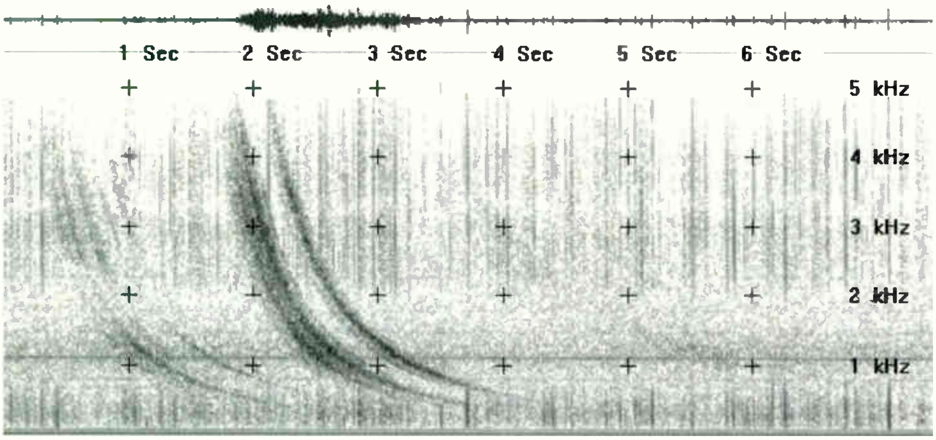
This, and my suggested whistler duct crossings, jumps, and re-combinations, must be partial explanations of why lightning in Texas sometimes causes strong two hop whistlers in California, or why Nebraska lightning generates huge whistlers in Manitoba that are weaker in Nebraska. Where was the Nevada lightning of the morning of September 17, 1993, sending strong whistlers (if any)? Where were the rather weak lightning sferics that generated such giant eastern Nevada whistlers?

One can't neatly package the fascinating whistler phenomenon with magnetic conjugate points, lightning stroke counts, fixed impact zones, etc, and expect to easily explain what in reality is a mind-boggling dynamic process that changes like a kaleidoscope and never repeats. While it is intriguing and fun to try to scientifically unravel the phenomenon of whistlers, part of their allure is that they are just there to be listened to—they are as nice to hear as sunsets are to see, and the reasons for their existence must sometimes take a back seat to the beauty of their tones.

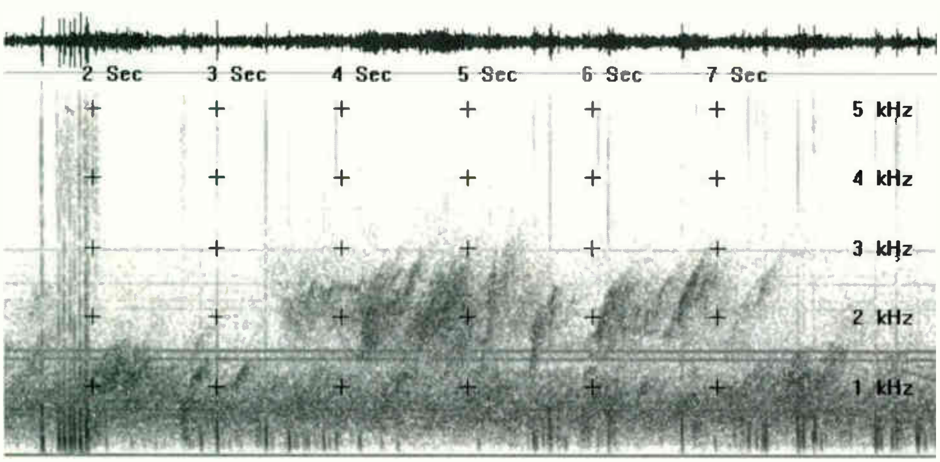
Neither I nor anyone else has yet determined if there are special places where, perhaps due to local terrain or geology, whistlers are louder and more frequent than average. But, such places may exist.

Intriguingly, Edson Hendricks, a researcher into the mysterious "Marfa Lights," heard extremely loud whistlers issuing forth from a very crude and seemingly insensitive receiver during a display of these strange and spooky, colored balls of lights which have occasionally been seen in the desert near Marfa, Texas, for nearly 50 years. Ed was listening right near powerlines, and their hum would surely have been overpowering to more sensitive whistler receivers.

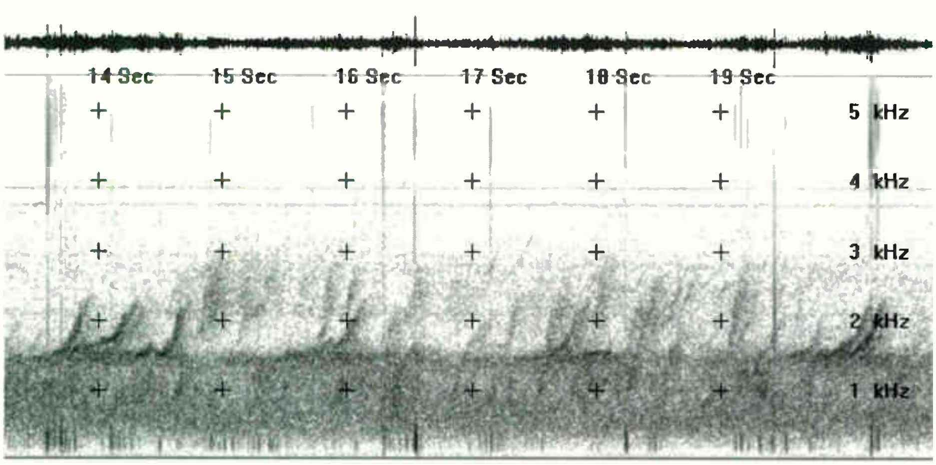
Visualizing the Earth's Radio Symphony—by Spectrogram



Author's spectrogram of strong 2-hop whistler (and a weaker one) recorded in northern Nevada on 19 April 1996 at 2358 UTC. Graphs on this page may be found at the author's website, where corresponding sound files ("WAV" format) can be launched by your web browser so you can hear them, too.



"Gorgeous loud bursts of risers and other components of chorus, with very-weak background," says author. This spectrogram is from 25 August 1996, 1700 UTC.



Long-duration chorus risers along with low-pitched "roaring" hissband.

But Ed testifies to these very pure whistler-like notes, far stronger than the weakish background hum, as heard in the output of his simple receiver. Something is going on there in west Texas that needs further checking, and it again points to the great need for more people to join in the whistler listening movement. We would know vastly more about whistlers if there were as many people listening to whistlers as were watching the prime-time fare on television (a silly and hopeless wish), but even 100 or more people joining the whistler listening movement and coordinating listening schedules would give a clearer idea of when and where whistlers are coming and going.

Whistlers Aren't the Only Thing You Will Hear

If whistlers aren't enough of a fascinating pursuit, there are a host of other natural radio sounds which can be heard at the 0.1-10 kHz audio-frequency portion of the radio spectrum to keep enthusiasts hooked on these Earth radio sounds. One of the more common is the "chorus," which consists of a series of sharply-rising notes, called "risers."

This fairly common phenomenon (but not as common as whistlers) can mimic the sounds of a flock of birds chirping, frogs croaking, or seals barking. Chorus occurs during magnetic storms, when Earth's magnetosphere receives a barrage of high-speed energetic particles cascading into it from solar flares on the Sun or from energy ejections from the Sun's coronal holes which allow them to escape the Sun in streams traveling at sub-light speeds.

This phenomenon of magnetic storms is also responsible for the Aurora Borealis and Australis—the Northern and Southern lights—seen in the sky at higher latitudes close to Earth's Arctic and Antarctic regions.

Chorus can happen during visible aurora and is called "Auroral Chorus"—this sometimes can also be heard over a widespread area at around local sunrise, when it is called the "Dawn Chorus." Often accompanying Earth's magnetic storm associated auroral displays and natural radio chorus, are hiss, wavering-tones, and other endless varieties of natural radio sounds.

Red Sprites and Blue Blobs

Just when lightning seemed a rather common and well studied phenomenon, awesome as she is, Mother Nature throws another "wow" at mankind. It seems we can now add the terms "red sprites" and "blue jets" to our lightning storm vernacular. I am fascinated by recent videotaped evidence presented to the world scientific community and the general public pertaining to massive red and blue bursts of lights occurring as high as 20 to 30 miles above lightning storms.

For years, pilots of high-altitude aircraft were reporting sightings of strange blue and red lights seen above lightning storm clouds which were occurring at the same time as lightning flashes in the clouds below.

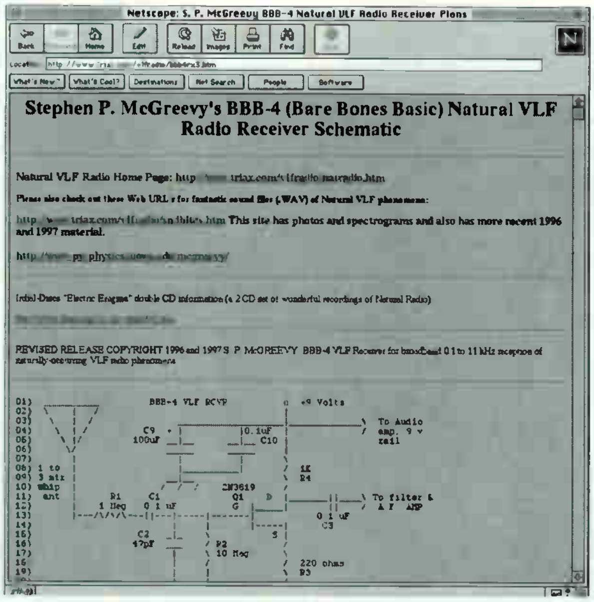
In the summer of 1994, scientists from the University of Alaska Geophysical Institute in Fairbanks, Alaska, were at last able to very clearly videotape these incredible lights using high-speed video cameras located on the ground and aboard two aircraft flying over storms in the U.S. Midwest. As though squirted out of a spray bottle, bursts of red light can be seen shooting upward in a stream right over lightning strokes and flourishing in a great cloud of light, lasting for about one-tenth of a second.

Fascinating as these baffling red and blue lights are, what's even more intriguing to natural radio listeners like myself is a quote from one of the researchers, David Sentman of the University of Alaska Geophysical Institute, who says that the radio signals, when played through an audio speaker "sound like eggs hitting a griddle."

That description sounds like the hundreds of thousands "crackling" sferics I have heard and recorded through the years; many of them (but certainly not all or most) have set off nice whistlers.

I have always pondered at the sheer length of many of these lightning sferic crackles—quite a few of them are about a second in duration, and there are occasionally crackles which carry on for almost two seconds. These times seem far longer than any actual flashes of lightning I've ever witnessed, although it would seem lightning strokes can trigger other lightning strokes (via these immense radio energy impulses) which could support such lengthy sferic crackles.

Now, it looks like I've been hearing the radio sounds of sprites and jets—I wonder if renaming my WR-3 whistler receiver to a "Sprite and Jet receiver" might be appropriate. Seriously, there is some thought among whistler listeners that these wierd lightning strike emissions may be what is causing whistlers, since they offer visible evidence of a link between energy emitted from above the lightning storm clouds directed toward the ionosphere. Sprites do not occur during every lightning stroke, just as whistlers do not happen after every lightning stroke.



Author's extensive web site (see URL below) includes free details on how to build the McGreevy BBB-4 whistler receiver.

Since the aurora borealis and australis also generate fantastic VLF radio sounds, it remains a dream of mine to videotape the northern lights while simultaneously recording their radio emissions onto the audio sound track. I have watched aurora in Canada dance in the skies and listened to their beautiful whistling and squawking in the whistler receiver—bursts in intense aurora would also create bursts of auroral radio sounds.

I understand the University of Alaska Geophysical Institute in Fairbanks (the same folks studying the red sprites and blue jets) has created an extremely sensitive (equivalent to two million ISO) video camera. They videotaped beautiful auroral displays in the Alaskan nighttime skies with astounding high clarity and detail, something never before achieved. Most auroral photography requires time-exposures with still cameras to expose the film to sufficient light to turn out brightly. But that smears the fine detail of the auroral curtains due to the motion of the auroral displays.

What Do You Need to Hear Natural Radio?

The most basic receiver required to pickup and record whistlers and all of the other natural radio signals of Earth is a tape-recorder audio amplifier connected to a wire antenna (aerial). The antenna should be of sufficient length to transfer enough radio energy into the tape-recorder's audio amplifier to successfully record them. In actual practice, however, this crude tape-recorder/audio-amplifier/receiver will most likely also intercept your local broadcast station transmitting in the long or medium-wave band, as well as other signals.Iit may also not have enough sensitivity since tape-recorder inputs rarely are well matched in impedance for wire aerials, but prefer input from microphones, etc.

Fortunately, whistler receivers are rather easy to construct and are for the most part less complicated than a $5 AM pocket radio. A handful of parts and a couple of fairly commonplace transistors can form the basis of a very good whistler receiver that will perform very satisfactorily—almost as well as the professional study units that cost upwards of several hundred dollars.

One such receiver is called the McGreevy BBB-4 (Bare Bones Basic, version four). This whistler receiver circuit has proven to be a very fine "basic" whistler receiver that I have been using (along with several other VLF receiver designs) during the past five years of my natural radio recording efforts. It is similar to Mike Mideke's RS-3 and RS-4 designs, except it does not include the second audio filter that is present in Mike's designs, and the "front-end" of the BBB-4 is of the design I primarily employ in my whip-antenna receivers. More information on how to build this circuit can found found at the following web address: **http://www.triax.com/vlfradio/bbb4rx3.htm**

In closing, I invite readers to join in and listen to the wonderful radio sounds of Mother Earth. You needn't be interested in science or be a radio buff, but need only to have the desire to lend an ear to the extraordinary yet ordinary. Like star gazing, natural radio listening redirects the mind and heart toward the wonder and beauty of the natural world. ST

A 'Meat and Potatoes' Guide to Monitoring Natural Earth Radio

By Larry Van Horn
Managing Editor, Satellite Times

It's the weekend. You're off from work and looking for just the right challenge to help you relax on your two days off. Are you tired of tuning around on that old shortwave receiver and listening to the same old signals? Well, I have just the thing for you, oh, great master of the radio aerial, how about *DXing the Planet Earth*?

Yes, I know you have over 200 countries heard and 175 of them are verified. You listen continuously to the police and fire and one good parade of human earthly events after another.

But you're wrong, old coax breath! You're even in the wrong part of the spectrum and totally missing the point. I am talking about really *DXing the Planet Earth*—those natural Earth signals/sounds that occur in the VLF (Very Low Frequency) and ELF (Extremely Low Frequency) portions of the frequency spectrum. We are going to examine the lowest part of the radio spectrum—the basement—and what we find here is simply going to amaze you.

So what is this Earth DXing all about?

The earth is alive with natural electromagnetic activity. On any given day, we can expect roughly 44,000 thunderstorms to occur. This adds up to around a million lightning strokes a day. With voltages on the order of 250 million volts, currents of 200,000 amperes, and internal temperatures reaching 30,000 degrees centigrade per stroke, any one of these awesome sparks is a major event on the human scale of things. Needless to say, there is a lot of energy in lightning. Not all that energy dissipates in the flash and bang.

Lightning is a spark discharge which also generates huge amounts of radio energy—millions of watts at very low frequencies (3 to 30 kHz). This impulse of radio energy occurs not just on one frequency, like a broadcast station, but on all frequencies simultaneously. The spark channel acts as an antenna, briefly radiating a burst of static. But not only static.

At these frequencies the static bursts propagate with particular efficiency in the wave guide formed by the Earth's surface and the lower regions of the atmosphere. This allows some of the lightning's energy to travel great distances.

Tweeks

Tuning through most of this frequency range, you will hear static that sounds pretty much like what you hear on your AM receiver. But if you tune below 5 kHz, you will discover that sometimes (though not always) the crackle becomes a liquid musical pinging or chirping notes. Each pop of static produces a rapid descending note. These sounds are called tweeks. Typically, they drop a few hundred Hertz in a fraction of a second, then cut off abruptly.

The mechanism for the production of tweeks is quite well understood. For the purist, the next two paragraphs explain the mechanics.

Tweeks are a result of propagation in a wave guide near the cutoff frequency. The same effect would occur if the space between the earth's surface and the ionosphere was a vacuum, and/or if it was infinitesimally thin. Now consider waves propagating between two horizontal conducting surfaces (earth/ionosphere): As the frequencies decrease (like a tweek does), planes of equal phase incline increasingly away from the vertical. At frequency cutoff, these phase planes are horizontal surfaces and the waves are moving now up and down only; there is no horizontal propagation of energy at this point.

Horizontal phase velocities—close to the speed of light far above cutoff—become faster and faster as the frequency decreases, approaching infinity at cutoff. The group velocity (the speed at which energy propagates) is inversely related to the phase velocity in this case and becomes slower and slower, approaching zero at cutoff.

The degree of *tweeking* is an indication of how far signals have traveled. A tweek's duration is roughly proportional to its path—the longer the path, the longer the tweek. Tweeks coexist with the more familiar crackling noises, the mixture varying from a scattering of tweeks among the static, to the rare occasions when almost everything is *tweeking.*

Tweeks are generally heard at night, though they will sometimes appear late in the afternoon, and winter is probably their best season.

Static

Receivers designed for man-made signals are not kind to 'sferics (natural atmospheric radio noise). But with the proper receiver, listening even to "ordinary" static can be engaging.

If you hear crisp sharp clicks, this indicates that lightning is relatively close by. When such clicks get very strong, and especially if they are accompanied by sizzling, frying sounds, it is time to stop listening, ground everything, and prepare for a thunderstorm!

By the time the lightning static has traveled a few hundred miles, its sound is less distinct. As the distance from the listener grows, the received strength of each impulse decreases. More and more signals of smaller and smaller magnitude blend into a fluctuating background texture. Foreground and background interpenetrate in complex subtle rhythms that never quite repeat. Layers of tweeks may thread their way through the clicks and crackles. Sometimes, when least expected, another signal called a whistler may come howling through like a voice from another world.

Whistlers

If you spend long enough listening to static and tweeks below 10 kHz, you are almost certain to hear a few whistlers. These, too, are descending notes but the frequency range is wider. These signals are of much longer duration as they occupy seconds rather than milliseconds. They can be extremely loud, and they usually command the listener's attention in no uncertain terms.

These strange radio visitors have been heard as high as 40 kHz, though they usually commence around 6-10 kHz and glide down to 4 kHz. This can take three seconds or more. Last August, I actually received a whistler on my shack receiver at around 59 kHz. This is probably one of the highest frequencies recorded for a whistler transmission.

Whistlers can come thick and fast, sometimes too fast to even count them. At other times there may be fewer than one whistler per minute, or fewer than one in ten minutes. For hours or even days at a time, there may be no whistlers at all. Whistlers can appear singly or in clusters, or with resounding "echo trains" that may last for minutes, each successive echo longer and lower in pitch than the one before it.

Sometimes a sharp click is heard just before the whistler arrives at your antenna. This is static from the originating

Jet sprites may be responsible for some whistlers, particularly the kind described as "eggs hitting a griddle." Sprites occur directly above lightning strikes and may shoot upwards some 20-30 miles. (University of Alaska photo)

lightning traveling to the listener via the earth-ionosphere wave guide, while the whistler has been on another, longer journey. When you hear a scenario like this it usually means that the lightning that triggered that particular whistler was within a couple of thousand miles of your location.

Beginning with German scientist H. Barkhausen during World War 1, researchers have toyed with the idea that whistlers, like tweeks, are dispersed lightning static. There was a great deal to recommend this explanation, but it had one bad problem—no one could find signal paths that were anywhere near long enough to account for the huge amount of dispersion seen in whistlers.

Another magnificent sprite viewed from space. (University of Alaska photo)

Propagation around and around the world was hypothesized, as were strange radio-reflective clouds somewhere out in space. But these theories didn't fit the observed phenomena very well.

After some research, it turns out that the long dispersive whistler paths were found neither in terrestrial propagation nor in the depths of space. They were traced to an intermediate region known as the magnetosphere. This is the region where earth's magnetic field interacts with the continuous (but varying) influx of charged particles known as the solar wind.

In essence, the magnetosphere's magnetic field lines capture charged particles (ions) from the solar wind in tubular vortices that follow the lines of magnetic force. These vortices act as VLF wave guides or ducts. If VLF energy from a lightning bolt penetrates the ionosphere, it, too, may get trapped into this magneto-ionic duct. It then follows this duct far out into space, crossing the equator and returning to earth in the opposite hemisphere. Then it may reenter to earth as a whistler, its spectrum dispersed by the long path it has taken to get to your receiver. Some energy may also bounce and return to the duct and the other hemisphere one or more times. This is what causes the previously mentioned echo trains that have been associated with whistlers. These echoes become even longer in duration and lower in pitch as the number of hops increases.

Scientists have been quick to realize that the study of whistler dispersion could yield valuable data about the characteristics of the magnetosphere. Every whistler is a magnetospheric probe!

Two gentlemen who have done a lot of work in this field are Mike Mideke and Steve McGreevy. Mike has performed all kinds of related studies on these phenomena including a project which involved a space shuttle mission. In fact, the bulk of the material used to prepare this article has come from Mike to whom I am deeply indebted.

Here is Michael Mideke's *Basic Guide to Whistlers, Emissions and Associated Phenomena.*

Static is the impulsive crackling and popping of lightning generated broad spectrum radio bursts. Static can be heard throughout the radio spectrum. Its character varies according to the structure of the lightning producing it, distance from the receiver and the path which it propagates. Static impulses are also referred to as 'sferics.'

Tweeks are sferics subjected to dispersive distortion by subionospheric propagation. They are sharp falling notes with a duration of 25 to 150 milliseconds.

Whistlers are descending tones generated through the propagation of sferics over very long paths formed by field-aligned plasmas (ducts) in the magnetosphere. The magnetospheric propagation of whistlers is between magnetic conjugate regions in the northern and southern hemispheres. Terrestrial reception of whistlers results from subionospheric propagation of these signals.

Whistler duration ranges from a fraction of a second to several seconds. The frequency range of whistlers can extend from above 30 kHz to below 1 kHz, but those readily heard with simple equipment will mostly lie between 1 and 9 kHz, with their maximum energy usually concentrated between 3 and 5 kHz.

Whistlers are categorized according to hops. One hop equals a single traverse between conjugate regions. A one hop whistler is generated by lightning in the opposite hemisphere from the listener. It has traversed the magnetosphere just once and, as a consequence, it tends to be a high pitched whistler of short duration. Since the causative sferic is very far away, it is rarely heard in association with single hop whistlers.

Two hop whistlers are produced by lightning in the same magnetic hemisphere as the listener. The signal has traveled to the opposite hemisphere and echoed back to the region of its origin. Subject to roughly twice the dispersion of a single-hop whistler, its duration is longer and its pitch lower than its one-hop cousin. Causative sferics can often be heard in very distinct association with two hop whistlers. Delays of 1.5 to 3 seconds between sferic and whistler are typical.

Odd order hops (1,3,5, etc.) indicate opposite hemisphere lightning while even order progressions (2,4,6, etc.) follow from the same hemisphere lightning. On occasion, whistlers generate multiple echoes or progressions known as echo trains. While trains exceeding a dozen echoes are uncommon, progressions of more than 100 have been observed on rare occasions.

Whistler notes range from extremely pure tones to breathy, diffuse swishes. The breathy quality is described as diffuseness. It results from whistler mode excitation of multiple ducts; the slightly different travel time for each duct serves to spread or diffuse the signal.

Whistlers were the first-studied and most easily understood class of magnetospheric radio events, but they are far from being the only ones that can be observed by a patient listener using basic tools.

VLF/ELF Emissions

In his book *Whistlers and Related Ionospheric Phenomena,* Robert Helliwell divides other naturally occurring phenomena found on very low and extra low frequencies into seven basic categories:

Hiss, as the term suggests, is a hissing sound. Unlike white noise, it is more or less band-limited. Its center frequency and bandwidth can vary widely with different conditions. Hiss may be stable in amplitude and frequency for minutes or hours. Or it may show distinct short-term fluctuations which may or may not be periodic in nature. Hiss is often found in conjunction with other emissions.

Discrete emissions are brief, transient events more like whistlers. They may be pure or fuzzy tones which rise (*risers*) or fall (*fallers*) in frequency. Sometimes fallers abruptly turn about and rise in frequency as *hooks.* Other descriptive terms that come to mind are *chirps, croaks, honks, pops, roars, barks,* and other complex sound patterns that defy description.

Periodic Emissions—When clusters of discrete emissions form regularly spaced repeating patterns, they are known as periodic emissions. They may be singular or multiple, relatively stable in frequency or drifting.

Chorus—Multiple closely-spaced or overlapping events are known as chorus. Chorus may resemble the sound of birds at sunrise but more often it is reminiscent of croaking frogs or seals barking. Chorus is frequently found rising out of the upper edge of a band of hiss and occasionally goes on for hours.

Quasi-Periodic Emissions—These are events consisting of discrete emissions, periodic emissions or chorus which appear at long but fairly regular intervals on the order of tens of seconds. They are less regular than periodic emissions.

Triggered Emissions—Sometimes one magnetospheric event triggers another. Triggered emissions are those which appear to be clearly associated with a triggering source. Whistlers, discrete emissions, manmade VLF signals and atmospheric nuclear explosions may all serve as triggers. Whistlers and other signals may also be seen to modify the spectrographic signatures of other events occurring in the same duct.

In short—to take a simplistic view—the whole system can be considered to be a gigantic electronic synthesizer programmed by solar and terrestrial processes. The resulting music can be complex, sustained and hauntingly beautiful.

Stalking the Elusive Whistler

Whistlers and chorus signals are among the most exquisite and exciting natural radio phenomena that one can hear. These signals occur at frequencies that are within the range of the human ear. Since this is the case, to hear these signals all that is required is to amplify the antenna output and convert the electrical energy into sound waves.

The simplest of receivers used for whistler work is just an audio amplifier with the chassis grounded and the high impedance input connected to a long wire antenna. That antenna can be strung through trees and bushes.

There are some obstacles when monitoring this frequency range using our simple receiver. You will find a wide assortment of obnoxious hums and buzzes from power lines, and voices and music from nearby communications signals.

Trying to listen in residential areas is far from optimum when listening to sferics. Most of these areas are saturated with 50 and 60 Hz power systems. Other sources of noise in a residential area will include electric motors and car ignitions. Hunting for whistler signals has a tendency to make you all too aware of the pervasiveness of man made noise pollution.

About one quarter mile is the minimum distance you need to be from power line sources to have a reasonable chance to hear whistlers and VLF emissions. The rule of thumb for the experimenter is: the farther away from the noise source, the more sensitive the receiver and the better the chance for success.

Receivers

Two companies currently manufacture natural radio receivers. Just a few years ago (1990), no one was producing a commercial model.

LF Engineering Co, 17 Jeffry Road, East Haven, CT 06512 has a free catalog and it contains a wealth of information on VLF receiving products and a well written tutorial on natural radio.

One of the original companies in this field is S.P. McGreevy Productions (formerly Conversion Research). This com-

As profiled in the January 1997 issue of Monitoring Times, two poplular VLF units are the S.P. McGreevy handheld (left) and the Low Frequency Engineering Unit with tree-tapping probles and a belt loop.

WR-3 and WR-3E VLF Receiver Specifications:

Receive frequency range: 0.1-12 kHz (100-12,000 Hz)

Original WR-3: peak frequency approx. 1.0 kHz with roll-off below 400 Hz and above 2 kHz. RFI protected to reduce LF-VHF broadcast and utility station overload and intermod.

WR-3 Audio Output: Maximum 100 mW into 16-Ohm stereo headphones. Highest sensitivity freq. range 0.5 - 3 kHz where nearly all natural emissions occur which are readily audible to human ears easily. Internal RCfilter in the basic WR-3 is peaked at 1 kHz with gradual roll-off above 1 kHz (6 dB per octave)-reduces Omega reception.

Noise as a Signal

Most of us over our years of listening have developed very distinct feelings about radio noise. Here is another way to look at noise from Michael Mideke's perspective.

Noises are signals we don't want to hear—usually because they happen to interfere with signals we do want to hear. Every bit of noise comes from somewhere, is caused by something, is a report of an event like the report of a distant gunshot. Considered as a signal, noise can tell us in great detail about the location and conditions of its origin and as much again about the path it took to reach us.

The static impulses created by lightning are now routinely plotted by computerized direction-finding networks (The National Lightning Network) to produce accurate, nearly real-time maps of lightning incidence.

The more we listen to these "noises" the more informative they become. There is accumulating evidence that whistlers, generated by lightning, may themselves trigger lightning discharges. The Earth communicates with itself—and it's not just random mumbling.

pany produces two natural VLF radio receivers. The original receiver is the WR-3 ($99.95) receiver.The WR-3 has one control knob for audio gain/power switch.

Their top of the line receiver is the enhanced WR-3E ($149.95). It comes in the same enclosure as the original WR-3. This unit has an RCA microphone level output jack for tape recording and a 3-position audio filter switch enabling the internal LC audio filter to be used in a broad-band, 1-2 kHz peak mode, or high-pass 3-4 kHz peak mode.

Both receivers come with a listening guide which is also available from the worldwide web. Subtract $5.00 off each receiver's price if either of two online versions of the WR-3/3E Listening Guide is downloaded at this URL address:

http://www.triax.com/vlfradio/wr3gde.htm

There is an HTML version with embedded/inline images viewable and printable from a web browser, and also a Word 6.0 file with images and compressed/zipped into a zip file.
There is a link to the Word 6.0 version file from the HTML version.

A 90-minute cassette VLF sounds demo cassette is included free with each receiver ordered. This tape presents a wide-variety of VLF phenomena and is quite an enjoyment in itself to listen to.

You can order the WR-3 or the WR-3E from Grove Enterprises by calling 800-438-8155 or via e-mail at: **order@grove.net.** You can send your order via mail to: Grove Enterprises, P.O. Box 98, Brasstown, NC 28902.

McGreevy Productions also has cassette tapes of natural radio sounds. These are available in the U.S. and Canada via direct-mail from S. P. McGreevy Productions, P.O. Box 928, Lone Pine, CA 93545-0928, e-mail: **vlfradio@triax.com** or check the following web address: **http://www.triax.com/vlfradio/index.htm** for more information.

If you prefer compact disc, Irdial-Discs of London has released a beautiful double-CD set of Steve McGreevy's Natural VLF Radiofield recordings, entitled *Electric Enigma.* This CD set has two booklets, a 33-page booklet with *The VLF Story* in it as well as photographs of McGreevy in-the-field receivers. A second booklet explains in detail about each track presented on this fantastic CD!

The "Electric Enigma" Double CD set costs: £18.50 or approximately US$28.35 (at the current one Pound-Sterling = US$1.53 rate)

European Air Mail: £2.00 postage and packing, U.K. and surface mail anywhere: £18.50 sterling plus £1.50 postage and packing.
U.S. Air Mail: £3.00 postage and packing. (£18.50 + £3.00 = £21.30 Sterling or approximately US$33.00)
Zone 2 Air Mail (Japan, Australia, etc.): £3.75 postage and packing.

You can order the *Electric Enigma* double CD set from These Records, 112 Brook Drive, London, SE11 4TQ United Kingdom (England), tel 44+171+587+5349, fax 44+171+582+5278 You may pay by VISA, Mastercard, Access, American Express, Cheque* and International money order* (*in pounds Sterling (£) only)

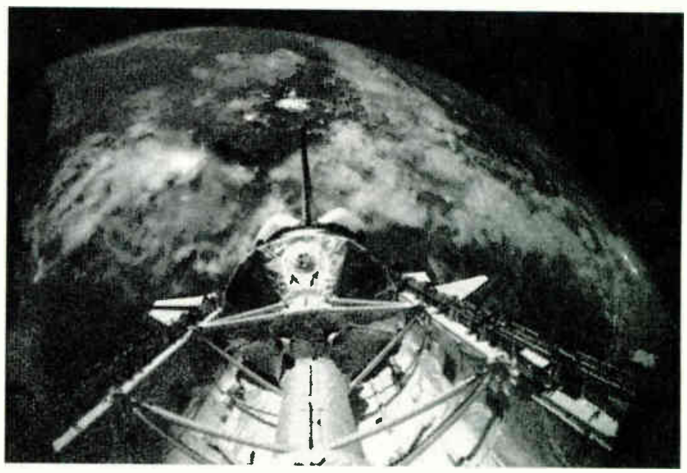
Whistler Hunting

Once the receiver system is working properly and you've gotten accustomed to setting it up, the time has come for more serious whistler hunting. The questions are "When?" and "Where?"

When?

Whistlers and other emissions may be heard at any hour of the day or night, but odds are best around dawn. Atmospheric and manmade noise are usually at their lowest then and the magnetosphere seems to be especially sensitive, as well. If you begin listening at the first glimmer of daylight and continue until the sun is well above the horizon, chances are fairly good that you'll catch the day's best activity. But this is only a general rule. Sometimes nothing will happen at dawn and there will be a peak of activity at sunset or a few hours after dark.

Whistler and emission activity seems to occur in "runs" of about three to seven days. There can also be periods of days or even weeks with very little activity. At one



STS-55 Onboard view of lightning, and city lights. Taken from Columbia's crew cabin. (NASA photo)

extreme; you'll find more than 20 whistlers a minute; at the other—less than one per hour or none at all.

VLF/ELF emissions often appear during or shortly after magnetic storms (this should not surprise you). Magnetic storms are produced by interactions between the earth's magnetic field and particles ejected from regions of the sun undergoing violent activity.

Sometimes the activity persists through the sun's 27 day rotation period. This can lead to terrestrial magnetic storms and VLF/ELF emission events that follow a periodicity of roughly 27 days. Whistler activity also tends to be especially interesting during and after magnetic storms. Long, spectacular echo trains are most common at such times.

Where?

Locally speaking, the place to go is as far as you can from AC power lines. It's all relative: If you are a kilometer from the power lines, you'll have a moderate hum level unless atmospheric noise (lightning static) is strong. Doubling the distance (2 kilometers) will make a quite noticeable improvement, as will doubling that to 4 kilometers.

Surprisingly good sites can often be found along public roads. Look for new roads and scenic routes that have been built away from power lines. Seek out rough terrain and complex shores that tend to separate roads from power lines. Elevated scenic lookouts sometimes diverge from the power lines. Even 1/2 kilometer can make a difference.

If you're into mountain climbing or backpacking, the place to listen is wherever you feel like stopping. Overnight camps are probably best because they get you set for the dawn window.

If you have access to a boat and even a medium-sized body of water, by all means give it a try. Use a whip antenna with its base at least a couple of meters above the water (or the boat's structure if it is metal) and ground the receiver with about 30 meters of wire in the water.

In general, whistler reception is best at middle latitudes and worst in the equatorial regions. Whistlers and emissions can certainly be heard in fair numbers anywhere in the US. There appear to be differences in the character and occurrences of whistlers heard in Eastern and Western North America. Amateur observations could readily address questions of how reception differs between the two coasts and how either coast may differ from mid-continent. More monitors are needed to answer this question definitively.

While the low latitudes (below 20 degrees geomagnetic) reception of VLF phenomena is a good deal more challenging than reception at middle and high latitudes, this also represents an area where relatively little research has been carried out. Patient investigation of the tropical VLF environment might yield some interesting surprises.

Recording Your Catches

You don't have to record the VLF phenomena you hear. If you don't, however, who's going to believe your wild tales of strange sounds overheard while everyone else with any sense is sound asleep? Very little research can be accomplished in the absence of recordings.

Unless you can get your hands on quality portable reel-to-reel or digital tape equipment, standard audio cassettes are certainly the most convenient way to get into whistler recording.

It is Time toCatch a Whistler

During a recent chat with Steve McGreevy he brought up that we are now entering the *Golden Age* of natural radio for three reasons:

1. The Omega radio navigation system has gone away,
2. Sunspots numbers are on the rise, and
3. Two commercially made receivers are now available (plus construction plans for McGreevy's BBB-4 receiver is on the Internet at **http://www.triax.com/vlfradio/bbb4rx3.htm**). It seems to me there has never been a better time to get started in this exciting portion of the radio hobby!

So let's see: 'sferics receiver—check; fresh batteries—check; flashlight—check; and tape recorder—check. OK, folks, how about joining me this weekend and let's go listen to our planet? Why not take the challenge and make a trip to the bottom of the radio spectrum? It's time to go hunting for some natural radio signals and monitor planet Earth. ST

Reading Lightning's Palm

Outside this ragged darkening cloud
air grows heavy, cringes
while inside, tension builds

a forked tongue flickers
squanders all
in one great leap to earth
or to the heavens

air breathes out
-but inside the cloud
tension builds again.

This story older
than recorded history
dinosaurs
our planet's green
-the spark, perhaps
that kindled life.

Looking up, we see it
rip the helpless sky,
we marvel at its power
to scorch forests
wreck cathedrals
put out a city's lights
weave glass serpents
in the desert sand.

Looking down, as now we can,
our globe scintillates
always
-flurries of dagger-strokes
accompanying great storms
over oceans
jungles, mountains

a fireworks show
blazoning messages
in code
which we must crack.

J. Latham

By Lawrence Harris
lawrenceh@ndirect.co.uk

Three New Weather Satellites

The last twelve months have seen three geostationary weather satellites added to the constellation monitoring Earth's weather. In quick succession we have had GOES-10 (US—launched April 1997), Fengyun-2 (China—launched June 10), and, in early September, Meteosat-7 (European).

New European WXSAT

Meteosat-7 is the latest in the series of EUMETSAT geostationary satellites that provide data and images to Europe's weather forecasting centers. It was launched successfully (with the Hot Bird-3 television satellite) by Arianespace on an Ariane-44LP rocket (equipped with two solid and two liquid strap-on boosters) at 2221 UTC on September 2, 1997. Launch was from the Guiana Space Center in Kourou, French Guiana, South America. It entered geostationary transfer orbit (GTO), a highly elliptical orbit with an apogee at the height of the geostationary arc (35,800 km), and perigee within a few hundred kilometers of the Earth. During an early perigee, the apogee boost motor was fired, injecting Meteosat-7 into geostationary orbit.

After Meteosat-7's orbit was confirmed, some further control maneuvers were required to bring the satellite to its correct attitude towards the Earth (the spin axis must be perpendicular to the equator). Spin rate was changed to 100 revolutions per minute, and the orbit was carefully adjusted. All these maneuvers were successfully executed using the on board hydrazine propulsion system.

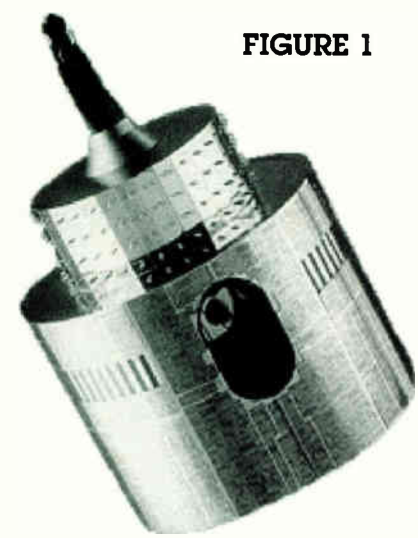


FIGURE 1

FIGURE 2: ***Meteosat-7 first image (Courtesy Eumetsat)***

On September 8, control of Meteosat-7 was handed from ESOC (European Space Operations Center) to EUMETSAT; their control center in Darmstadt handles all commissioning activities. The satellite's systems will be checked out by EUMETSAT's Control Center before Meteosat-7 is declared operational in about three months' time. Before that, I hope to locate its carrier and possibly collect test images.

The new weather satellite's arrival in orbit marks nearly 20 years of European meteorological satellites, the first having been launched in November 1977. Meteosat-7 will serve the national weather services of EUMETSAT's 17 European member states and others in neighboring countries and continents until the first of the Meteosat second generation satellites becomes operational early in the next century. As with data from GOES weather satellites, Meteosat provides an invaluable service which has led to an improvement in weather forecasting and aided the monitoring of climate change.

Fengyun-2

The Fengyun-2 (Chinese) meteorological satellite remains in a stable condition and has sent back many clear photos of the Earth since it was launched on June 10, according to the Chinese Academy of Sciences. The pictures have been shown as part of the weather forecast broadcast by China Central Television (CCTV). The satellite will soon be turned over to the State Meteorological Administration. Information courtesy *China Daily.*

One From Each

As at late-September, and probably for several weeks yet, the operational polar weather satellites remain NOAA-12, NOAA-14, and METEOR 3-5. Remembering that

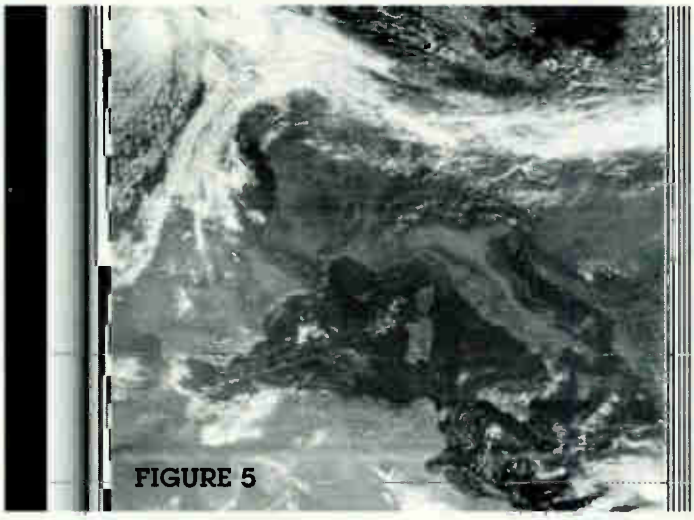
Although the recommended size for a Meteosat WEFAX dish is about 2.4-meters, most users have a dish of 1-meter, resulting in the unwanted reception of the standby Meteosat satellite. In the United Kingdom, local authorities frown on any dish larger than 90-cm.

new readers may be unfamiliar with what we all take for granted, I am including one image from each of these weather satellites to show what can be received with a basic APT (automatic picture transmission) receiving system.

Figure 3 shows the seasonal channel change which occurs as NOAA-12 crosses the terminator from night-time (to the east), into late autumnal daytime, causing the thermal infrared channel to switch to visible-light. As fall progresses into winter, so the change becomes later and later, finally remaining nighttime throughout the pass.

Figure 4 shows the infrared (water vapor) channel on the left, and the thermal infrared channel on the right-hand side. Calibration grayscales and minute markers are seen on the image edges.

The CIS (Russian) weather satellite Meteor 3-5—see figure 5—only transmits over land which is in daylight.



METEOR 3-5 image September 19 at 1050 UTC, showing image scan line fault.

Satellite WEFAX Testing

There are several weather satellites located at various positions along the geostationary arc, and when one or the other is tested, reports are heard concerning the effect the transmissions have on those people (the majority of us) using moderate sized dishes. During early September, reports of a third GOES carrier were reported in the Internet WXSAT forum.

NOAA-12 September 20 at 1732 UTC

NOAA-14 Aug 30 0251 UTC (descending) overnight infrared image

Samuel Patterson of NESDIS quickly responded to queries and explained, "There is a WEFAX carrier on GOES-10 which is located at 104 degrees West. The carrier was brought up to provide heat to the WEFAX transponder during eclipse. We also think this carrier is causing the interference (diagonal/herringbone effect) on the GOES-8 and GOES-9 WEFAX products. We are working with the Wallops CDA and the Satellite Operations Control Center to alleviate the interference."

Meanwhile GOES-E (currently 8) and GOES-W (currently 9) operate from 74 degrees West and 135 degrees West respectively. GOES-10 remains an on-orbit spare in case of failure of either satellite.

Meteosat users occasionally report such interference during similar tests. Meteosat-6 is the current European WXSAT, operating from zero degrees longitude. Meteosat-5 (and now -7) has been periodically powered up for tests as the backup, and its carrier is easily received by anyone with a smaller than optimum dish. Suppliers of Meteosat receiving equipment have been able to use ever smaller dishes as improvements to electronic component noise figures have been achieved. Although the recommended size for a Meteosat WEFAX dish is about 2.4-meters, most users have a dish of 1-meter, resulting in the unwanted reception of the standby Meteosat satellite.

In the United Kingdom, local authorities frown on any dish larger than 90-cm, and require planning permission before one can be used—at least that is the theory!

WEFAX Format Change

Well, just a small one! The information processing division (IPD) at NOAA implemented a change to the polar WEFAX products of GOES-8 and GOES-9 on September 16, 1997, when a modification to add a 16 step grayscale immediately after the binary coded header was implemented—see figure 6. Even with the addition of the grayscale, the transmission window remains less than three minutes and forty seconds, its maximum allotted time.

FIGURE 6

Goes Gray Scale: new gray-scale section on GOES WEFAX images.

The grayscale is 5 seconds (20 lines) in duration, and has 16 segments going left to right from total black (numerically 0) to total white (numerical 255). Segments are

The Moon is clearly seen in this GOES-8 WEFAX picture (figure 7) from Roger Beale, received on August 22, 1997, at 2130 UTC. This type of image (showing the Moon) is not seen on Meteosat images because the Moon is edited out during image processing.

linear, so have values of 0, 17, 34, 51, up to 255.

INTERNET Web Sites Update

While downloading from one of the main GOES image sites, the geostationary satellite browse server appeared slightly slower than usual—remember that I am downloading from across the Atlantic—so I made a few enquiries. NOAA experienced an increase in Internet web traffic during early September which caused them to limit the number of simultaneous users. Plans have been made to upgrade the servers carrying NOAA information.

http:/www.goes.noaa.gov/messages.html

The website has links to specific image sequences (including sectors and animations) from GOES-8 and 9; the sample image that I collected was less than thirty minutes old. A reliable supplier of current European WXSAT images can be found at:

http://www.ccc.nottingham.ac.uk/pubsat-images.htm

This is Nottingham University's site in Britain and it puts Meteosat WEFAX images on the Internet within minutes of their reception. They are JPEG compressed to about 100-kb. Formats on this site include the GOMS, GMS, some colorized composites, and oddities such as the cloud-top heights and animated sequences, all from Meteosat. Nottingham collects WEFAX images using a 2.5-meter dish. Meteosat primary data is not routinely disseminated via the Internet due to licensing limitations on the data. Only six-hourly images are freely available—these are the only ones unencrypted.

Commercial U.S. Weather Satellite Equipment Suppliers

I am updating my list of sources of U.S. suppliers of weather satellite equipment and propose to include regular summaries in the column. Suppliers are welcome to contact me and provide product release information.

VAS-Data Acquisition Systems (VAS-DAS), Inc. responded to my enquiry about their web page. VAS-DAS is a small independent business with over 15 years experience in satellite imagery and specializes in the manufacturing of GOES GVAR high resolution weather satellite imaging systems. They supply WXSAT Earth stations for GOES-8, -9, and -10 GVAR as complete turn-key systems including dish. An upgrade route for WEFAX/HRPT users is also available.

Solar eclipse June 30, 1992 via Meteosat

http://www.vas-das.com
Email: **roger.beale@vas-das.com**

I confess to being a serious web surfer of weather satellite sites, and the large number of GOES sector and full-disk images on VAS-DAS's site pleasantly surprised me. Many are available for immediate download, and GOES-8 real-time imagery every 15 minutes, including all states at 1-km resolution, is available by subscription.

The Moon is clearly seen in this GOES-8 WEFAX picture (figure 7) from Roger Beale, received on August 22, 1997, at 2130 UTC. This type of image (showing the Moon) is not seen on Meteosat images because the Moon is edited out during image processing.

Hurricane Linda broke some records for a Pacific storm as the strongest hurricane ever— reaching 185 mph! Figure 8 shows a close-up from GOES-8 imaged on September 14.

Many thanks to Roger for providing these images. For (non-Internet) enquiries contact VAS-DAS, INC., VAS-Data Acquisition Systems, Inc., 4014 Bethel Church Rd., Evington, VA 24550-3962. Tel/FAX: 804-525-5202.

Terminology

For newcomers to the WXSAT scene some of the terms used so freely in features can be confusing, especially where terms themselves contain other acronyms. VAS (VISSR Atmospheric Sounder) refers to the sensors on NOAA weather satellites. VISSR is the basic system and is the Visible and Infrared Spin Scan Radiometer, the instrument (basically a telescope) onboard the GOES (and some other weather satellites).

Nostalgia—An Eclipse Viewed by Weather Satellite

Nothing can compare with actually seeing a total eclipse of the sun, but not everyone can manage to visit the locations concerned. A satisfactory alternative for me has been to watch the effects of such eclipses by weather satellite. On June 30, 1992, there was a total eclipse of the sun during which the shadow of the Moon crossed the south Atlantic. I watched it from Plymouth—

Nothing can compare with actually seeing a total eclipse of the sun, but not everyone can manage to visit the locations concerned. A satisfactory alternative for me has been to watch the effects of such eclipses by weather satellite.

using Meteosat images. The huge shadow of the Moon could be seen slowly crossing the ocean.

Figure 9 is a Meteosat primary data (PDUS) whole-disc image recorded at my home shortly after I had set up a PDUS system—the first system produced by the British company Timestep.

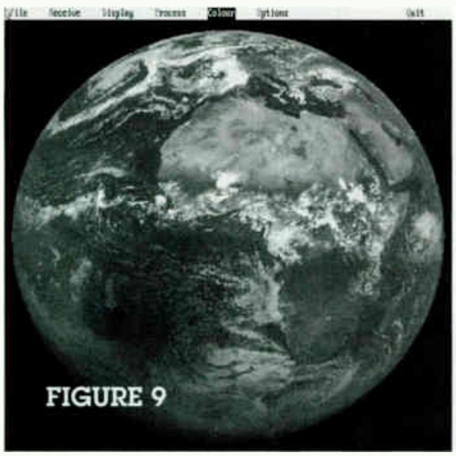


FIGURE 9

Seawifs

The first Seawif images were just being received at presstime (see Fig. 10 right). The frequency is near that of HRPT transmissions—1702.50 MHz. Picture published by courtesy of Dave Cawley of Timestep, and Alex Fox of ORBIMAGE. ST

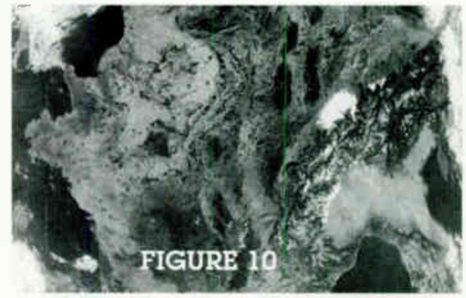


FIGURE 10

Right: Image of Europe September 25 received at Timestep near Cambridge, UK

FREQUENCIES

NOAA-11 beacon on 137.770 MHz
NOAA-12 transmits APT on 137.500 MHz and beacon data on 136.770 MHz
NOAA-14 transmits APT on 137.620 MHz and beacon data on 137.770 MHz
METEOR 3-5 transmits APT on 137.850 MHz
METEOR 2-21 is currently off
OKEAN-4 (1-7) and SICH-1 periodically transmit on 137.400 MHz
GOES-8 (74 degrees West) and GOES-9 (135 degrees West) use 1691MHz for WEFAX
Mir voice can be monitored on 143.625 MHz (FM)

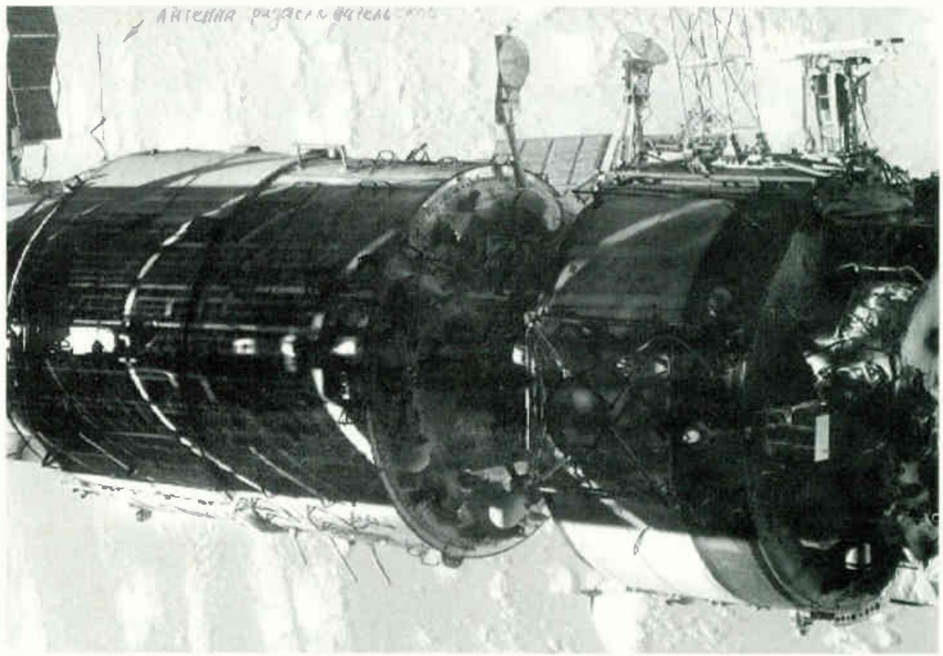
By John Magliacane, KD2BD
magliaco@email.njin.net

Mir Gives UHF a Try

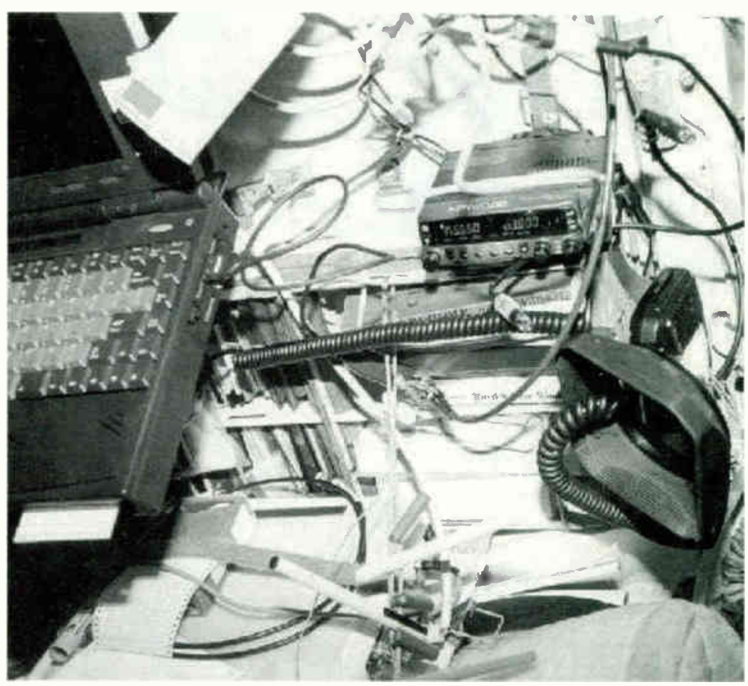
The MIREX team conducted a 70-cm UHF amateur radio communications experiment on-board *Mir* between September 8, 1997, and September 28, 1997. The three week experiment involved moving all amateur radio communications that normally took place on the 2-meter band to the 70-cm band.

The experiment was conducted to investigate the practicality of conducting amateur radio communications with groundstations on the 70-cm band. The biggest problem for groundstations communicating with *Mir* during this period was the difficulty in compensating for as much as 20 kHz of Doppler shift. While accurate Doppler tracking was needed for packet radio communications because of its wide bandwidth, voice communications were less difficult. 70-cm communications on *Mir* experienced no interference with any of *Mir*'s on-board equipment, and the general lack of uplink contention made communications quite pleasurable. Mike Foale, KB5UAC, expressed many positive comments regarding the ease of 70-cm operations and the lack of interference from competing groundstations. Many groundstations got their first chance to make voice contact with *Mir* during the 70-cm experiment.

The move to UHF did cause problems for some groundstations, however. The problems stem from the fact that the 70-cm amateur band is shared with government and commercial services in many parts of the world. Amateurs are considered secondary users of the band, and must accept any interference from primary users. They must also not cause any interference to primary users of the band. In countries such as Guatemala, the government recently seized control of the 70-cm band for commercial purposes, effectively preventing any amateur radio operator in the country from contacting *Mir*. Some stations in Europe also reported experiencing interference from terrestrial sources in their area.



The core module of Mir showing the some external antennas on the spacecraft including an amateur radio dual-band vertical whip antenna on the left-hand side of the image. (NASA Photo)



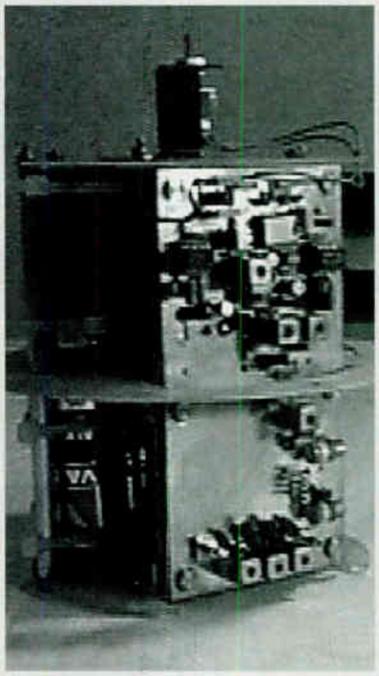
Interior view of Mir showing the Kenwood TM-733 dual-band transceiver used to make voice and packet radio contacts with amateur radio operators on the ground. (NASA Photo)

The move to UHF did cause problems for some groundstations, however. The problems stem from the fact that the 70-cm amateur band is shared with government and commercial services in many parts of the world. Amateurs are considered secondary users of the band.

SAFEX (Space Amateur Funk EXperiment) principal investigator Thomas Kieselbach, DL2MDE, found fault with the three week long experiment on *Mir.* Mr. Kieselbach stated that more lead time was needed prior to the experiment so that amateurs could adequately prepare for the frequency change. In his view, the lack of lead time and lack of adequate preparation on the part of many groundstations will have a significant impact on any experimental data gained through the exercise. Mr. Kieselbach feels that an experiment involving crossband communications may have produced more interesting results since 70-cm simplex communications have already been carried out using the SAFEX module on *Mir.* The Kenwood model TM-733 dual-band FM transceiver and the dual-band exterior whip antenna carried onboard *Mir* are both capable of crossband communications.

Above: Internal view of the Sputnik-1 spacecraft. Batteries used to power the beacon transmitter are visible on the lower level of the structure. (Photo via FR5FC Web Site)

Below: Internal view of Sputnik-1 showing spacecraft electronics. (Photo via FR5FC Web Site)

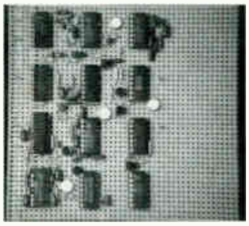


Students Help Celebrate Sputnik's 40th Birthday

On October 4, 1957, *Sputnik 1*, the first man-made satellite was successfully launched in low-earth orbit, thus ushering in the dawn of the space age. *Sputnik 1* was joined less than a month later by *Sputnik 2* on November 3, 1957. *Sputnik 1* decayed in the earth's atmosphere in early January 1958, while *Sputnik 2* survived until April 14, 1958.

To help celebrate the 40th anniversary of *Sputnik 1*'s historic space voyage, the L'Aeroclub of France, and the Russian Aeronautical Federation joined forces to coordinate the construction of a miniature satellite similar in construction to *Sputnik 1.* Students from the Jules Reydellet College in St. Denis, Reunion Island, and the Polytechnic Laboratory of Nalchik Kabaradine, Balkar Republique, were called upon to develop a working model of the original Sputnik satellite that would be hand deployed from the *Mir* space station during an EVA on *Sputnik 1*'s 40th birthday (October 4, 1997). The satellite carries a low-power (100 mW to 200 mW) 2-meter VHF-FM beacon transmitter that emits a pulsating tone similar to the original Sputnik. The audio frequency of the tone is a function of the internal temperature of the spacecraft in keeping with the design and operation of the original Sputnik. Its lifetime in orbit is expected to be between one and two months.

A New 9600 Baud Modem is Born



A new 9600 baud frequency shift keying (FSK) modem for terrestrial and satellite communications was developed by your *ST* amateur satellite columnist (KD2BD) in August 1997 in just one week's time. The modem was developed due to the need to access the *KITSAT-OSCAR-25* satellite, and almost daily use since its completion on several satellites have proven the design to be both effective and practical.

Unlike previous 9600 baud modem designs such as those by K9NG, G3RUH, and TAPR, the KD2BD design uses commonly available components with no reliance on special EPROMS for transmit waveform generation or bit-clock detection. Since it has been shown that 9600 baud FSK data carries baseband spectral energy down to a few hertz, the KD2BD design uses full DC signal coupling throughout both the modulator and demodulator sections of the modem for maximum performance.

DC coupling to the uplink transmitter can be a bit tricky in some circumstances, but the improvements this coupling method yields in the quality and the stability of the uplink signal over AC coupling make the effort worthwhile. Design details of the KD2BD 9600 baud modem will be covered in a future issue of *Satellite Times.*

RS-12 Makes Up For Loss of RS-10

The *RS-12* satellite was switched from mode KT (15-meters up with both 10 and 2-meters down) to mode A (2-meters up, 10-meters down) in late September to make up for the loss of *RS-10. RS-10*'s loss still

A new UoSAT satellite known as TMSAT-1 is being prepared for launch before the end of the year. TMSAT-1 will offer the amateur satellite community services such as a multi-spectral advanced Earth imaging system and a high speed, store-and-forward digital communication system.

remains a mystery, but one explanation that appears to be gaining strength is that its silence is due to an unfortunate result of a well-intentioned upload made by spacecraft controllers. As *RS-10*'s tenth birthday approached, controllers switched the spacecraft off so that some text celebrating its birthday could be included in the satellite's telemetry transmissions. Spacecraft controllers have not been able to switch *RS-10*'s transponder back on since that time.

While the switch to mode A was welcome news to fans of *RS-10*, those using *RS-12*'s mode KT transponder were very disappointed by the loss of mode KT service. Many exciting DX contacts were being made through *RS-12*'s HF transponder just prior to the switch to mode A. RS satellite users were quick to point out that *RS-12* is also capable of mode KA (15-meters and 2-meters up with 10-meters down), so this mode may be adopted over mode A to help service the needs of all RS satellite users.

TABLE 1:

Message from astronaut Mike Foale, KB5UAC, following the EVA in September to repair damage due to the collision with the Progress vessel earlier in the year.

Stat:	PR
Posted:	09/07/97 19:59
To:	N6CO
From:	R0MIR
@ BBS:	
BID:	
Subject:	*Mir* Status

Anatoli and I had the pleasure of doing the EVA on Saturday, while most of the world was occupied with the sad loss of Princess Diana and her funeral, about which we are also very sad. During the EVA, Anatoli worked much longer than planned to be sure that under the buckled radiator panels there is no deformation of the pressure hull of Spekter. After moving to the area of the broken solar array motor drive foundation, we found that it was significantly out of alignment, suggesting there could be substantial damage under the motor, and therefore the pressure hull. More EVA will be required to investigate further this area. Anatoli was successful in aligning the working arrays properly to the sun, so that *Mir* can now fly in a power efficient attitude without effecting the on-orbit resource of the Soyuz spacecraft because of higher than desirable temperatures of the H2O2 fuel in the descent module.

Personally, this EVA was very rewarding for me, and was different in many ways from my first spacewalk on Shuttle. The suit is well suited to working on *Mir*, and allowed me to use three attachment tethers for translation, the whole time. On shuttle, I was mostly translated around on the end of the arm. This time I was the driver, moving Anatoli around on the end of the Strela 20m crane. I will remember the views of the Earth and Milky Way, and station, in the light of a sickle moon, forever. These night views were possible, because the only external lights we had were those mounted on our helmets, and which I could turn off when appropriate. I hope more people in the future, and many more supporters of human space flight, will one day get the chance to have such experiences as I have been lucky to be granted.

Mike. KB5UAC.

Preparations Being Made for TMSAT-1

A new UoSAT satellite known as *TMSAT-1* is being prepared for launch before the end of the year. *TMSAT-1* will offer the amateur satellite community services such as a multi-spectral advanced Earth imaging system and a high speed, store-and-forward digital communication system. *TMSAT-1* will differ from previous digital communication satellites in that it will employ a downlink transmitter operating at a data rate of 38,400 bits per second, effectively four times faster than any other OSCAR satellite. The reason for the high speed downlink capability is so groundstations can capture data from the Earth Imaging System (EIS) cameras and other on-board experiments in a reasonable amount of time. TMSAT-1 is even equipped with a 76,800 bit per second transmitter, although this transmitter is not expected to be used for normal operations.

TMSAT-1 has broken tradition and employed an on-board computer (OBC) designed around an Intel 386EX micro-controller aided by a 387 math co-processor running at 50 MHz. Prior to commissioning, the OBC will be under the control of a UoSAT-traditional SCOS operating system, but will later be switched to a real-time variant of Unix known as QNX. QNX was selected because its multi-tasking capabilities will help to make the best use of the hardware carried on the spacecraft, and to realize the full processing power of the 386EX micro-controller.

TMSAT-1's proposed orbit will be sun synchronous with an inclination of 98.75 degrees, an orbital period of 101.3 minutes, and an orbital altitude of 821 kilometers.

Groundstations wishing to access *TMSAT-1* must be capable of uplinking 9600 bit per second FSK data on the 2-meter band while receiving the 38,400 bit per second FSK downlink on 70-cm. The format of the high speed downlink from *TMSAT-1* is the same as the 9600 bit per second downlinks from other satellites such as *UoSAT-OSCAR-22*, *KITSAT-OSCAR-23*, *KITSAT-OSCAR-25*, and *FUJI-OSCAR-29*. It will, however, be necessary to operate the groundstation TNC at dissimilar transmit and receive data rates, and requires a 38,400 bps FSK demodulator, a 9600 bps FSK modulator, and an FM detector and wideband IF strip capable of operating satisfactorily over a 65 kHz bandwidth.

The Growing Trend in Satellite Communications

While Phase 3-D's missed launch attempt in September has disappointed many amateurs who enjoy long distance voice and CW communications via satellite, it is important to realize that there is more to amateur satellites than communicating through analog transponders. At the present time, the amateur satellite program's greatest strength is in digital communication satellites. Future plans call for additional satellites carrying digital store-and-forward transponders to be launched over the next few years.

Additionally, it is the digital communications technology employed on OSCAR satellites that makes satellite communications significantly different from those taking place on terrestrial circuits. Even unattended operation is possible. New high-

As a result of the growing trend toward new and innovative communication systems, it is time to get back to basics in amateur radio and begin developing our own inexpensive hardware to meet our growing and changing communications needs.

speed birds such as *TMSAT-1* will effectively make traditional, analog-based, (expensive) OSCAR groundstation equipment obsolete.

As a result of the growing trend toward new and innovative communication systems, it is time to get back to basics in amateur radio and begin developing our own inexpensive hardware to meet our growing and changing communications needs. Large commercial manufacturers have been shown to be reluctant to keep up with our advancements. The "homebrewing philosophy" was the philosophy responsible for the tremendous success of the amateur radio service and for providing many decades of growth. It is the same philosophy needed to keep amateur radio growing into the future.

Get those soldering irons ready! ST

TABLE 2

Astronaut Mike Foale, KB5UAC, provided the following message prior to his departure from the *Mir* space station in September 1997.

Stat:	PR
Posted:	09/28/97 14:50
To:	ALL
From:	R0MIR
@ BBS:	
BID:	
Subject:	*Mir* Status

Well STS-86 made its docking smoothly yesterday, and I must honestly say I am looking forward to seeing my wife Rhonda, daughter Jenna, and 3 yr old son Ian, who my shuttle crew say has grown twice his size, since I last saw him. I will be sad leave my good russian friends Anatoli and Pavel here on *Mir*, but it is now time for me to say goodbye to them, and to all the Hams in the world who have spent the time to talk to us.

Thank you.

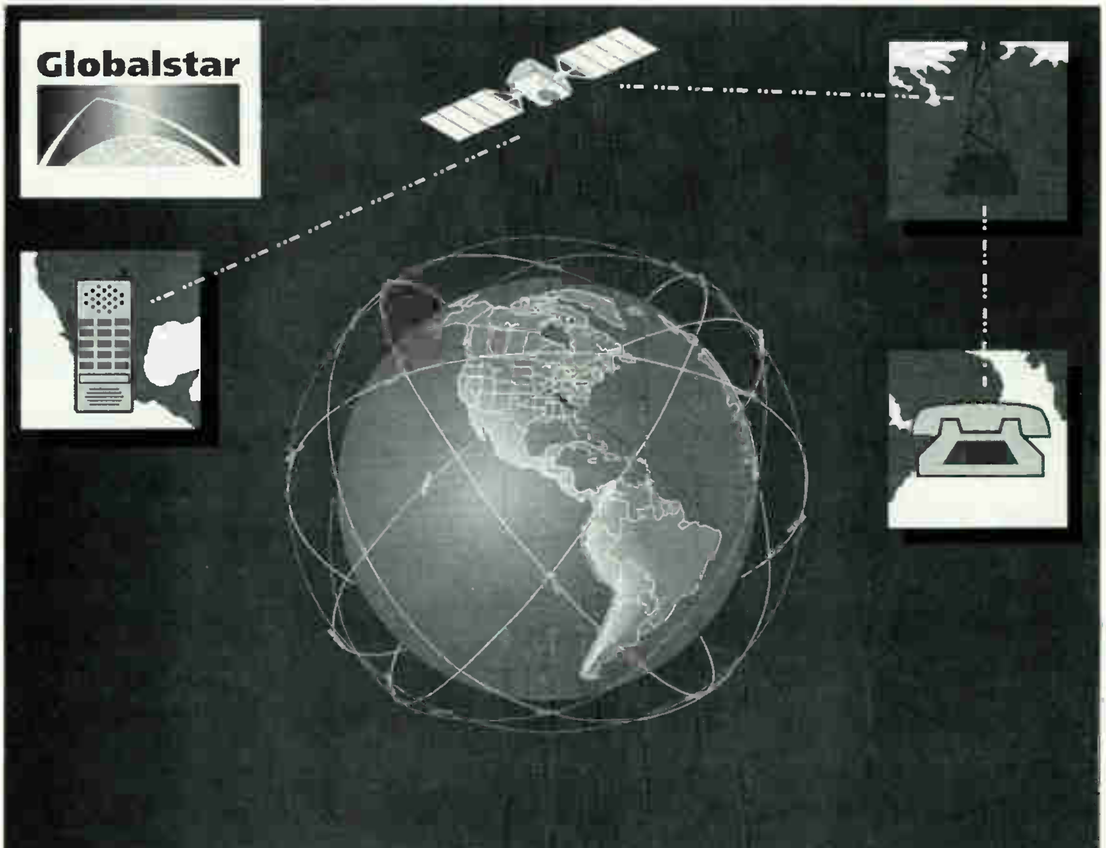
I will be showing David Wolf, my replacement, how to operate the PMS here, and I hope you will enjoy many contacts with him. For now, the 70cm experiment is over. and MIREX will later post its findings.

Best wishes
Michael Foale KB5UAC, NASA 5.

By Donald E. Dickerson, N9CUE

Globalstar Diversity

Diversity is one of the first words that comes to mind when you take a look at Globalstar's proposed Personal Communication Satellite system. It does not, however, begin to describe the unique Globalstar technology. This Spread Spectrum, CDMA, dual band, bent-pipe transmission, 400 mW Global-phone system not only uses right hand circular polarization (RHCP) and left hand circular polarization (LHCP) simultaneously, but also incorporates diversity reception techniques with its unique rake (not Drake) receivers! That should get the attention of just about any steely eyed satellite sleuth. We will come back to the diversity of the system a little later. First, let's get an overview of the satellite system, then delve into the technology behind it.



Globalstar System Satellite Constellation
Orbit Parameters: 759 nautical miles x 52 degrees inclination
Eight orbital planes with six satellites each

The Globalstar constellation will consist of 48 little Earth orbit (LEO) satellites—eight satellites in each of six orbital planes. They will maintain an altitude of 1414 km (870 miles) with an inclination of 52 degrees. This altitude will minimize path loss and allow the antenna to provide a beamwidth covering approximately 3,500 miles. The inclination allows 100 percent coverage between 70 degrees north and 70 degrees south worldwide. This orbit also falls below the Van Allen belt but well above the debris belt. Atmospheric drag is at a minimum at this location and no compensation is required. This means the proper orbit can be maintained with small and economical hydrazine monopropellant propulsion systems.

Not surprisingly the spacecraft uses a Global Positioning System (GPS) receiver to provide position and attitude control. In addition, GPS assists in timing and frequency reference for the satellite payload.

The satellite receives the user signals in the L-band (1610-1626.5 MHz), amplifies it, and converts it to C-band (6875-7075 MHz) for the downlink to the gateway stations. The gateway station also transmits the uplink to the satellite in C-band (5090-5250 MHz). This is amplified and converted to S-band (2483.5-2500 MHz) and transmitted (downlinked) to the customer's hand held unit or Globalphone.

When dealing with frequencies this high one must always be mindful of path loss and possible interruptions of the direct line-of-sight requirements if the system is to maintain signal quality. A row of trees, a mountain, or building can block the signal temporarily in mobile or portable operation. To combat this possibility Globalstar has come up with path diversity. This is simply configuring the satellite constellation so that several satellites (three or four in this case) all see the signal from the customer's location. In order for this system to work each spacecraft must simultaneously link your signal to the gateway station.

Simply put, it is the high-tech, spaceborn version of diversity reception techniques used in conventional terrestrial radio systems. Well, it's a little more compli-

The spacecraft are comparatively simple in that they utilize bent-pipe transmissions or retransmission. This simply means that the satellites do little signal processing on board. The signal that goes up to the satellite is relayed, as-is, to the gateway station where the complicated signal processing takes place.

cated than that. The customer's terminal uses what is called a rake receiver to track a calling signal from each of the spacecraft in its line-of-sight. The hand held unit will access any satellite within range or not being blocked by some natural or man-made object. This multi-path routing of signals provides redundant reliability and ensures signal quality.

The spacecraft are comparatively simple in that they utilize bent-pipe transmissions or retransmission. This simply means that the satellites do little signal processing on board. The signal that goes up to the satellite is relayed, as-is, to the gateway station where the complicated signal processing takes place. This keeps spacecraft cost down: fixing a satellite in space is not cost effective if it can be done at all. Reliability is required.

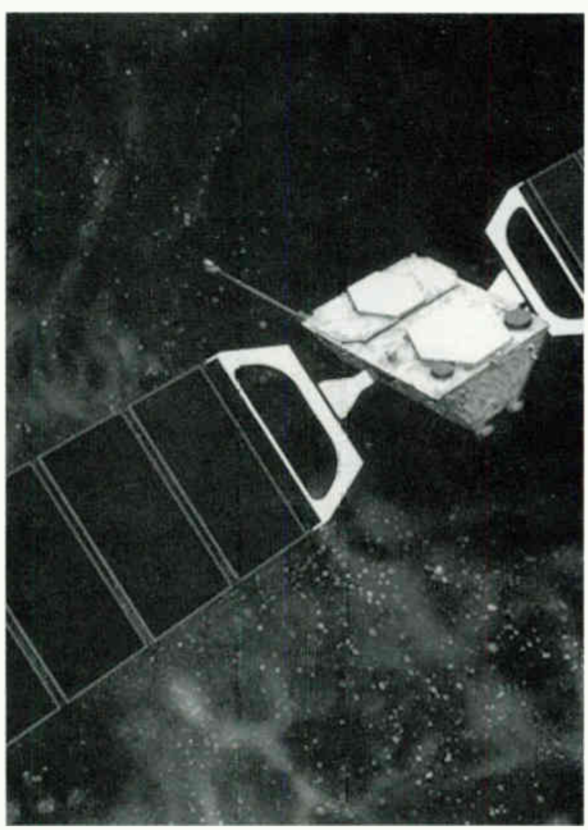
The spacecraft carry a sophisticated array of L- and S-band antenna: A honeycomb-shaped array of 16 spot beams provide wide area coverage. A single spot beam is surrounded by a circle of six spot beams; a second circle consisting of nine beams completes the array. The gain of the antenna increases towards the outside edges of the array. This helps compensate for weaker signals arriving at lower angles and therefore greater distances.

The C-band gateway links use a single beam antenna. It uses FDMA. By transmitting half the signals by RHCP and half by LHCP, the bandwidth requirement is cut in half.

Globalstar is planning to build 100 gateway stations worldwide. These stations will be connected through a digital communications link to the ground operation control centers. These sites will determine capacity allocations of the system and handle billing information. The satellite operation's control center will communicate directly with the spacecraft for housekeeping functions on the C-band link.

Globalstar's first gateway station to be completed was in the village of Aussaguel, just south of Toulouse, France. It uses four 5.5 meter three-axis positioning dish antennas to communicate with the spacecraft. A second gateway station in Yeo-ju, South Korea, is currently under construction.

This Big LEO system will roam and be compatible (interface) with Europe GSM protocol standards and the PLMN standards of North America. In addition, roaming will be possible on the AMPS and MAP standards.



Globalstar is the end product of research done in the 1980s by Qualcomm and Loral Space Systems. These are the fine folks that brought us the CDMA communications standard (see the Sept/Oct 1997 *ST* PCS column for details on CDMA technology). The spread spectrum technology used by Globalstar results in an increased capacity (frequency utilization) over analog systems by a factor of 20. It was thought that the CDMA format might require data rates of up to 9600 bps. With CDMA's much lower duty cycle no more than 2400 bps has been required.

Diversity describes Globalstar's full service communications options. Voice, messaging, data, and fax are just the basics. Caller ID, storage of incoming calls, speed dialing, large memory for storing calls, and much more are available. Globalstar can even set up networks for thousands of user terminals. They not only supply worldwide handheld Globalphones, but they can equip any vehicle or office with a transceiver or desktop satellite phone for your Learjet, oil rig, or remote telephone booth on your own desert island. Check into their website at **http:/www.Globalstar.com**, for more information. With Globalstar, diversity is your only option. Till next time around. ST

SATELLITE LISTENING POST

By Keith Stein
kstein@erols.com

Planetary Exploration and Beyond

So how long will the Energizer bunny last? You know, that little pink rabbit that walks across your TV screen banging his little drum in the Energizer battery commercial. I think we have a serious contest going on here, the Energizer bunny vs. NASA's two Voyager spacecraft, they just keep going, and going, and going ...

But I think Voyager spacecraft has the better track record. They encountered four planets and have now left our solar system. The Energizer bunny has encountered King Kong, Dracula, and Storm Chasers.

Voyager, like all of NASA's other deep space probes, sends back its telemetry data in the S- and X-bands. We will discuss the X-band in a later issue, but for now let's looks at the 2290-2300 MHz region known as the S-band.

NASA's deep space probes use this region of the S-band. The information provided below is on NASA's Deep Space Network, the primary user of the 2290-2300 MHz spectrum.

The Deep Space Network consists of three major locations: Goldstone, Calif; Madrid, Spain; and Canberra, Australia. These are NASA's big guns for keeping contact with their deep space probes. Goldstone, Madrid and Canberra are equipped with dish antennas ranging from 9-meters to 70-meters. I would love to have one of these babies in my backyard (*Your wife probably wouldn't, Keith-editor*). When Voyager passed by Neptune, it took nearly 4.5 hours to send a command to the spacecraft, and the same amount of time to get a response.

Pioneer 6, 7, 8

The primary objective of the Pioneer 6 through 8 missions was to collect scientific data relative to interplanetary phenomena in a range from 119,680,000 to 179,520,000 kilometers (0.8 to 1.2 AU) from the Sun.

Scientific data of particular interest included the characteristics of electric and magnetic fields, electron density along the Earth-spacecraft path, temporal and spatial distribution of plasma, cosmic rays, high-energy particles, and cosmic dust.

Each of the Pioneer spacecraft were launched into heliocentric orbits by a Delta launch vehicle. Following injection, each spacecraft was oriented with its spin axis normal to the ecliptic plane so that the solar panels would be fully illuminated and the high-gain antenna pattern would be aligned with Earth's orbit.

System	Downlink (MHz)
S-band telemetry	2292.407407 MHz
S-band tracking	2292.037037 MHz
Signal Polarization	Linear
Signal Format	PCM (NRZ-L)/PSK PM
Subcarrier Frequency	2048 Hz
Signal Bit Rates	8-512 b/s

Pioneer 10 and 11

Launched on March 2, 1972, Pioneer 10 was the first spacecraft to travel through the Asteroid belt, and the first spacecraft to make direct observations and obtain closeup images of Jupiter. The most remote object ever made by man, Pioneer 10 is over 6.3 billion miles away, and made valuable scientific investigations in the outer regions of our solar system until the end of its mission on March 31, 1997. Pioneer 10 is headed towards the constellation of Taurus (The Bull). It will take Pioneer over 2 million years to pass by one of the stars in the constellation.

Launched on April 5, 1973, Pioneer 11 followed its sister ship to Jupiter (1974), made the first direct observations of Saturn (1979), and studied energetic particles in the outer heliosphere. The Pioneer 11 Mission ended in September 1995, when the last transmission from the spacecraft was received. Its electrical power source exhausted, the spacecraft could no longer operate any of its scientific instruments, nor point its antenna toward Earth.The spacecraft is headed toward the constellation of Aquila (The Eagle), northwest of the constellation of Sagittarius. Pioneer 11 may pass near one of the stars in the constellation in about 4 million years.

System	Downlink (MHz)
S-band telemetry	2292.407407 MHz
S-band tracking	2292.037037 MHz
Signal Polarization	RHCP (Right hand circular polarization)
Signal Format	PCM (NRZ-L)/PSK/PM
Signal Bit Rates	16-2048 b/s

Ulysses

Ulysses is a space mission designed to explore the unknown region of space above the poles of the Sun. The primary objectives of Ulysses is to extend scientific knowledge and understanding through exploration of the Sun and its environment. Its mission is to investigate possible mechanisms coupling solar variability to terrestrial weather and climate by studying the Sun's structure and emission as a function of latitude from the solar equator to the solar poles.

Ulysses consisted of a single European Space Agency (ESA) spacecraft. The spacecraft was launched on October 6, 1990, from the Kennedy Space Center (KSC) by space shuttle *Discovery* using an Inertial Upper Stage (IUS)/Propulsion Assist Module (PAM) to inject the spacecraft into an interplanetary orbit toward Jupiter.

Ulysses flew by Jupiter in February 1992, where a gravity assist maneuver placed the spacecraft in a unique solar polar orbit, allowing it to fly over the south pole of the Sun in 1994 and over the north pole in 1995. With the first phase of its mission successfully completed, Ulysses has now embarked on a second orbit of the Sun, which it will complete in December 2001. Ulysses is a joint project of the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA).

System	Downlink (MHz)
S-band telemetry	2293.148148 MHz
X-band tracking	8408.209876 MHz
Signal Polarization	RHCP (Right hand circular polarization)
Signal Format	PCM (NRZ-L)/PSK/PM
Signal Bit Rates	512-8192 b/s

The Galileo spacecraft, consisting of an orbiter and probe together with an Inertial Upper Stage (IUS), was placed in Earth orbit by space shuttle Atlantis on October 18, 1989. The IUS placed the spacecraft on a trajectory that encountered Venus on February 10, 1990.

Galileo

The purpose of the Galileo mission is to make observations of Jupiter and its satellites using an orbiting spacecraft and an atmospheric entry probe. The mission will determine the chemical composition and physical state of the Jovian atmosphere and its satellites, and the topology and behavior of the magnetic field and energetic particle flux of Jupiter.

The mission followed a Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory starting off a mission duration of approximately 8 years.

The Galileo spacecraft, consisting of an orbiter and probe together with an Inertial Upper Stage (IUS), was placed in Earth orbit by space shuttle *Atlantis* on October 18, 1989. The IUS placed the spacecraft on a trajectory that encountered Venus on February 10, 1990. The first Earth encounter (1,000-km altitude) occurred on December 8, 1992, and that established the final trajectory to Jupiter for a December 7, 1995, arrival date.

The probe was released on July 31, 1995, and entered the Jovian atmosphere just prior to the Jupiter orbit injection (JOI) maneuver. During descent, the Probe transmitted its telemetry data directly to the orbiter for playback to Earth.

The orbiter is now conducting a 23-month, 10-Jovian satellite tour and end of mission is expected December 1997.

System	Downlink (MHz)
S-band telemetry	2295.000 MHz
S-band telemetry	2296.500 MHz
X-band telemetry	8415.000 MHz
X-band telemetry	8420.400 MHz
Signal Polarization	Linear/RHCP (Right hand circular polarization)
Signal Format	PCM (NRZ-L)/PSK/PM
Signal Bit Rates	8-134.4 kb/s*

*Only the 8-16 bits per second data rates are currently available and these are sent through the low gain antenna. The high gain antenna failed early during the mission.

Voyager Interstellar Mission (VIM)

The continuation of the Voyager Project beyond the outer planets is called the Voyager Interstellar Mission. It makes use of both Voyager spacecraft for science from January 1, 1990 through December 31, 2019.

The general mission objectives of the VIM are: to investigate the interplanetary and interstellar media, and to characterize the interaction between the two, along with the continued successful Voyager program of ultraviolet astronomy (more information can be found in this issue in the *Space Watch* column).

System	Downlink (MHz)
S-band telemetry	2295.000 MHz
S-band telemetry	2296.481481 MHz
X-band telemetry	8415.000 MHz
X-band telemetry	8420.432097 MHz
Signal Polarization	RHCP/LHCP (Right hand/ left hand circular polarization)
Signal Format	PCM (NRZ-L)/PSK/PM
Signal Bit Rates	40-7200 b/s

Cassini

Cassini is a deep space mission scheduled for launch as this issue of *ST* goes to press. It is scheduled to arrive at Saturn in June 2004. After arrival, Cassini will send a probe into the atmosphere of one of Saturn's moons—Titan. After the Titan encounter, Cassini will continue to tour Saturn's moons for four years, using repeated gravity assists of Titan to shape the trajectory.

The Cassini mission will accomplish a variety of science objectives during its exploration of the Saturn system. Saturn's atmosphere, rings, satellites and magnetosphere are the prime areas of interest. The chemical composition, physical state, and dynamic behavior of the atmosphere of Titan and Saturn will be examined. The three-dimensional structure and dynamical behavior of the rings and the magnetosphere will be mapped, as well as the interactions between the satellites and the magnetosphere. The satellite investigations will study the atmosphere of Titan and its surface, and map the icy satellite.

The Cassini mission to Saturn is scheduled to cover a 10.7-year period from 1997 to 2008. The spacecraft will be launched from Cape Canaveral using a Titan IV launch vehicle and Centaur upper stage. The Titan will place the Centaur/Cassini into a slightly elliptical orbit with an altitude of approximately 150 km. After separation from the Titan, the Centaur will burn for about two minutes to establish the final parking orbit. Up to 90 minutes later, the Centaur will ignite again and burn for about eight minutes to inject the spacecraft into the interplanetary trajectory. When the burn has been completed, the Centaur will point the minus Z axis of Cassini toward the Sun for attitude acquisition. Cassini will then separate from the Centaur upper stage, establish contact with a Deep Space Network station, and deploy into its cruise configuration.

Following launch, Cassini will use gravity assists with Venus, Earth and Jupiter to obtain the required energy to get to Saturn. The spacecraft will perform maneuvers and calibration activities during the interplanetary cruise, as well as limited science data collection.

System	Downlink (MHz)
S-band telemetry	2295.000 MHz
S-band telemetry	2296.481481 MHz
X-band telemetry	8415.000 MHz
X-band telemetry	8420.432097 MHz
Signal Polarization	RHCP/LHCP (Right hand/ left hand circular polarization)
Signal Format	PCM (NRZ-L)/PSK/PM
Signal Bit Rates	40-7200 b/s

Tracking Stations Say Farewell to the Shuttle

The NASA Madrid, Spain, and Canberra, Australia, tracking stations supported their last space shuttle pass during orbit 138 of the STS-86 mission in October.

Due to major budget reductions imposed by NASA Headquarters and a NASA proposal for a commercial ground network (CGN), the Jet Propulsion Laboratory (JPL) developed a plan to decommission the use of their 26-meter antennas at Madrid and Canberra. A third antenna, at Goldstone, California, will continue providing shuttle support until NASA's Dryden Flight Research Center (DFRC) is upgraded.

A message was read by the STS-86 crew thanking both stations for their support of the manned spaceflight program over the past 32 years.

Satellite Radio Guide

By Robert Smathers and Larry Van Horn

AUDIO SUBCARRIERS

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

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

Classical Music

SuperAudio—Classical Collections	G5, 21	6.30/6.48 (DS)
WFMT-FM (98.7) Chicago, IL—Fine Arts	G5, 7	6.30/6.48 (DS)

Satellite Computer Services

Planet Connect, Planet Systems, Inc 19.2 kbps service	G4, 6	7.398
	T4, 4	7.398
Planet Connect, Planet Systems, Inc 100 kbps service	G1, 9	7.80
	T4, 4	7.80
Skylink, Planet Systems, Inc	G1, 9	7.265
	T4, 4	7.264
	G4, 6	7.264
Storyvision	G5, 3	7.30
Superguide	G5, 7	5.48

Contemporary Music

SuperAudio—*Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
Unidentified station —Upbeat music	GE1,22	5.58
WRR (from Philippines)	G4, 24 (Ku-band)	6.80
WPHZ-FM (96.9) Bremen (South Bend market), IN	G4, 15	6.48, 7.30 (DS)

Country Music

SuperAudio—*American Country Favorites*	G5, 21	5.04/7.74 (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 (English)	T5, 14	6.80
Easy Listening Music (French)	T5, 14	6.20
IAM Radio-easy listening music	G4, 6	7.69
SuperAudio—*Soft Sounds*	G5, 21	5.58/5.76 (DS)
FCC mandated safe-harbor program audio-easy listening music	G3R, 10	6.80
	G5,2	6.80
United Video—easy listening music	C4, 8	5.895 (N)

Foreign Language Programming

Antenna Radio (Greek)	S4, 14	7.80
Apna Sangeet Radio India	T5, 12	6.80
Arab Network of America radio network	GE2, 22	5.80
CBC Radio Canada-East (French)	E2, 1	5.38/5.58 (DS)
	E2, 1	7.36
DZMM-Radyo Patrol (Philippines)	G4, 24 (Ku-band)	6.20
Indian Ethnic Radio	GE1,16	7.38
La Cadena CNN Radio Noticias (CNN Radio News in Spanish)	G5,17	7.56
KAZN-AM (1300) Pasadena, CA—Asian Radio	GE1, 22 (Ku-band)	6.20
RAI Satelradio Italy (Italian)	G7, 14	7.38
Radio Dubai United Arab Emirates (Arabic)	G7, 10	7.48
Radio Maria (Italian)—religious programming	G7, 10	5.80
Radio Maria	G7, 10	8.03
Radio Tropical	GE1,4	7.60
Unidentified station-foreign language	GE-1,22 (Ku-band)	5.80
WCRP-FM (88.1) Guyama, PR (Spanish)—religious	G4, 6	6.53
XEQ-FM (92.9) Mexico City, DF Mexico (Spanish)	M2, 14	7.38
XEW-AM (900) Mexico City, DF Mexico (Spanish), ID-*La Voz de la America Latina*—contemporary music	M2, 8	7.38

Jazz Music

Jazz Worldbeat Radio (2300-0500 UTC)	T4, 15	6.20
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	G5, 2	7.24 (N)
CNN Headline News	G5, 22	7.58
CNN Radio News	GE3, 9	5.62
	G5, 5	7.58
	G5, 22	6.30
Standard News	GE3, 17	5.20
USA Radio Network—news, talk and information	GE3,13	5.01 (ch 1), 5.20 (ch 2)
Virginia News Service/WBVS-AM (670) Clairemont, VA	G5,11	5.94
WCBS-AM (880) New York, NY—news	G7, 19	7.38
WCCO-AM (830) Minneapolis, MN	G6, 15	6.20
WTLT-AM (1480) Charlotte, NC—news/talk	G1R, 17	7.92

Religious Programming

Ambassasor Inspirational Radio	GE3, 15	5.96, 6.48
Brother Staire Radio	G5, 6	6.48
Christian Music Network, Lakeland, FL	GE1, 14	6.20, 7.60
KHCB-FM (105.7) Houston, TX	C1, 10	7.28
Salem Radio Network	GE3,17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
WHME-FM (103.1) South Bend, IN, ID-*Harvest FM*	G4, 15	5.58/5.78
WROL-AM (950) Boston, MA (occasional Spanish)	GE3, 3	6.20
Z-music—Christian rock	G1R, 6	7.38/7.56

Rock Music

SuperAudio—*Classic Hits*-oldies	G5, 21	8.10/8.30 (DS)
SuperAudio—*Prime Demo*-mellow rock	G5, 21	5.22/5.40 (DS)
WCNJ-FM (89.3) Hazlet, NJ/Skylark Radio network—Oldies	GE1, 6	5.80

Sports

Prime Sports Radio—sports talk and information	GE3, 24	5.80

Speciality Formats

Aries In Touch Reading Service	C4,10	7.87
California State Legislature audio	S4, 24	6.80
Colorado Talking Book Network	C1,3	5.60
Ozarkana Satellite Radio network	G4, 6	7.96
SuperAudio—Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
Weather Channel—background music	C3, 13	7.78
Wisdom Radio Network	GE1, 12	7.10
Yesterday USA—nostalgia radio	G5, 7	6.80
	G1R, 24	7.38

Talk Programming

American Freedom radio network	GE1, 7	5.80
For the People radio network	C1, 6	7.50
Friday Night Live (Friday 8 p.m.-12 a.m. ET)	GE1, 6	5.80
Orbit 7 Radio Network	C1, 14	7.48
Radio America Network	C1, 2	5.58
Talk America Radio Network #1—talk programs	GE3, 9	6.80
Talk America Radio Network #2—talk programs	GE3, 9	5.41
Talk Radio Network—talk programs	C1, 5	5.80
United Broadcasting Network	C1, 2	7.50
WOKIE Network—tech talk (network is active when Megabingo is present)	SBS6, 13B (Ku-band)	6.20
World Web News Network	G7, 14	7.70
Worldwide Freedom Radio network	GE1, 7	7.56
WWTN-FM (99.7) Manchester, TN—news and talk	G5, 18	7.38, 7.56

Variety Programming

CBC Radio (occasional audio)	E2, 1	5.78
CBM-AM (940) Montreal, PQ Canada—variety/fine arts	E2, 1	6.12
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 (*Road Gang*-overnight)/BYU Sports	C1, 6	5.58
West Virginia Public Radio	GE1, 12	7.38
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 carrier is known as FM Squared. FM Squared signalsdo not require a video carrier to exist. These signals are similar to audio subcarriers as we know it except that they are normally located below the 5.00 MHz audio subcarrier frequency that a normal satellite receivers can tune to. The new Universal SC-50 can tune these frequencies and was used to update this section.

GE-3 Transponder 13 (C-band)

Ambassador Inspirational Radio: 1.410, 4.470 and 4.650 MHz
Blank audio carriers: 1.050, 3.570 and 3.750 MHz
Focus on the Family
.510 (ch. 1), .780 (ch. 2) and 1.230 MHz
Information Radio Network
3.390 MHz
International Broadcasting Network: 4.830 MHz
USA Radio Network: .330, 5.010 (ch 1) and 5.200 MHz (ch. 2)

GE-3 Transponder 17 (C-band)

Blank audio carriers: 3.570 MHz
Data Transmission: .800 MHz
Focus on the Family: 1.050 and 1.400 MHz
In-Touch—religious: 4.470 MHz
Salem Satellite Network: 4.650, 4.840, 5.010 (ch.1) and 5.200 MHz (ch. 2)
SRN News: .330 MHz
Skylight Radio Network—religious: 1.770 MHz

GE-3 Transponder 24 (C-band)
Data Transmissions: 4.800 MHz

Galaxy 4 Transponder 3 (Ku-band)

Blank Audio Carriers: 1.150, 2.060, 3.250, 3.620, 4.340, 4.400 and 4.450 MHz
Data transmissions: 1.000, 2.950, 3.070 and 3.190 MHz
Generic News: 3.530 MHz (occasional audio)
In-Store audio network ads (various companies): .710, .810, .910, 1.260, 3.440, 3.700, 3.800, 3.880 and 3.970 MHz
Muzak Services .150, .270, .390, .510, 1.360, 1.480, 1.600, 1.720, 1.840, 1.960, 2.190, 2.310, 2.440, 2.560, 2.680, 2.800, 3.340, 4.080 and 4.200 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 4. WEFAX transmissions and Accu-Weather (for subscribing stations) are transmitted on this transponder.

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

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

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

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

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

1178.70 (81.3)	NASA space shuttle audio

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

1207.90 (52.1)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming
1206.70 (53.3)	Data Transmission
1204.45 (55.55)	KJAV-FM (104.9) Alamo, Tex—Spanish language religious programming/ *Nuevo Radio Christiana Network*
1204.25 (55.75)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming
1201.50 (58.5)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming
1201.30 (58.7)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming

Galaxy 4 Transponder 1-Horizontal (C-band)

1443.80 (56.2)	Voice of Free China (International Shortwave Broacaster) Taipei, Taiwan
1443.60 (56.4)	KBLA-AM (1580) Santa Monica, CA—*Radio Korea*
1443.40 (56.6)	Voice of Free China (International Shortwave Broadcaster) Taipei, Taiwan
1438.30 (61.7)	WWRV-AM (1330) New York, NY—Spanish religious programming and music, ID - *Radio Vision Christiana de Internacional*
1436.50 (63.5)	West Virginia Metro News—network news feeds

Galaxy 4 Transponder 3-Horizontal (C-band)

1405.00 (55.0)	Illinois News Network—network news feeds
1404.80 (55.2)	KOA-AM (850)/KTLK-AM (760) Denver, Colo—news and talk radio/Denver Bronocs NFL radio network
1404.60 (55.4)	WGN-AM (720) Chicago, IL—news and talk radio/Chicago Bears NFL radio network
1404.40 (55.6)	Illinois News Network—network news feeds
1404.20 (55.8)	Tribune Radio Networks
1404.00 (56.0)	KFRC-AM (610) San Francisco, CA—oldies music
1402.70 (57.3)	WLAC-AM (1510) Nashville, TN—news and talk/*Road Gang* trucker program (overnight)
1401.80 (58.2)	Michigan News Network—network news feeds
1401.50 (58.5)	Occasional audio/Agrinet—Agriculture news/USA Radio Network—network feeds
1399.60 (60.4)	Talk America Radio Network 1—talk radio
1399.20 (60.8)	Talk America Radio Network 2—talk radio
1399.00 (61.0)	Sports Byline USA/Sports Byline Weekend/*On Computers* radio show
1398.80 (61.2)	United Broadcasting radio network—talk radio
1398.50 (61.5)	Occasional audio
1398.30 (61.7)	WSB-AM (750) Atlanta, GA—news and talk radio
1398.00 (62.0)	Occasional audio

(Continued on Page 42)

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

(Continued from Page 41)

1397.80 (62.2)	Occasional audio
1397.50 (62.5)	Minnesota Talking Book Radio Network-reading service for the blind
1397.30 (62.7)	Occasional audio
1397.10 (62.9)	WTMJ-AM (620) Milwaukee, WI - talk radio/Green Bay Packers NFL radio network/Wisconsin Radio Network—network news feeds
1396.90 (63.1)	WMVP-AM (1000) Chicago, IL—sports talk radio
1396.70 (63.3)	Radio America/American Entertainment Network
1396.40 (63.4)	Georgia Network News (GNN)—network news feeds
1396.20 (63.8)	WCNN-AM (680) Atlanta, GA—all sports talk radio
1396.00 (64.0)	WHO-AM (1040) Des Moines, IA—talk radio/Iowa News Network—network news feeds
1395.80 (64.2)	WTMJ-AM (620) Milwaukee, WI - talk radio/Green Bay Packers NFL radio network/Wisconsin Radio Network—network news feeds
1395.60 (64.4)	WGST-AM/FM (640/105.7) Atlanta, GA ID *Planet Radio*—news and talk radio/Atlanta Falcons NFL radio network
1395.40 (64.6)	Michigan News Network—network news feeds
1395.00 (65.0)	Occasional audio
1394.70 (65.3)	WJR-AM (760) Detroit, MI—news and talk radio/Michigan News Network—network news feeds
1394.50 (65.5)	XEPRS-AM (1090) Tijuana, Mexico—Spanish language programming
1394.30 (65.7)	Occasional audio
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 and talk radio/Denver Broncos NFL radio network
1384.20 (75.8)	WSB-AM (750) Atlanta, GA—news and talk radio
1383.70 (76.3)	Motor Racing Network (occasional audio) NASCAR racing
1383.40 (76.6)	United Broadcasting Network—talk radio
1383.90 (76.9)	KIRO-AM (710) Seattle, WA—news and talk radio/Seattle Seahawks NFL radio network
1382.90 (77.1)	Michigan News Network—network news feeds
1382.60 (77.4)	Soldiers Radio Satellite (SRS) network—U.S. Army information and entertainment radio
1382.00 (78.0)	Tennessee Radio Network—network news feeds
1381.80 (78.2)	WHO-AM (1040) Des Moines, IA - news and talk radio/Iowa News Network—network news feeds
1381.60 (78.4)	KEX-AM (1190) Portland, OR—news and talk radio
1381.40 (78.6)	Occasional audio
1381.20 (78.8)	KJR-AM (950) Seattle, WA - sports talk radio
1377.40 (82.6)	Data transmission (packet burst/tones)
1377.10 (82.9)	In-Touch—reading service for the blind
1376.90 (83.1)	Data Transmissions
1376.00 (84.0)	Kansas Audio Reader Network—reading service for the blind
1375.40 (84.6)	USA Radio Network/Agrinet Agriculture news service

Galaxy 4 Transponder 4-Vertical (C-band)

1376.00 (64.0)	Data Transmissions

Galaxy 4 Transponder 6-Vertical (C-band)

1346.90 (53.1)	WCRP-FM (88.1) Guayama, PR—Spanish language religious programming

Anik E2 Transponder 1-Horizontal (C-band)

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

Anik E2 Transponder 13-Horizontal (C-band)

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

Anik E2 Transponder 17-Horizontal (C-band)

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

Anik E2 Transponder 23-Horizontal (C-band)

1006.00 (54.0)	Radio Canada International (International Shortwave Broadcaster)
1005.50 (54.5)	Canadian Broadcasting Corporation (CBC) Radio-Yukon service

Anik E1 Transponder 21-Horizontal (C-band)

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

SBS5 Transponder 2-Horizontal (Ku-band)

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

SBS5 Transponder 12-Vertical (Ku-band)

1095.00 (91.0)	Russian-American Radio Network

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2)	RFD Radio Service
1404.60 (55.4)	Wyoming News Network—network news feeds
1400.60 (59.4)	Learfield Communications
1400.40 (59.6)	Learfield Communications/Missouri Net.ST. Louis Rams NFL radio network
1400.20 (59.8)	Occasional audio/Data transmissions
1400.00 (60.0)	Learfield Communications
1396.60 (63.4)	Kansas Information Network/Kansas Agnet—network news feeds
1396.40 (63.6)	Nebraska Agriculture Network/University of Nebraska sports
1396.20 (63.8)	Missouri Network
1396.00 (64.0)	Occasional audio
1395.70 (64.3)	Missouri Net/WIBW-AM (580) Topeka, KS—country music
1386.40 (73.6)	Learfield Communications/Kansas City Chiefs NFL radio network
1386.20 (73.8)	Radio Iowa
1386.00 (74.0)	United broadcasting Network—talk radio
1384.60 (75.4)	Capitol Radio Network/Washington Redskins NFL radio network
1384.00 (76.0)	Occasional audio/ABC Direction Network—network news feeds
1383.80 (76.2)	Occasional audio
1383.40 (76.6)	Capitol Radio Network/Carolina Panthers NFL radio network
1382.90 (77.1)	Missourinet
1382.30 (77.7)	Virginia News Network—network news feeds
1382.10 (77.9)	Learfield Communications/Missourinet

RCA C5 Transponder 21-Vertical (C-band)

1045.00 (55.0)	Blank audio carrier
1043.60 (56.4)	Blank audio carrier
1043.40 (56.6)	CNN Radio Network
1043.20 (56.8)	Blank audio carrier
1042.80 (57.2)	Blank audio carrier
1042.60 (57.4)	Blank audio carrier
1042.40 (57.6)	Blank audio carrier
1042.20 (57.8)	Data transmissions
1042.00 (58.0)	Blank audio carrier
1041.80 (58.2)	CNN Radio Network
1034.40 (65.6)	Blank audio carrier
1034.20 (65.8)	Data transmissions
1034.00 (66.0)	Blank audio carrier
1033.20 (66.8)	Blank audio carrier
1032.80 (67.2)	Data transmissions
1032.40 (67.6)	Blank audio carrier

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

Alphastar (United States/Canada)

The Alphastar DBS service is no longer operational. Based on press reports we have received, the company has gone bankrupt.

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™

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

100	Direct Ticket Previews
101-199	Direct Ticket Pay Per View
120/121	Letterbox
140-142	Unknown service (LC)
200	Direct Ticket Previews
202	CNN: Cable Network News
203	Court TV
204	CNN HN: Headline News
205	DirecTV Special Events Calendar
206	ESPN
207	ESPN 2
208	ESPNews
211	DirecTV Sports Schedule
212	TNT: Turner Network Television
213	HSC: Home Shopping Network
214	HGTV: Home and Garden TV
215	TV Food Network
217	E! Entertainment TV
218	DirecTV Access Card Information
220	AMC: American Movie Classics
221	TCM: Turner Classic Movies
222	Romance Classics
224	Direct Ticket Previews
225	STARZ! (East)
226	STARZ! (West)
227	STARZ! 2 (West)
228	STARZ! 2 (East)
230	Encore (East)
231	Encore (West)
232	Encore 2—Love Stories
233	Encore 3—Westerns
234	Encore 4—Mysteries
235	Encore 5—Action
236	Encore 6—True Stories!
237	Encore 7—WAM!
238	Bravo
239	IFC: Independent Film Channel
240	A&E: Arts and Entertainment
241	The History Channel
242	Disney Channel (East)
243	Disney Channel (West)
245	Discovery Channel
246	TLC: The Learning Channel
247	Cartoon Channel
248	Animal Planet
253	USA Network
254	Sci-Fi Channel
256	WGN Chicago, IL
257	Games Show Network
258	The Family Channel
259	WTBS Atlanta, GA
260	Trio
261	QVC Shopping Channel
262	TNN: The Nashville Network
263	CMT: Country Music TV
265	Access Television
267	Platinum Presents Channel
268	BET: Black Entertainment TV
269	MuchMusic USA
271	C-SPAN 1
272	C-SPAN 2
274	Bloomberg Information Television
275	CNBC
276	MSNBC
277	TWC: The Weather Channel
278	FOX News Channel
279	CBC Newsworld International
280	CBS Eye on People
281	CNN International/CNN fN
283	Channel Earth
286	TBN: Trinity Broadcasting
289	America's Health Network
290	WSEE-CBS Erie, PA
291	KPIX-CBS San Francisco, CA
292	WNBC-NBC New York, NY
293	KNBC-NBC Los Angeles, CA
294	PBS National Service
295	WKRN-ABC, Nashville, TN
296	KOMO-ABC Seattle, WA
297	FOXNet
299	Guthy-Renker TV
302	Sports Calendar
304	The Golf Channel
305	Classic Sports Network
306	Speedvision
307	Outdoor Life Channel
308	Platinum Presents Channel
309	SportsChannel New England
310	Madison Square Garden
311	New England Sports Network
312	SportsChannel New York
313	Empire Sports Network
315	Fox Sports Pittsburgh
316	Home Team Sports
317	Fox Sports South
318	Sunshine
319	SportsChannel Florida Sports
320	Fox Sports Detroit
321	SportsChannel Ohio
322	SportsChannel Cincinnati
323	SportsChannel Chicago
324	Midwest SportsChannel
325	Fox Sports Southwest
326	Fox Sports Rocky Mountain
327	Fox Sports Midwest
329	Fox Sports Arizona
330	Fox Sports Northwest
331	Fox Sports West
332	Fox Sports West 2
333	SportsChannel Pacific
337	DirecTV Sports Schedule
340-399	Professional/College Sports Packages
380	DirecTV Sports Calendar
400	Adult Television pay-per-view
401	Spice
402	Playboy
501	Music Choice—Hit List
502	Music Choice—Dance
503	Music Choice—Rap
504	Music Choice—R&B Hits
505	Music Choice—Reggae
506	Music Choice—Blues
507	Music Choice—Jazz
508	Music Choice—Lite Jazz
509	Music Choice—New Age
510	Music Choice—Eclectic Mix
511	Music Choice—Alternative Rock
512	Music Choice—Metal
513	Music Choice—Classic Rock
514	Music Choice—80s Power
515	Music Choice—70s Super Hits
516	Music Choice—Solid Gold Oldies
517	Music Choice—Soft Rock
518	Music Choice—Today's Country
519	Music Choice—Country Horizons
520	Music Choice—Classic Country
521	Music Choice—Easy Listening
522	Music Choice—Big Bands
523	Music Choice—Singers and Standards
524	Music Choice—Show Tunes
525	Music Choice—Classics Favorites
526	Music Choice—Classical Masterpieces
527	Music Choice—Contemporary Christian
528	Music Choice—For Kids Only
529	Music Choice—Sounds of the Seasons
530	Music Choice—Spectrum I
531	Music Choice—Spectrum II
550	Music Choice—Lite Classical
551	Music Choice—EE-Vocals
552	Music Choice—Soft Album Mix
553	Music Choice—The Trend
554	Music Choice—Tropical
555	Music Choice—Mexicana
599	Music Choice-NRTC (realtor channel)
757	Microsoft TV
790	RealNet — Real Estate Channel

USSB

USSB (United States)

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

899	USSB Programming Higlights
900	Special Event programming
905	Special Event programming
910	HBO East
911	HBO 2 East
912	HBO 3
913	HBO West
914	HBO 2 West
916	HBO Family East
917	HBO Family West
920	Showtime East
921	Showtime 2
922	Showtime 3
923	Showtime West
929	FLIX
930	Cinemax East
931	Cinemax 2
932	Cinemax West
940	The Movie Channel East
941	The Movie Channel West
945	Sundance Channel
960	Nick at Nite's TV Land
962	Lifetime TV
963	All New Channel
964	Comedy Central
965	VH1: Video Hits One
966	MTV: Music Television
967	M2: Music Television 2
999	USSB Programming Highlights

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

ECHOSTAR

EchoStar (United States)

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. Liberty sports services are the major coming attractions to DISH.

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
102	USA Network
104	Comedy Central
106	Nick at Nite's TV Land
108	Lifetime
110	TV Food Network
112	HGTV: Home and Garden Network
114	E! Entertainment TV
116	Game Show Network
118	A&E: Arts and Entertainment
120	The History Channel
122	Sci-Fi Channel
124	BET: Black Entertainment TV
132	TCM: Turner Classic Movies
138	TNT: Turner Network Television
140	ESPN
141	ESPN Alternate
142	ESPN2
143	ESPN2 Alternate
144	ESPNews
160	MTV: Music Television
161	M2: Music Television 2
162	VH-1: Video Hits 1
166	CMT: Country Music Television
168	TNN: The Nashville Network
170	Nickelodeon (East)
171	Nickelodeon (West)
172	The Disney Channel (East)
173	The Disney Channel (West)
176	The Cartoon Network
178	TLC: The Learning Channel
180	The Family Channel
182	The Discovery Channel
184	Animal Planet
200	CNN: Cable News Network
202	CNN HN: Headline News
204	Court TV
206	CNN International/CNN fN
208	CNBC
210	C-SPAN 1
212	C-SPAN 2
214	TWC: The Weather Channel
216	NET: National Empowerment TV
220	The Travel Channel
222	HSC: Home Shopping Channel
230	TBS: WTBS Atlanta, GA
232	KTLA Los Angeles, CA
234	WPIX New York, NY
236	WSBK Boston, MA
240	WGN Chicago, IL.
241	WNBC-NBC New York, NY
242	KNBC-NBC Los Angeles, CA
243	WSEE-CBS Erie, PA
244	KPIX-CBS San Francisco, CA
245	WKRN-ABC Nashville, TN
246	KOMO-ABC Seattle, WA
247	FOXNet
249	PBS National Service
260	TBN: Trinity Broadcasting Network
261	EWTN: Eternal Word TV Network
270	The Worship Channel
271	Praise TV
272	FamilyNet
273	Cornerstone TV
274	100 Plus Ministries
275	Home School Channel
300	HBO East
301	HBO 2 East
302	HBO 3 East
303	HBO West
304	HBO 2 West
305	HBO Family
310	Showtime East
311	Showtime West
312	Showtime East 2
318	Sundance
319	FLIX
320	Cinemax East
321	Cinemax East 2
322	Cinemax West
330	The Movie Channel East
331	The Movie Channel West
401	The Golf Channel
412	MSG: Madison Square Garden
414	Fox Sports Rocky Mountain
416	Fox Sports Southwest
417	Fox Sports West
418	Fox Sports Midwest
420	Fox Sports South
422	Sunshine Network
424	Home Team Sports
426	Fox Sports Northwest
428	Fox Sports Pittsburgh
430	Fox Sports Detroit
432	Empire Sports Network
434	New England Sports Network
436	Midwest Sports Channel
500	PPV 1 DISH-on-Demand (events)
501	PPV 2 DISH-on-Demand
502	PPV 3 DISH-on-Demand
503	PPV 4 DISH-on-Demand
504	PPV 5 DISH-on-Demand
505	PPV 6 DISH-on-Demand
506	PPV 7 DISH-on-Demand
507	PPV 8 DISH-on-Demand
508	PPV 9 DISH-on-Demand
509	PPV 10 DISH-on-Demand
551	AgCast (Data Service)
600	RAI (Italy)
602	ART (Arab Radio and Television)
604	Antenna TV Greece
620	MTV Latino
626	Fox Sports Americas
628	Telemundo
700	DISH 2 (Showroom Promo)
900	Strategic Telecom Systems
901	Business TV 2
TBA	Lawyers Communications Network, The Health Channel

DISH CD ™

950	New Country
951	Country Classics
952	Country Currents
953	Jukebox Gold
954	70s Song Book
955	Adult Favorites
956	Adult Contemporary
957	Adult Alternative
958	Hot Hits
959	Classic Rock
960	Modern Rock Alternative
961	Power Rock
962	Non-Stop Hip Hop
963	Urban Beat
964	Latin Styles
965	Fiesta Mexicana
966	Eurostyle
967	Jazz Traditions
968	Contemporary Jazz Flavors
969	Americana
970	Contemporary Instrumentals
971	Concert Classics
972	Light Classical
973	Easy Instrumentals
974	Big Band Era
975	Contemporary Christian
976	Kid Tunes
977	New Age
978	Blues
979	Reggae
980	LDS Radio Network
995	American Family Radio
996	Calvary Satellite Network
997	Bob Jones University Radio

ExpressVu (Canada)

Canadian digital medium power direct-to-home satellite TV service. Expressvu will provide Canadian, American, and international video and audio programs. The service will be offered using Canada's Anik E2 (Ku-band 11-.7-12.2 GHz) satellite at 107.3° West. Channel assignments 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**

Programming: CBC Network, SRC Network (French), TV Ontario, La Chaine Francaise de TV Ontario, Open Learning Agency-Knowledge Network, Saskatchewan Communications Network, Alberta Access-Access Network, Radio Quebec, CTV Network, Global, Quartre Saisons, CFTM-TVA, Atlantic Satellite Network, CPAC (English/French), Television Northern Canada, CFMT-Multicultural TV, CTEQ-Multicultural TV, ExpressVu Electronic Programming Guide, ExpressVu PPV Marketing Channel, ExpressVu Marketing Channel, CFCF (CTV), BCTV (CTV), CFTO (CTV), ATV (CTV), CHCH-Hamilton, CITY-Toronto, CITV-Edmonton, WXYZ-ABC, WTOL-CBS, WUHF-FOX, WDIV-NBC, WTVS-PBS, The Sports Network, Reseau des Sports (French), MuchMusic, Musique Plus, Vision TV, Weather Network, Meteo Media, Canadian Home Shopping Network, Discovery Channel, Showcase, Life Network, Bravo!, WTN, CBC Newsworld, RDI-SRC, Canal Famille, Canal D, TV-5, New Country Network, YTV, Fanily Channel, A&E, Learning Channel, CNN, Headline News, CNBC, Nashville Network, Black Entertainment TV, WGN-Chicago, WPIX-NY, KTLA-Los Angeles, TBS-Atlanta, WSBK-Boston, WWOR-NY, Fairchild TV, Telelatino, The Movie Network, Superchannel, Super Ecran, MoviePix, MovieMax, PPV-30 channels, digital pay audio channels.

Allego audio channels: Just For Kidz, Divertimento, Nos Souvenirs en Musique, Blues Deluzxe, Country Coast-to-Coast, Jazz-Plus, Love Songs, The Beat, Classic Rock,

Direct Broadcast Satellite (DBS) Systems

Hot Hits, The Edge, 70s-90s Superstars, 50s-60s Soundtrack From Your Life, Today's Country, 30s-50s Silver Memories, Rock Leger

Galaxy audio channels: Rock Gold, Brave New Waves, Francophone Pop Rock, Adult Contemporary, Contemporary Hits, Urban Contemporary, Musical Poets, Blues, Chansons of Yesterday, Chansons of Today, The Great Chansons, Celtic, World Roots, Tropical, Country Classics, New Country, Big Band, Classic Jazz, Contemporary Jazz, Light Classics, Music from the Movies, All Baroque, Classical Hits, The Classical Salon, Opera, The Gothic Ages, The New Music, Tranquility Base, For Kids, Pour Penfance

Canadian Radio Stations: CBC-FM Atlantic/Eastern/Pacific, CBW-AM Winnipeg, CBU-AM-Vancouver, CHFI-FM Toronto, CIRK-FM Edmonton, CISN-FM Edmonton, CHFA Edmonton, CFMI-FM Vancouver, CKNM Yellowknife, CKRW-FM Whitehorse, CHON Whitehorse, VOCM St. John's, CBL-AM Montreal (French), CBF-AM Montreal (French), CBM-AM/FM Montreal (English), CKAC Montreal (French), CITE-FM Montreal (French)

Galaxy Latin America (Mexico, Central and South America)

Galaxy Latin America, 2400 East Commerical Boulevard, 9th Floor, Ft. Lauderdale, FL USA
Web site has instructions for obtaining service in each country or write the provider direct.
Web site: **http://www.directvnet.com**
Latin American digital medium power direct-to-home satellite TV service carried on Galaxy 3R at 95° West (Ku-band, 11.7-12.2GHz). Service for Caribbean, Mexico, Central, and South America. Galaxy Latin America will have 144 channels of video (72 channels, 12 transponders in Spanish/72 channels, 12 transponders in Portuguese). Pay-per-view movies (Cinedirect) and events (Direct Events) are available. A 1.1-meter dish is needed to utilize the service. Channel assignments were not available at presstime. Galaxy Latin America (GLA) is backed by DirecTV International, Venezuela's Cisneros Group, Mexico's MVS Multivision, and Televisao Abril.

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 Dos, ESPN South, TV Senado, CMT, MTV Brasil, 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

PRIMESTAR®

Primestar (United States)

Primestar is a medium power Direct-to-Home satellites service carried on GE-2 satellite at 85° West (Ku-band 11.7-12.2 GHz). Primestar uses GE-2 satellite transponders 1-6 and 8-24 transponders).

Primestar Partners, 3 Bala Plaza West, Suite 700, Bala Cynwyd, PA 19004, 1-800-966-9615
Web Site: **http://www.primestar.com**

1-21 News and Info Channels

1	PrimeView One (Information/Preview Channel)
2	Prevue Guide
3	CNN HN: Headline News
4	CNN: Cable News Network
5	CNNSI
6	CNBC
7	CNNfn/CNNI
8	MSNBC
9	MSNBC Weather by Intellicast: Northeast
10	MSNBC Weather by Intellicast: Mid Atlantic
11	MSNBC Weather by Intellicast: Southeast
12	MSNBC Weather by Intellicast: Midwest
13	MSNBC Weather by Intellicast: South Central
14	MSNBC Weather by Intellicast: North Plains
15	MSNBC Weather by Intellicast: Four Corners
16	MSNBC Weather by Intellicast: Southwest (Pacific)
17	MSNBC Weather by Intellicast: Northwest
18	C-SPAN 1
19	C-SPAN 2
20	TWC: The Weather Channel
21	CourtTV

33-43 Broadcast Channels

33	WSB-ABC Atlanta, GA
34	KABC-ABC Los Angeles, CA
35	WUSA-CBS Washington, DC
36	KOIN-CBS Portland, OR
37	WHDH-NBC Boston, MA
38	KCRA-NBC Sacramento, CA
39	WTXF-FOX Philadelphia, PA
40	KTVU-FOX San Francisco, CA
41	PBS National Service
42	WGN Chicago, IL
43	TBS: WTBS Atlanta, GA

44-53 Variety Channels

44	A&E: Arts and Entertainment
45	USA Network
46	TNT: Turner Network Television
47	Nick at Nite's TV Land
48	Comedy Central
49	TNN: The Nashville Network
50	BET: Black Entertainment Television
51	QVC Shopping Channel
52	E! Entertainment TV
53	Game Show Network

66-69 Music Channels

66	VH1: Video Hits 1
67	MTV: Music Television
68	CMT: Country Music TV
69	MuchMusic (U.S.)

77-85 Family Channels

77	Nickelodeon/Nick At Nite
78	Cartoon Network
79	Disney Channel (East)
80	Disney Channel (West)
81	Lifetime
82	Family Channel
83	Sci-Fi Channel
84	Odyssey
85	TBN: Trinity Broadcasting Network

88-93 Living and Learning Channels

88	Discovery Channel
89	TLC: The Learning Channel
90	Animal Planet
91	The History Channel
92	TV Food Network
93	HGTV: Home and Garden TV Net

99-115 Movie Channels

99	Movie Prevue Channel
100	HBO
101	HBO 2
102	HBO 3
103	HBO Family (West)
105	Showtime (East)
106	Showtime 2 (West)
107	Showtime 3 (East)
108	STARZ!
109	STRAZ! 2 (West)
110	Encore
111	Encore Westerns
112	Encore Mystery
114	Cinemax
116	Cinemax 2
117	Sundance Channel
118	IFC: Independent Film Channel
119	TCM: Turner Classic Movies
120	AMC: American Movie Classics
121	Romance Classics

122-143 PrimeCinema Channels

122	Prime Cinema Prevue Guide/Playboy TV
123	PrimeCinema Today (Promo for PPV)
124	PrimeCinema 1
125	PrimeCinema 2
126	PrimeCinema 3
127	PrimeCinema 4
128	PrimeCinema 5
129	PrimeCinema 6
130	PrimeCinema 7
131	PrimeCinema 8
132	PrimeCinema 9
133	PrimeCinema 10
134	PrimeCinema 11
135	PrimeCinema 12
136	PrimeCinema 13
137	PrimeCinema 14
138	PrimeCinema 15
143	Playboy TV

166-215 Sports Channels

166	Sports Prevue Guide
167	ESPN
168	ESPN 2
170	ESPN Alternate

Direct Broadcast Satellite (DBS) Systems

By Larry Van Horn

171	ESPN 2 Alternate
172	CNNSI
173	Classic Sports Network
174	Outdoor Life Network
175	Speedvision
176	The Golf Channel
177	NESN
178	SportsChannel New England
179	MSG
180	SportsChannel New York
181	Empire Sports Network
183	HTS
184	Fox Sports South
185	Sunshine Network
186	SportsChannel Florida
187	Fox Sports Pittsburgh
188	Fox Sports Detroit
189	Fox Sports Midwest
190	SportsChannel Ohio
191	SportsChannel Cincinnati
192	SportsChannel Chicago
193	MSC
194	Fox Sports Rocky Mountain
195	Fox Sports Southwest
196	Fox Sports Arizona
197	Fox Sports Northwest
198	Fox Sports West
199	SportsChannel Pacific
211	Sports Plus 1
212	Sports Plus 2
213	Sports Plus 3
214	Sports Plus 4
215	Sports Plus 5

288-299 Spanish Channels

288	Prevue Guide-Spanish/DMX
289	Univision
290	Cartoon Network
291	Family Channel
292	HBO en Espanol
293	HBO 2 en Espanol
294	HBO 3 en Espanol
295	Showtime En Espanol
296	STARZ!
297	Encore en Espanol
298	Cinemax Selecciones
299	Cimemax 2 Selecciones

311-340 PrimeAudio by DMX

311	Symphonic
312	Bluegrass
313	Children's
314	Christian Inspirational
315	Gospel
316	Contemporary Christian
317	Hottest Hits
318	Alternative Music
319	80s Music
320	Album Rock
321	Adult Contemporary
322	Contemporary Instrumentals
323	Soft Hits
324	Traditional Blues
325	Traditional Country
326	Classic Jazz
327	Modern Country
328	Lite Classical
329	Lite Jazz
330	Folk Music
331	70s Oldies
332	Classic Rock
333	60s Oldies
334	Big Band/Swing
335	50s Oldies
336	Motor City Sound
337	Urban Adult Contemporary
338	R&B/Rap Hits
339	Latin Contemporary
340	Salsa

401-402 Other Channels

401	TV Japan (English)
402	TV Japan (Spanish)

500-699 Sports Channels

501-554	NBA League Pass Package
556-599	NHL Center Ice package
656-699	MLB Extra Innings package
TBA	The People's Network Private Television Network

STAR CHOICE Marketing Inc.

StarChoice (Canada)

Canadian digital medium power direct-to-home satellite TV service. The service will provide English and French language Canadian broadcast networks, specialty and multi-cultural channels, eligible U.S. broadcast networks and specialty channels, and licensed Canadian pay-per-view channels. The receive system must be purchased (manufactured by Echostar) and uses a 24-inch dish. Channel assignments were not available at presstime. This service was formerly known as Direct Choice TV.

Fredericton, New Brunswick Canada
Telephone: 1-888-554-STAR (7827)/506-328-4608
Web site: **http://www.starchoice.com**

Programming: A&E, ABC-E/W, Access Alberta, Atlantic Satellite Network, Bravo, Canal Indigo PPV (French), CBC-E/W, CBC Newsworld, CBS-E/W, CNN, CNN Headline News, CPAC, CTV, CTV (West), CTV-ATV Halifax, CTV News 1, Canal D, Canal Famille, Canal Vie, City TV, Comedy Network-E/W, Country Music TV, Discovery Channel, Family Channel-E/W, FOX-E/W, Headline Sports, History Channel, Home and Garden TV, Le Canal Nouvelles TVA, The Learning Channel, Life, Movie Max, The Movie Network-1/2/3/4, Movie Pix, MuchMusic, MusiMax, Musique Plus, NBC-E/W, The Nashville Network, Outdoor Life, PBS-E/W, RDI, Ruseau des Sports (RDS), SCN, The Shopping Channel, Showcase TV-E/W, Space: The Imagination Station, SRC-E (Montreal)/-W (Calgary), StarChoice Channel Listings and Info-E/W, SuperChannel, Super Ecran-1/2, Telelatino, Tele-Quebec, TeleToon (English/French), TFO East (French), TSN, TQS, TV5-La Television Internationale, TVA-Tele-Metropole, TVO, Treehouse, Viewer's Choice-15 Channels (English), Vision TV-E/W, WGN-Chicago, WSBK-Boston, WTBS-Atlanta, Youth TV-E/W, 30 CD-quality, commercial free music channels

Coming Soon: Black Entertainment TV, CNBC, CTV Sportsnet, Canal Indigo PPV (more offerings), Fairchild (Chinese), KTLA Los Angeles, CA, The Weather Network, WPIX New York, NY, Women's Television Network

Sky TV (Mexico)

Mexican digital medium power direct-to-home satellite TV service. SKY TV, a service which is being offered by News Corp., Brazil's Globo, Mexico's Grupo Televisa and TCI International. The service will provide Spanish language Mexican broadcast networks, specialty channels, eligible U.S. cable channels in Spanish and 48 channels of Sky audio. No additional information is available on channel assignments, equipment, subscription cost, or service contacts is available at presstime. Sky TV is carried on Solidaridad 2 Ku-band at 112.9 degrees.

Programming: 48 Sky Audio channels, Art, Arte, Banda Max, BBC World, Canal 2, Canal 22, Canal 4, Canal Fox, Cartoon Network, Casa Club, Cinecanal, Cinecanal 2, CineCanalb, Cinemax-E/W, CNBC, CNI Canal 40, CNN Espanol, CNN International, Conexion Financiera, Corte Latino, Deutschelle Welle, Discovery Channel, Discovery Kids, E! Latino, ECO, ESPN 2, ESPN International, Estrellas, Family Channel, Film Y Arts, Fox Kids, Fox Sports Americas, Fut Todo Futbol, Galeusca, Galicia TV, Gems, Golden Choice 1/2, Golf Channel, Guadlajara, Hallmark, HBO Ole-E/W, HBO Ole 2, Headline News, Jewish TV, Monterrey, Mosiaco, Movie City-1/2, MSNBC, MTV Latino, Mundo Ole, NHK TV Japan, Nickelodeon, Outdoor Life, RAI, Ritmoson, Sky Promo, Sky Premier PPV, Sky Special-1/2/3/4, Sony, Speedvision, Tele Uno, Telehit, THTV, TNT, Toro, Travel Channel, TV Food, TV5, TVE, Unicable, USA, Warner, Weather Channel, XEIPN Once TV, XEQ-TV Canal 9, XEW-TV Canal 2, XHDF Canal 13, XHGC Canal 5, XHIMT Canal 7, XNTV Canal 4.

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

SBS 6 (SBS6) 74° West

1	11717-H	Data transmissions/FamilyNet [digicipher]
2	11749.5-V	FOX SNG feeds
3	11774-H	MSNBC feeds
4	11798.5-V	Data Transmissions
5	11823-H	Occ video
6	11847.5-V	Unknown user [digital video]
7	11872-H	Occ video
8	11896.5-V	Occ video/[digital video] (occ)
9	11921-H	Occ video
10	11945.5-V	Occ video/CONUS Communications (occ)/ CONUS [digital video] (upper half)
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	Unknown user [digital video]
18	12141.5-V	Occ video
19	12174-H	CNN Newsbeam (occ)

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

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

1	11725-H	Data transmissions

Satcom K2 (K2) 82° West

1	11729-H	Data transmissions
4	11817.5-V	Occ video
6	11876.5-V	Occ video
7	11906-H	Occ video
13	12083-H	Occ video
15	12142-H	GE Americom K2 ID slate

GE-2 (GE2) 85° West

Transponders 1-24 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.

GE-3 (GE3) 87° West

1	11720-H	Data transmissions
11	11920-H	Data transmissions
13	11960-H	NY Lottery feeds (occ)/Occ video
17	12040-H	Oregon EdNet
18	12060-V	PBS leased digital services
19	12080-H	PBS leased analog services/ *The Business Channel*
20	12100-V	PBS adult learning service (ALS)
21	12120-H	PBS High Definition TV testing
22	12140-V	PBS leased digital services
23	12160-H	PBS stations/regionals 1, 2 and 3 [Digicipher 2 SCPC]
24	12180-H	PBS six-channel affiliate feeds [Digicipher 2]

Telstar 4 (T4) 89°West

1	11730-V	Loral Skynet services [digital]
2	11743-H	Loral Skynet services [digital]
3	11790-V	Loral Skynet services [digital]
4	11803-H	Loral Skynet services [digital]
5	11850-V	Loral Skynet services [digital]
7	11910-V	Occ video
8	11923-H	Data transmissions
9	11971-V	Occ video
10	11984-H	Occ video
11	12033-V	South Carolina Educational TV [digicipher]
12	12046-H	Occ video
13	12095-V	Florida Public TV (occ)/Occ video
15	12157-V	DMX for Business [digital data-lower half transponder]
16	12170-H	Unknown User [digital video]

Galaxy 7 (K7) 91° West

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

2	11750-H	Data transmissions
3	11750-V	Indiana Higher Education [Spectrumsaver]
5	11810-H	Data transmissions
8	11870-H	Data transmissions
11	11930-H	Wescott Communications? [Spectrumsaver]
14	11990-H	Occ video (half transponders common)
16	12020-V	Occ video
17	12050-H	Westcott Communications [Spectrumsaver]
17	12050-H	Westcott Communications ASTN [B-MAC]/National Weather Networks (upper half occasional)
18	12050-V	Westcott Communications [Spectrumsaver]
20	12110-H	Data transmissions
23	12170-H	Data transmissions
24	12170-V	Data transmissions

Galaxy 3R (G3R) 95° West

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

Telstar 5 (T5) 97° West

2	11735.0-H	Data transmissions
3	111789.5	Occ video
8	11873.5-H	Data transmissions
9	11898.0-V	Occ video
11	11929.0-V	Occ video
12	11935.5-H	Occ video
13	11960.0-V	Occ video
14	11966.5-H	Data transmissions
17	12022.0-V	Data transmissions
19	12053.0-V	Data transmissions
23	12115.0-V	Data transmissions
26	12152.5-H	Business TV [MPEG2/DVB]
27	12177.0-V	Business TV [MPEG2/DVB]

Galaxy 4 (K4) 99° West

1	11720-H	Data transmissions
2	11750-V	Data transmissions
3	11750-H	FM² services/Muzak/Data transmissions
4	11780-H	FM²/FM³ services/Planet Connect computer service (19.2 kbps)/Other data transmissions
5	11810-V	Data transmissions
6	11810-H	Unknown user [digital video]
7	11840-H	Chinese Television Network *Chung Ten* - Chinese/Taiwan all-news service
8	11870-V	Data transmissions
9	11870-H	Data transmissions
10	11900-H	CNN Airport Network [Powervu]/Data transmissions
11	11930-V	Occ video (half-transponders common)/The Asian Network (TAN)
12	11930-H	Occ video
13	11960-H	Occ video
14	11990-V	Data transmissions
15	11990-H	Fordstar [Digicipher 2]
16	12020-H	FM² services/Data transmissions
17	12050-V	CBS Newsnet and affiliate feeds (half-transponders)
18	12050-H	Honk Kong TVB Jade Channel (Chinese) [videocrypt]
19	12080-H	Unknown User [digital video]
20	12110-V	Data transmissions
21	12110-H	Asian-American TV Network (occ)/Occ video
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

Transponders 19, 21, and 23 have failed on this satellite.

20	11820-H	Data transmissions
22	11980-H	Data transmissions
24	12140-H	Georgia Public TV [Digicipher] (lower half)
24	12140-H	E.M.G. courses [Digicipher] (upper half)

DBS-1 101.2° W./DBS-2 & DBS-3 100.8° W.

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

GE-1 (GE1) 103° West

2	11740-V	Data transmissions
3	11760-H	NBC Eastern Time Zone programming
4	11780-V	Data transmissions
6	11820-V	Empire Sports [Wegener digital]/Kentucky Educational TV (KET) [Digicipher]
7	11840-H	NBC Pacific Time Zone programming
8	11860-V	Qualcomm data [digital]
9	11880-H	NBC Mountain Time Zone programming
10	11900-V	Qualcomm data [digital]
11	11920-H	NBC feeds [Wegner digital] (occ)
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	Serbian TV/TV Polonia [MPEG-2/DVB]
17	12040-H	NBC Contract Channel
18	12060-V	Starnet [Digicipher]
19	12080-H	NBC News Channel [Wegener digital]
20	12100-V	Cyclesat [Digicipher]/Occ video
21	12120-H	NBC/MSNBC/CNBC/NBC NewsChannel SNG feeds [Wegner digital]
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]
4	11913-H	Data transmissions
5	11974-H	Occ video/Court TV Backhauls (occ video)
6	12035-H	CBS NewsNet SNG feeds
7	12096-H	CNN Newsbeam/Occ video
8	12157-H	CNN Newsbeam (occ vdieo)/ CNN Newsource International
9	11744-V	Data transmissions
10	11805-V	Data transmissions
11	11866-V	ABSAT (ABC) SNG feeds
12	11927-V	Data transmissions
13	11988-V	CNN Newsbeam/occ video
14	12049-V	Data transmissions
15	12110-V	CNN Newsource (secondary)/ occ video
16	12171-V	Data transmissions

Anik E2 (A1) 107.3° West

Expressvu DBS service uses transponders 2, 11, 13-14, 21-23, and 32. Star Choice DBS service uses transponders 9-10 and 27-28.

1	11717-V	Telesat Canada DVC: MovieMax!, Family Channel E&W, SuperChannel [digital video]
3	11778-V	CanCom [digital video]
4	11804-V	Shaw [digital video]
5	11839-V	Canadian Parliamentary Access Channel, Youth TV E&W, Vision TV, CHSC Shopping [digital video]
6	11865-V	Moviepix!; The Movie Network [digital video]
7	11900-V	Rogers Network [digital video]
8	11926-V	Rogers Network [digital video]
12	12048-V	Saskatchewan CommunicaNetwork [digital]
15	12144-V	Telesat Canada stationkeeping (GLACS)
16	12170-V	Knowledge Network [digital video]
17	11730-H	Bravo Canada, MuchMusic Canada [digital video]
18	11756-H	Showcase E&W/Discovery Channel Canada/Life Network/ The Sports Network/CBC Newsworld [digital]
19	11791-H	Telesat [digital video compression]
20	11817-H	Telesat [digital video compression]
24	11939-H	Ontario Legislature [Digicipher]
25	11974-H	La Chaine (TV Ontario's French lanaguage service) [Digicipher]
26	12000-H	TV Ontario (English) [Digicipher]
29	12096-H	Atlantic Satellite Network (ASN)
30	12122-H	Telesat Canada stationkeeping (GLACS)
31	12157-H	CBC feeds

Solidaridad 1 SD1 109.2° West

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

Anik E1 (A2) 111° West

Note: Due to loss of power from the satellite south solar panel on March 26, 1996, Anik E1 Ku-band transponders 7-8, 11-16, 21-26, and 29-32 are off indefinitely according to Telesat officials.

1	11717-V	Data transmissions
2	11743-V	Data transmissions
3	11778-V	Data transmissions
4	11804-V	Data transmissions
5	11839-V	DirectPC [digital]
6	11865-V	NovaNet FM² Services
9	11961-V	Occ video
10	11987-V	Occ video
17	11730-H	Woman's Television Network E&W [digital video]
18	11756-H	Data transmissions
19	11791-H	Data transmissions
20	11817-H	SCPC/Data transmissions/ Shaw:New Country Network, Access Network of Alberta [digital video]
27	12035-H	Expressvu DBS
28	12061-H	RDI feeds

Solidaridad 2 (SD2) 112.9° West

Sky TV services can be found in the DBS section of *Satellite Times*. Sky TV uses transponders 1-4, 6-9, 14-16 on SD2.

5	11974-H	Data Transmissions
10	11805-V	Data Transmissions
11	11866-V	Data Transmissions
12	11927-V	Data Transmissions
13	11988-V	Data Transmissions

Anik C3 (C3) 114.9° West (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)

Anik C1 (C1) 118.6° West

32	12183-H	Occ video

EchoStar 1/2 & Tempo 1 119°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	National Technology University (NTU) [Spectrumsaver]
2	11780-H	SCPC services/Data transmissions [Spectrumsaver]
3	11823-H	Data transmissions
4	11872-H	Data transmissions
5	11921-H	Data transmissions
6	11970-H	Data transmissions
7	12019-H	Data transmissions
8	12068-H	Data transmissions
9	12117-H	Data transmissions
10	12166-H	WalMart [V2+]/Occ video
11	11748-V	Data transmissions
12	11898-V	WMNB Russian-American TV [inverted video]
13	11994-V	Data transmissions
14	12141-V	Occ video/Data Transmissions

Satellite Transponder Guide

By Robert Smathers

	Galaxy 6 (G6) 74°	GE-2 (GE2) 85°	GE-3 (GE3) 87°	Telstar 4 (T4) 89°	Galaxy 7 (G7) 91°	Galaxy 3R (G3R) 95°	Telstar 5 (T5) 97°	Galaxy 4 (G4) 99°	Spacenet 4 (S4) 101°	GE-1 (GE1) 103°	Anik E2 (A1) 107.3°
1	Tokyo BS New York feeds	o/v	Data Transmissions/AP TV [MPEG/DVB]	o/v	Sega Channel Interactive [digital]	TVN Theatre 1 [V2+]	Unknown User [digital video]	SCPC services	Data Transmissions	o/v	CBC-H English Eastern
2	o/v	o/v	American Independent Network (AIN) [CLI Spectrumsaver]	Data Transmissions	CBS West [occ VC1]	TVN Theatre 2 [V2+]	(none)	Buena Vista TV distribution	STARZ! 2 [V2+]	Data Transmissions	o/v
3	Gospel Music Television	o/v	WSBK-UPN Boston [V2+]	XXXplore TV (adult) [V2+]	Action PPV [V2+]	TVN Theatre 3 [V2+]	Unknown User [digital video]	SCPC services	Data Transmissions	PBS Alaska/Caribbean 7 [Digicipher]	CBC feeds (occ)
4	Horse Racing [digital video]	La Cadena de Milagro	Nebraska Educational TV (NETV) [4DTV]	Shop at Home	fX East [V2+]	TVN Theatre 4 [V2+]	(none)	Data Transmissions	Encore- Westerns [V2+]	SC Ohio/Cincinnati [V2+]	Cancom [PowerVu]
5	CNN feeds (o/v)	NASA Contract Channel	Univision [V2+]	FOX feeds	fX West [V2+]	TVN Theatre 5 [V2+]	Unknown User [digital video]	4 Media Company feeds	Data Transmissions	Hero Teleport (GEMS/HTV) [Digicipher]	o/v
6	NHK (TV Japan) feeds	o/v	(none)	Eurotica/X! TV Promo (adult) [V2+]	Game Show Network [V2+]	TVN Theatre 6/TVN Promo [V2+]	(none)	Shepherd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	WNBC-NBC New York (PT24E) [V2+]	o/v
7	Video Catalog Channel (VCC)	Data Transmissions	Data Transmissions	Adam and Eve/Spice (adult)/Hot Spice [Digicipher]	The Golf Channel [V2+]	Guthy-Renker TV (infomercials)	o/v	(none)	3BTV	Cornerstone TV (Rel)	CBC-M English
8	Horse Racing [digital video]	Data Transmissions	Data Transmissions	ABC feeds East [LEITCH]	o/v	Pandamerica Home Shopping	ABC NewsOne	Telemundo/Telenoticias [PowerVu]	KOMO- ABC Seattle (PT24W) [V2+]	SC Chicago [V2+]	Global TV [PowerVu]
9	MuchMusic U.S. [V2+]	NASA TV	WPIX-Ind New York [V2+]	Horse Racing [digital video]	CBS Eye on People/WI Sports Network [PowerVu]	TVN Theatre 9 [V2+]	FOX Feeds	WB Dom TV/Network	Data Transmissions	Fox Sports South [V2+]	CBC-B English Atlantic
10	Horse Racing [digital video]	Data Transmissions	Data Transmissions	FOX News Edge	United Arab Emirates TV Dubai	TVN Theatre 10 - adulTVision (adult) [V2+]	FOX Feed East	o/v	FOXNet (PT24E/W) [V2+]	WKRN-ABC Nashville, TN (PT24E) [V2+]	Cancom [PowerVu]
11	o/v	o/v	CNN/SI	Xxxcite (adult) [V2+]	Encore [V2+]	Gem Shopping Network/o/v	Exxxtasy (adult) [V2+]	o/v	STARZ! East [V2+]	Univision [digital video]	CBC-A French [Powervu]
12	TV Asia [PowerVu]/Horse Racing [digital video]	Data Transmissions	Data Transmissions	Horse Racing [digital video]	Romance Classics [V2+]	RAI TV/Infomercials	Exotica (adult) [V2+]	o/v	Hero Teleport Contract Channel	Wisdom Network	Cancom [PowerVu]
13	RTPi (Portugal)	Data Transmissions	SCPC/FM2 services	FOX feeds West	Ovation/CSN/Kaleidoscope/Bloomberg/Box [Digicipher]	Horse Racing [digital video]/o/v	FOX feeds East	o/v	Data Transmissions	Fox Sports South/SC Alternate (occ)/o/v	CBC-C English Pacific
14	Horse Racing [digital video]	USIA Worldnet TV/VOA radio [PowerVu]	Data Transmissions	ABC NewsOne Channel	Independent Film Channel [V2+]	Eurotica Promo (adult)	True Blue (adult) [V2+]	o/v	WWOR-UPN New York [V2+]	SC New England [V2+]	Cancom [PowerVu]
15	Midwest Sports Channel [V2+]	Unknown User [digital video]	KTLA-Ind Los Angeles [V2+]	The X! Channel (adult) [V2+]	Your Choice TV [Digicipher]	o/v	Paramount Syndication/o/v	World Harvest TV (Rel)	Data Transmissions	o/v	Unknown User [digital video]
16	Horse Racing [digital video]	Data Transmissions	CNN International/CNN fN [V2+]	Eurotica (adult) [V2+]	Access Television [Digicipher]	HBO 2 East [V2+]	UPN Network/o/v	CBS West [occ VC1]	NPS Promo Channel	SC Pacific [V2+]	Cancom [PowerVu]
17	o/v	Data Transmissions	FM2 services	FOX feeds	Unknown User [digital video]	Cinemax 2 East [V2+]	o/v	CBS feeds [occ VC1]	(none)	SC Alternates (occ)	CBC-D feeds
18	Unknown user [digital video]	o/v	(none)	PBS National Schedule	Teleport Minnesota/CBS feeds/o/v	Inforamerica TV (Informercials)	o/v	CBS feeds/ Eyemark syndicated feeds	STARZ! West [V2+]	SC New York [V2+]	Telesat [digital video]
19	University Network-Dr. Gene Scott (Rel)	Data Transmissions	Fox Sports Detroit [V2+]	Natl Jewish TV/Exotica Promo (adult) [V2+]	CBS East [occ VC1]	HBO 3 [V2+]	America's Collectibles Network	CBS East [occ VC1]	(none)	National Empowerment TV (Net)	Telesat [digital video]
20	o/v	o/v	(none)	(none)	FOX News Channel	HBO 2 West [V2+]	o/v	CBS East [occ VC1]	(none)	AFRTS [Powervu]	(Inactive)
21	o/v	o/v	SSN Extra [V2+]	ABC feeds West [LEITCH]	BET on Jazz	o/v	ABC West Hot Backup [LEITCH]	CBS feeds/o/v	Data Transmissions	Univision feeds (occ)	Telesat [digital video]
22	Horse Racing [digital video]	Arab Network of America (ANA)	(none)	ABC feeds East [LEITCH]	o/v	Horse Racing [digital video]	ABC East Hot Backup [LEITCH]	o/v	Data Transmissions	Deutsche Welle TV	o/v
23	Worship TV/Praise TV (Rel) [Nokia]	NHK Secondary Feeds	SSN Home Teams Sports (HTS) [V2+]	FOX Feeds	fX Movies [V2+]	3 Angels Broadcasting	o/v	SCOLA [Wegener]/LDS TV (occ)	Data Transmissions	o/v	CBC-E English
24	Horse Racing [digital video]/o/v	o/v	America One	(none)	Intl Channel/Encore Themed Channels [4DTV]	Horse Racing [digital video]	o/v	CBS Newspath	KPIX-CBS San Francisco (PT24W) [V2+]	WSEE-CBS Erie, PA (PT24E) [V2+]	CTV [PowerVu]

SATELLITE SERVICES GUIDE

Satellite Transponder Guide

By Robert Smathers

Solidaridad 1 (SD1) 109.2°	Telesat E1 (A2) 111°	Solidaridad 2 (SD2) 112.9°	Morelos 2 (M2) 116.8°	Galaxy 9 (G9) 123°	Galaxy 5 (G5) 125°	Satcom C3 (F3) 131°	Galaxy 1R (G1) 133°	Satcom C4 (F4) 135°	Satcom C1 (F1) 137°	
Data Transmissions	Data Transmissions	Data Transmissions	Data Transmissions	BBC Breakfast News/Reuters Newsfeeds/o/v	Disney East [V2+]	Family Channel-E/W/ FIT TV/IFE [PowerVu]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	o/v	1
Data Transmissions	(Inactive)	Data Transmissions	Unknown User [digital video]	Reuters Newsfeeds/o/v	Playboy (adult) [V2+]	The Learning Channel [V2+]	Univision/Galavision [PowerVu]	Request TV PPV [Digicipher]	KMGH-ABC Denver [V2+]	2
SCPC services	Data Transmissions	Data Transmissions	Data Transmissions	NHK TV	Trinity Broadcasting (Rel)	Viewer's Choice PPV [digital video]	Encore Themed Services [4DTV]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2+]	3
Data Transmissions	Data Transmissions	Data Transmissions	Data Transmissions	General Communication [digital video]	Sci-Fi [V2+]	Lifetime West [V2+]	TV Food/Outdoor Life Networks [Digicipher]	Lifetime East [V2+]	(none)	4
(none)	Data Transmissions	o/v	(none)	Showtime/TMC/S-DC (West) [4DTV]	CNN [V2+]	Odyssey (Rel)	Classic Arts Showcase	(none)	KDVR-Fox Denver [V2+]	5
Data Transmissions	(Inactive)	Data Transmissions	Unknown User [digital video]	o/v	WTBS-Ind Atlanta [V2+]	Court TV/NW Cable News [4DTV]	Z-Music	Madison Square Garden [V2+]	KCNC-CBS Denver [V2+]	6
Unknown User [digital video]	Data Transmissions	o/v	Data Transmissions	TVN Digital Theaters 1-8 [4DTV]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN FOX Sports West [V2+]	7
Data Transmissions	(Inactive)	Data Transmissions	XHGC canal 5	General Communication [digital video]	HBO West [V2+]	QVC-2 Fashion Channel	Cartoon Network [V2+]	Prevue Guide	NBC-East	8
Multivision DBS [Digicipher]	(Inactive)	(none)	Unknown User [digital video]	TVN Digital Theaters 9-16 [4DTV]	ESPN [V2+]	Music Choice [4DTV]	ESPN2 Blackout [V2+]/SAH	QVC Network	FOX Sports Net Base	9
Mexican Government Channel	(Inactive)	(none)	XEIPN canal 11	TVN Digital Theaters 17-24 [4DTV]	MOR Music	America's Store	MSNBC [V2+]	Home Shopping Network (HSN)	SSN FOX Sports SW [V2+]	10
Multivision DBS [Digicipher]	(Inactive)	Unknown User {digital video]	Unknown User [digital video]	TVN Digital Theaters 25-32 [4DTV]	Family Channel East [V2+]	Prime Network [V2+]	Eternal Word TV Network (Rel)	SpeedVision	Network One 'N1'	11
(none)	o/v	(none)	Data Transmissions	General Communication [digital video]	Discovery West [V2+]	History Channel [V2+]	Valuevision	(none)	Data Transmissions	12
(none)	(Inactive)	(none)	Unknown User [digital video]	TVN Digital Theaters 33-35/GRTV [4DTV]	CNBC [V2+]	The Weather Channel [V2+]	Encore Themed Services [4DTV]	Travel Channel [V2+]	Fox Sports Midwest [V2+]	13
Data Transmissions	o/v	Data Transmissions	XEW canal 2	Sundance Channel [V2+]	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Alternate [V2+]/SAH	California Channel [PowerVu]	KUSA-NBC Denver [V2+]	14
Multivision DBS [Digicipher]	(Inactive)	Data Transmissions	Unknown user [digital video]	Showtime West [V2+]	HBO East [V2+]	Showtime East [V2+]	CNNSI/CNN fn/CNN Intl/CNN Spanish [4DTV]	Animal Planet [V2+]	SC Florida [V2+]	15
ata Transmission	(Inactive)	Data Transmissions	XEIMT Canal 22	General Communication [digital video]	Cinemax West [V2+]	M2: Music Television	Turner Classic Movies [V2+]	Request TV 1 [V2+]	FOX Sports Arizona/Americas [Digicipher]	16
o/v	(Inactive)	(none)	Unknown User [digital video]	Nickelodeon West [V2+]	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	MTV East [V2+]	SSN FOX Sports (alternates) [V2+]	17
o/v	(Inactive)	(none)	(none)	The Movie Channel West [V2+]	TNN [V2+]	TVLand	HBO/Cinemax [4DTV]	Viewer's Choice [Digicipher]	FOX Sports Rocky Mountain [V2+]	18
Data Transmissions	TV Northern Canada [PowerVu]	Data Transmissions	Unknown user [digital video]	MTV West [V2+]	USA East [V2+]	Showtime/TMC/S-DC (East) [4DTV]	Cinemax East [V2+]	C-SPAN 2 [analog]/CSPAN 3 [digital]	FOXNet [V2+]	19
(none)	(Inactive)	(none)	Data Transmissions	General Communication [digital video]	BET [V2+]	Jones Computer/GAC/P-IN [4DTV]	Home and Garden Network [V2+]	Showtime East 2 [V2+]	Unknown User [digital video]	20
Data Transmissions	SCPC services/ Data Transmissions	(none)	Mexican Cable [Digicipher]	ESPNews [V2+]	Knowledge TV	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	FOX Sports West 2 [V2+]	21
(none)	(Inactive)	(none)	XHIMT canal 7	o/v	CNN/HN [V2+]	Animal Planet/Discovery Channel Services [Digicipher]	Nostalgia Channel [V2+]	FLIX [V2+]	SSN FOX Sports NW [V2+] (occ)	22
(none)	(Inactive)	Data Transmissions	Mexican Cable [Digicipher]	Computer Network TV	A&E [V2+]	E! Entertainment TV (East) [V2+]/E! (West) [PowerVu]	HBO/Cinemax [4DTV]	VH-1 [V2+]	KWGN-Ind Denver [V2+]	23
(none)	(Inactive)	(none)	XHDF canal 13	General Communication [digital video]	Showtime/Movie Channel [PowerVu]	Digital Music Express Radio (DMX) [digital audio]	Outdoor Channel	CMT [V2+]	SSN Sunshine Network [V2+]	24

LEGEND:

- Unscrambled/ non-video (white)
- Subscription (grey)
- Not available in U.S. (black)
- o/v = occasional video

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.

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.

International Shortwave Broadcasters via Satellite

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.

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 THE ARABS

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

VOICE OF SAHEL

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

VOICE OF THE IRAQI PEOPLE (CLANDESTINE)

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

WORLD HARVEST INTERNATIONAL RADIO, WHRI-South Bend, Indiana

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

WORLD RADIO NETWORK

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

WRN 1 North American English Program Schedule

Galaxy 5 (125 deg West) tr 6-3.820 GHz V (TBS) 6.8 MHz audio. WRN is also available on cable and local radio stations. WRN program details can be heard at 0625, 1425 and 1955 Eastern Time, and are also available on TBS text page 204. All times below are Eastern Daylight (UTC +4 hours)

0000	RTE Dublin, Ireland-*Irish Collection*
0100	SABC Channel Africa, Johannesburg (Mon-Sat)
	Copenhagen Calling (Sun)
0130	*BBC Europe Today* (Mon-Fri)
	Glenn Hauser's *World of Radio* (Sat)
	UN Radio from New York (Sun)
0200	Polish Radio-Warsaw
0230	Radio Canada International
0300	ABC Radio Australia
0400	Voice of Russia-Moscow
0500	Radio Prague, Czech Republic
0530	Radio Netherlands-Hilversum
0630	YLE Radio Finland
0700	ABC Radio Australia
0800	RTE Dublin, Ireland
0900	Radio Prague, Czech Republic
0930	SABC Channel Africa (Mon-Sat)
	UN Radio from New York (Sun)
1000	YLE Radio Finland
1030	Radio Vlaanderen-Brussels Calling
1100	Radio France International-Paris
1200	Caribbean Tempo from CANA Radio (Mon-Fri)
	Glenn Hauser's *World of Radio* (Sat)
	SABC Network Africa (Sun)
1215	Vatican Radio World News (Mon-Fri)
1230	ORF Radio Austria International
1300	BBC Europe Today (Mon-Fri)
	UN Radio from New York (Sat)
	Copenhagen Calling (Sun)
1330	RTE Dublin, Ireland
1400	Radio Vlaanderen-Brussels Calling
1430	Radio Netherlands-Hilversum
1530	Radio Sweden
1600	Voice of Russia-Moscow
1630	Polish Radio-Warsaw
1700	RTE Dublin, Ireland-*Ireland Tonight* at 1800
1900	Radio Netherlands, Hilversum
2000	ABC Radio Australia
2100	YLE Radio Finland-Helsinki
2130	Radio Sweden
2200	Radio Prague, Czech Republic
2230	ORF Radio Austria International
2300	Polish Radio-Warsaw
2330	Radio Budapest, Hungary

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. "WRN1"
PanAmSat 4 (68.5 deg East). MultiChoice digital direct-to-home service, audio channel 51

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 253 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/Janes *Spaceflight Directory* Editor: Mr. Phillip Clark; Baylin Publications: Dr. Frank Baylin; 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. *#* 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
23730	1995-067A Telecom 2C (France)	3.0E	Dom FSS/Gov-Mil (X/C/Ku)
23712	1995-060A USA 115 (Milstar-2) (US)	4.0E/i	Mil-Comm (P/S/K)
19919	1989-027A Tele X (Sweden)	4.9E#	Reg BSS (Ku)
20193	1989-067A Sirius/Marcopolo 1(BSB R-1)	5.0E	Reg BSS (Ku)
22921	1993-076A USA 98 (NATO 4B)	6.1E/i	Mil-Comm (P/S/X)
22028	1992-041B Eutelsat II F4	7.1E	Reg FSS (Ku)
21056	1991-003B Eutelsat II F2	9.9E	Reg FSS (Ku)
19596	1988-095A Raduga 22 (Russia)	11.2E/i	Dom FSS/Gov-Mil (X/C)
22557	1993-013A Raduga 29 (Russia)	11.8E#	Dom FSS/Gov-Mil (X/C)
22269	1992-088A Cosmos 2224 (Russia)	12.0E#	Mil-Earl Warning (X)
20777	1990-079B Eutelsat II F1	12.9E	Reg FSS (Ku)
21055	1991-003A Italsat 1 (Italy)	13.1E#	Dom-Telephone (S/K/Ka)
24665	1996-067A Eutelsat II F7 (Hot Bird 2)	13.2E	Reg BSS (Ku)
24208	1996-044A Italsat 2 (Italy)	13.2E#	Dom-Telephone/Mob (L/S/ K/Ka)
24931	1997-049A Hot Bird 3	13.5E#	Reg BSS (Ku)
23537	1995-016B Eutelsat II F6 (Hot Bird 1)	13.5E	Reg BSS (Ku)
21803	1991-083A Eutelsat II F3	16.0E	Reg FSS (Ku)
22653	1993-031A Astra 1C	16.8E	Reg BSS (Ku)
23686	1995-055A Astra 1E	19.2E	Reg BSS (Ku)
19688	1988-109B Astra 1A	19.2E	Reg BSS (Ku)
21139	1991-015A Astra 1B	19.3E	Reg BSS (Ku)
23331	1994-070A Astra 1D	20.0E	Reg BSS (Ku)
19331	1988-063B Eutelsat 1 F5 (ECS 5)	21.5E/i	Reg FSS (VHF/Ku)
23842	1996-021A Astra 1F	21.8E	Reg BSS (Ku)
22175	1992-066A DFS 3 (Germany)	23.5E	Dom BSS (S/Ku/K)
18351	1987-078B Eutelsat 1 F4 (ECS 4)	25.5E/i	Reg FSS (VHF/Ku)
23948	1996-040A Arabsat 2A (Arabsat)	25.9E	Reg FSS/BSS (C/Ku)
20659	1990-054A Gorizont 20 (Russia)	25.7E/i	Dom/Gov FSS (C/Ku)
20706	1990-063B DFS 2/Kopernikus (Germany)	28.5E	Dom BSS (S/Ku/K)
24652	1996-062A Arabsat 2B (Arabsat)	30.6E	Reg FSS/BSS (C/Ku)
21894	1992-010B Arabsat 1C (Arabsat)	31.1E#	Reg FSS/BSS (S/C)
23200	1994-049B Turksat 1B (Turkey)	31.2E	Reg FSS (Ku)
15629	1985-025A Intelsat 510	32.9E/i	Int FSS (C/Ku)
20263	1989-081A Gorizont 19 (Russia)	33.7E/i	Dom/Gov FSS (C/Ku)
21821	1991-087A Raduga 28 (Russia)	35.0E/i	Dom FSS/Gov-Mil (X/C)
22963	1993-002A Gals 1 (Russia)	35.8E	Dom BSS (Ku)
23717	1995-063A Gals 2 (Russia)	36.1E	Dom BSS (Ku)
20929	1990-095A USA 65 (DSP F15) (US)	37.4E#	Mil-Early Warning (S/X)
23775	1996-005A Gorizont 31 (Russia)	39.8E#	Dom/Gov FSS (C/Ku)
23949	1996-040B Turksat 1C (Turkey)	42.4E	Reg FSS (Ku)
22981	1994-008A Raduga 1-3 (Russia)	49.1E#	Dom FSS/Gov-Mil (X/C)
23880	1996-034A Gorizont 32 (Russia)	52.8E#	Dom/Gov FSS (C/Ku)
19687	1988-109A Skynet 4B (UK)	52.9E/i	Mil-Comm (P/S/X/Ka)
13040	1982-006A DSCS II E15 (US)	57.0E/i	Mil-IOR reserve operational (S/X)
20203	1989-069B USA 44 (DSCS III A2) (US)	57.0E/i	Mil-IOR primary operational (P/S/X)
23305	1994-064A Intelsat 703	57.0E	Int FSS (C/Ku)
20667	1990-056A Intelsat 604	60.0E	Int FSS (C/Ku)
22913	1993-074A USA 97 (DSCS III B10) (US)	60.0E/i	Mil-IOR primary operational (P/S/X)
20315	1989-087A Intelsat 602	61.4E	Int FSS (C/Ku)
24742	1997-009A Intelsat 801	61.9E	Int FSS (C/Ku)
23839	1996-020A Inmarsat 3 F1	63.9E#	Int Mar (L/C)
21814	1991-084B Inmarsat 2 F3	65.1E#	Int Mar-POR (L/C)
23461	1995-001A Intelsat 704	65.8E	Int FSS (C/Ku)
23636	1995-040A PanAmSat 4 (PAS 4)	68.5E	Int FSS (C/Ku)
23448	1994-087A Raduga 32 (Russia)	70.1E#	Dom FSS/Gov-Mil (X/C)
10669	1978-016A Ops 6391 (FltSatCom 1) (US)	71.3E/i	Mil-IOR Reserve (P-Alpha/S/ X)
23589	1995-027A USA 111 (UFO-5) (US)	71.8E/i	Mil-IOR reserve (P/S/K)
22787	1993-056A USA 95 (UFO-2) (US)	71.9E/i	Mil-IOR primary (P/S)
08882	1976-053A Marisat 2 (US)	72.0E/i	Int Mar-IOR (P/L/C)
13595	1982-097A Intelsat 505	72.1E/i	Int FSS/Mar (L/C/Ku)
22027	1992-041A Insat 2A (India)	73.8E	Dom FSS/BSS/Met (S/C)
23327	1994-069A Elektro 1 (Russia)	76.0E#	Met (L)
23680	1995-054A Luch 1-1 (Russia)	77.0E#	Tracking & Relay SDRN-2 (Ku)
23314	1994-065B Thaicom 2 (Thailand)	78.5E	Reg FSS (C/Ku)
24768	1997-016A Thaicom 3 (Thailand)	78.5E	Reg FSS (C/Ku)
23653	1995-045A Cosmos 2319 (Russia)	79.5E#	Data Relay (C)
21759	1991-074A Gorizont 24 (Russia)	79.9/i	Dom/Gov FSS (C/Ku)
24435	1996-058A Express 2 (Russia)	79.9E	Int FSS (C/Ku)
20643	1990-051A Insat 1D (India)	82.9E	Dom FSS/BSS/Met (S/C)
22836	1993-062A Raduga 30 (Russia)	84.7E#	Dom FSS/Gov-Mil (X/C)
19548	1988-091B TDRS F3 (US)	85.2E/i	Gov-Tracking & Relay (C/S/ Ku)
18922	1988-014A Zhongxing 1 (DFH2A-1/PRC-22) (China)	88.4E/i	Dom FSS (C)
22880	1993-069A Gorizont 28 (Russia)	90.1E#	Dom/Gov FSS (C/Ku)
23731	1995-067B Insat 2C (India)	90.6E	Dom FSS/BSS/Met (S/C/Ku)
23765	1995-003A Measat 1 (Malaysia)	91.4E	Dom FSS/BSS (C/Ku)
22724	1993-048B Insat 2B (India)	93.3E	Dom FSS/BSS/Met (S/C)
22245	1992-082A Gorizont 27 (Russia)	95.9E#	Dom/Gov FSS (C/Ku)
20473	1990-011A Zhongxing 3 (DFH2A-3/PRC-26) (China)	98.1E#	Dom FSS (C)
22210	1992-074A Ekran 20 (Russia)	99.1E/i	Dom BSS (P)
23723	1995-064A AsiaSat 2	100.5E	Reg FSS (C/Ku)
21922	1992-017A Gorizont 25 (Russia)	103.0E/i	Dom/Gov FSS (C/Ku)
24834	1997-029A Fengyun 2B (China)	103.8E#	Met (L)
20558	1990-030A Asiasat 1	105.5E	Reg FSS (C/Ku)
20570	1990-034A Palapa B2R (Indonesia)	107.9E	Reg FSS (C)
23176	1994-040B BS-3N (Japan)	109.5E	Dom BSS (Ku)
21668	1991-060A BS-3B (Yuri 3B)(Japan)	109.5E	Dom BSS (Ku)
24769	1997-016B BSAT-1A (Japan)	109.8E	Dom BSS (Ku)
20771	1990-077A BS-3A (Yuri 3A)(Japan)	109.8E	Dom BSS (Ku)
19710	1988-111A Zhongxing 2 (DFH2A-2/PRC-25) (China)	110.8E#	Dom FSS (C)
23864	1996-030A Palapa C2 (Indonesia)	112.9E	Reg FSS (C/Ku)
14985	1984-049A Zhongxing 5 (Chinasat 5/Spacenet 1)	115.2E#	Dom FSS (C/Ku)
23768	1996-003A Koreasat 2 (Mugunghwa 2)	115.6E	Dom FSS/BSS (Ku)
23639	1995-041A Koreasat 1 (Mugunghwa 1)	115.8E	Dom FSS/BSS (Ku)
21964	1992-027A Palapa B4 (Indonesia)	117.9E	Reg FSS (C)
22931	1993-078B Thaicom 1 (Thailand)	119.9E/d	Reg FSS (C/Ku)
20217	1989-070A GMS-4 (Himawari 4) (Japan)	120.1E/i	Met (P/L)
24798	1997-021A Zhongxing 8 (DFH 3-2) (China)	124.8E	Dom (C)
23649	1995-043A JCSAT 3 (Japan)	127.9E	Dom FSS (Ku)
21132	1991-014A Raduga 27 (Russia)	127.9E/i	Dom FSS/Gov-Mil (X/C)
23651	1995-044A N-Star 1 (Japan)	131.8E	Dom/Mob FSS (S/C/Ku/Ka)
23781	1996-007A N-Star 2 (Japan)	133.5E	Dom/Mob FSS (S/C/Ku/Ka)
23943	1996-039A Apstar 1A (China)	133.9E	Reg FSS (C)
23185	1994-043A Apstar I (China)	138.0E	Dom BSS (C)
23522	1995-011B GMS-5 (Himawari 5) (Japan)	139.8E#	Met (P/L)
20953	1990-102A Gorizont 22 (Russia)	140.2E/i	Dom/Gov FSS (C/Ku)
17706	1987-029A Palapa B2P (Indonesia)	141.9E#	Reg FSS (C)
23108	1994-030A Gorizont 30 (Rimsat 2)	142.0E#	Reg FSS (C/Ku)
24880	1997-036A Superbird C (Japan)	144.0E	Dom FSS (Ku/K)
24901	1997-042A Agila 2 (Philippines)	144.2E#	Dom FSS (C/Ku)
20923	1990-094A Gorizont 21 (Russia)	144.3E/i	Dom/Gov FSS (C/Ku)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
19874	1989-020A JCSAT 1 (Japan)	147.9E	Dom FSS (Ku)
20066	1989-046A USA 39 (DSP F14) (US)	145.4E/i	Mil-Early Warning (S/X)
24653	1996-063B Measat-2 (Malaysia)	147.9E	Dom FSS/BSS (C/Ku)
18316	1987-070A ETS V/Kiku 5 (Japan)	149.9E/i	Experimental (L/C)
24732	1997-007A JCSAT 4 (Japan)	150.0E#	Dom FSS (Ku)
23779	1996-006A Palapa C1 (Indonesia)	150.4E	Reg FSS (C/Ku)
18350	1987-078A Optus A3 (Aussat K3)	152.0E#	Dom FSS/BSS (Ku)
19508	1988-086A CS 3B (Sakura 3B) (Japan)	153.8E	Dom FSS (C/K)
20402	1990-001B JCSAT 2 (Japan)	154.0E	Dom FSS (Ku)
23227	1994-055A Optus B3 (Australia)	156.0E	Dom BSS/Mob (L/Ku)
12994	1981-119A Intelsat 503	157.1E/i	Int FSS (C/Ku)
22253	1992-084A Superbird A1 (Japan)	158.0E	Dom FSS (Ku/K)
22087	1992-054A Optus B1 (Aussat B1)	160.0E	Dom BSS/Mob (L/Ku)
22907	1993-072A Gorizont 29 (Rimsat 1)	160.7E#	Reg FSS (C/Ku)
15873	1985-055A Intelsat 511	161.2E/i/d	Int FSS (C/Ku)
21893	1992-010A Superbird B1 (Japan)	161.9E	Dom FSS (Ku/K)
16275	1985-109C Optus A2 (Aussat 2)	164.0E/i	Dom BSS (Ku)
23175	1994-040A PanAmSat 2 (PAS-2)	168.9E	Int FSS (C/Ku)
12046	1980-087A OPS 6394 (FltSatCom F4)(US)	172.9E/i	Mil-POR reserve (P-Bravo/S/X)
24846	1997-031A Intelsat 802	174.0E	Int FSS (C/Ku)
22719	1993-046A USA 93 (DSCS III B9) (US)	175.0E/i	Mil-WPAC primary operational (P/S/X)
23124	1994-034A Intelsat 702	176.9E	Int FSS (C/Ku)
24674	1996-070A Inmarsat 3 F3	178.4E/i	Int Mar (L/C)
20918	1990-093A Inmarsat 2 F1	178.9E#	Int Mar-IOR (L/C)
22871	1993-066A Intelsat 701	179.9E	Int FSS (C/Ku)
16117	1985-092C USA 12 (DSCS III B5) (US)	180.0E/i	Mil-WPAC reserve operational (P/S/X)
23467	1995-003A USA 108 (UFO-4) (US)	177.9W/i	Mil-POR (P/S/K)
19121	1988-040A Intelsat 513	177.1W#	Int FSS (C/Ku)
21639	1991-054B TDRS F5 (US)	174.3W	Int FSS/Gov-Tracking & Relay (C/S/Ku)
23613	1995-035B TDRS F7 (US)	170.8W#	Int FSS/Gov-Tracking & Relay (C/S/Ku)
18631	1987-100A Raduga 21 (Russia)	169.8W/i	Dom FSS/Gov-Mil (X/C)
20499	1990-016A Raduga 25 (Russia)	169.7W/i	Dom FSS/Gov-Mil (X/C)
21392	1991-037A Satcom C5 (Aurora II)(US)	138.9W	Dom FSS (C)
20945	1990-100A Satcom C1 (US)	137.0W	Dom FSS (C)
23581	1995-025A GOES 9 (US)	135.3W#	Met (P/L/S)
22096	1992-057A Satcom C4 (US)	135.1W	Dom FSS (C)
21873	1992-006A USA 78 (DSCS III B14) (US)	135.0W/i	Mil-EPAC primary operational (P/S/X)
23016	1994-013A Galaxy 1R (US)	133.0W	Dom FSS (C)
22117	1992-060B Satcom C3 (US)	131.0W	Dom FSS (C)
13637	1982-106B DSCS III A1 (US)	130.2W/i	Mil-EPAC reserve operational (P/S/X)
21906	1992-013A Galaxy 5 (US)	125.1W	Dom FSS (C)
19484	1988-081B SBS 5 (US)	123.0W	Dom FSS (Ku)
23877	1996-033A Galaxy 9 (US)	122.9W	Dom FSS (C)
22988	1994-009A USA 99 (Milstar 1) (US)	120.0W	Mil-Comm (P/S/K)
15826	1985-048D Telestar 3D (303) (US)	120.0W#	Dom FSS (C)
24313	1996-055A Echostar 2 (US)	119.6W	Dom BSS (Ku)
24748	1997-011A Tempo 2 (US)	118.8W	Dom BSS (Ku)
23754	1995-073A EchoStar 1 (US)	118.8W	Dom BSS (Ku)
16274	1985-109B Morelos 2 (Mexico)	116.9W	Dom FSS (C/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)
23846	1996-022A MSAT M1 (Canada)	106.5W	Dom Mobile (L/X)
08747	1976-023B LES 9 (US)	105.6W/i	Mil-Experimental (P/Ka)
19483	1988-081A Gstar 3 (US)	105.3W/i	Dom FSS/Mob (L/Ku)
03029	1967-111A ATS 3 (US)	105.3W/i	Experimental (VHF/C)
15677	1985-035A Gstar 1 (US)	105.1W#	Dom FSS (Ku)
20946	1990-100B Gstar 4 (US)	105.0W	Dom FSS (Ku)
23696	1995-057A USA 114 (UFO-6) (US)	104.4W/i	Mil-CONUS (P/S/K)
24786	1997-019A GOES 10 (USA)	104.2W	Met (P/L/S)
24315	1996-054A GE-1 (US)	103.1W	DOM FSS (C/Ku)
23435	1994-084A USA 107 (DSP F17) (US)	103.0W#	Mil-Early Warning (S/X)
22930	1993-078A DBS 1 (US)	101.3W	Dom BSS (Ku)
21227	1991-028A Spacenet 4 (US)	101.1W	Dom FSS (C/Ku)
23553	1995-019A AMSC 1 (US)	101.0W	Dom Mobile (L/X)
23598	1995-029A DBS 3 (US)	100.9W	Dom BSS (Ku)
23192	1994-047A DBS 2 (US)	100.8W	Dom BSS (Ku)
22796	1993-058B ACTS (US)	100.1W	Experimental (C/K/Ka)
17181	1986-096A USA 20 (FltSatCom F7)(US)	99.8W/i	Mil-CONUS (P/S/X/K)
22694	1993-039A Galaxy 4 (US)	99.1W	Dom FSS (C/Ku)
17561	1987-022A GOES 7 (US)	98.1W	Met (P/L/S)

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
24812	1997-026A Telstar 5 (US)	97.1W	Dom FSS (C/Ku)
23741	1995-069A Galaxy 3R (US)	95.1W	Dom/BSS (C/Ku)
08746	1976-023A LES 8 (US)	94.9W/i	Mil-Experimental (P/Ka)
16650	1986-026B SBTS 2 (Brazil)	92.1W#	Dom FSS (C)
22205	1992-072A Galaxy 7 (US)	91.1W	Dom FSS (C/Ku)
23670	1995-049A Telstar 402R (US)	89.0W	Dom FSS (C/Ku)
24936	1997-050A GE-3 (US)	87.2W	Dom FSS (C/Ku)
24713	1997-002A GE-2 (US)	85.0W	Dom FSS (C/Ku)
16276	1985-109D Satcom K2 (US)	81.0W#	Dom FSS (Ku)
15561	1985-015B SBTS 1 (Brazil)	79.1W/i	Dom FSS (C)
15235	1984-093B SBS 4 (US)	77.1W/i	Dom FSS (Ku)
12309	1981-018A Comstar D4 (US)	76.5W/i	Dom FSS (C)
23051	1994-022A GOES 8 (US)	74.9W#	Met (P/L/S)
20873	1990-091B Galaxy 6 (US)	74.1W	Dom FSS ©
20872	1990-091A SBS 6 (US)	74.1W	Dom FSS (Ku)
24714	1997-002B Nahuel 1A (Argentina)	71.9W	Dom FSS (Ku)
23199	1994-049A Brazilsat B1 (Brazil)	70.1W	Dom FSS (C)
21805	1991-080B USA 75 (DSP F16) (US)	70.0W#	Mil-Early Warning (S/X)
23536	1995-016A Brasilsat B2 (Brazil)	65.0W	Dom FSS (C/X)
24916	1997-046A PanAmSat 5 (PAS 5)	58.1W	Reg BSS (C)
16101	1985-087A Intelsat 512	55.6W/i	Int FSS (C/Ku)
21149	1991-018A Inmarsat 2 F2	55.0W/i	Int Mar-AOR-W (L/C)
24819	1997-027A Inmarsat 3 F4	54.1W#	Int Mar-AOR-W (L/C)
23571	1995-023A Intelsat 706	53.1W	Int FSS (C/Ku)
23628	1995-038A USA 113 (DSCS III B4) (US)	52.5W/i	Mil-WLANT primary operational (P/S/X)
23915	1996-035A Intelsat 709	50.1W	Intl FSS (C/Ku)
22314	1993-003B TDRS F6 (US)	46.9W	Int FSS/Gov-Tracking & Relay (C/S/Ku)
19217	1988-051C PanAmSat 1 (PAS 1)	45.2W	Int FSS (C/Ku)
23764	1996-002A PanAmSat 3R (PAS 3R)	43.4W	Int FSS (C/Ku)
24891	1997-040A PanAmSat 6 (PAS 6)	43.3W	Int FSS (C/Ku)
16116	1985-092B USA 11 (DSCS III B7) (US)	42.5W/i	Mil-ATL reserve operational (P/S/X)
19883	1989-021B TDRS F4 (US)	41.1W#	Int FSS/Gov-Tracking & Relay (C/S/Ku)
12089	1980-098A Intelsat 502	40.4W/i	Int FSS (C/Ku)
23413	1994-079A Orion 1 (US)	37.7W	Int FSS (Ku)
20523	1990-021A Intelsat 603	34.6W	Int FSS (C/Ku)
20401	1990-001A Skynet 4A (UK)	34.0W/i	Mil-comm (P/S/X/Ka)
14077	1983-047A Intelsat 506	31.4/i	Int FSS/Mar (L/C/Ku)
22116	1992-060A Hispasat 1A (Spain)	30.1W	Dom BSS/FSS (Ku)
22723	1993-048A Hispasat 1B (Spain)	30.1W	Dom BSS/FSS (Ku)
21765	1991-075A Intelsat 601	27.6W	Int FSS (C/Ku)
24957	1997-053A Intelsat 803	26.4W	Int FSS (C/Ku)
15386	1984-114B Marecs B2	26.0W/i	Int Mar-AOR (L)
21653	1991-055A Intelsat 605	24.5W	Int FSS (C/Ku)
23967	1996-042A USA 127 (UFO-7) (US)	23.0W/i	Mil-AOR (P/S/K)
20253	1989-077A USA 46 (FltSatCom 8) (US)	22.5W/i	Mil-AOR (P-Charlie/S/X/K)
20391	1989-101A Cosmos 2054 (Russia)	22.4W/i	Tracking & Relay WSDRN (Ku)
21989	1992-032A Intelsat K	21.5W	Int FSS (Ku)
19772	1989-006A Intelsat 515	21.4W	Int FSS (C/Ku)
23528	1995-013A Intelsat 705	18.1W	Int FSS (C/Ku)
15391	1984-115A NATO III D	18.1W/i	Mil-Comm (P/S/X)
21047	1991-001A NATO IV A	17.9W/i	Mil-Comm (P/S/X)
21940	1992-021B Inmarsat 2 F4	17.1W/i	Int Mar-AOR-W (L/C)
23426	1994-082A Luch 1 (Russia)	16.5E#	Tracking & Relay CSDRN (Ku)
24307	1996-053A Inmarsat 3 F2	15.5W/i	Int Mar (L/C)
23132	1994-035A USA-104 (UFO-3)(US)	14.5W/i	Mil-AOR primary (P/S)
23319	1994-067A Express 1 (Russia)	14.0W	Int FSS (C/Ku)
23267	1994-060A Cosmos 2291 (Russia)	13.9W#	Dom Data Relay (C)
22009	1992-037A USA 82 (DSCS III B12) (US)	12.0W	Mil-ELANT primary operational (P/S/X)
22041	1992-043A Gorizont 26 (Russia)	11.0W/i	Dom/Gov FSS (C/Ku)
24932	1997-049B Meteosat 7 (MOP-4) (ESA)	10.3W#	Met (P/L/S)
21140	1991-015B Meteosat 5 (MOP 2) (ESA)	9.0E#	Met (L)
21813	1991-084A Telecom 2A (France)	8.0W	Dom FSS/Gov-Mil (X/C/Ku)
21939	1992-021A Telecom 2B (France)	5.0W	Dom FSS/Gov-Mil (X/C/Ku)
24209	1996-044B Telecom 2D (France)	5.0W	Dom-FSS/Gov-Mil (C/X/Ku)
23865	1996-030B Amos 1 (Israel)	4.0W	Dom FSS (C)
20776	1990-079A Skynet 4C (UK)	1.1W#	Mil-comm (P/S/X/Ka)
23816	1996-015A Intelsat 707	1.1W	Int FSS (C/Ku)
20762	1990-074A Thor 1/Marcopolo 2 (BSB R-2)	0.8W	Reg BSS (Ku)
24808	1997-025A Thor 2A	0.8W	Reg BSS (Ku)
20168	1989-062A TV Sat 2 (Germany)	0.6W	Dom BSS (Ku)
22912	1993-073B Meteosat 6 (MOP 3) (ESA)	0.2W#	Met (L)

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

Satellite	Mode		Frequencies															
OSCAR 10 (AO-10) (Notes 1 & 10)	B (u/V)	Dn	145.825	835	845	855	865	875	885	895	905	915	925	935	945	955	965	145.975
		Up	435.179	169	159	149	139	129	119	109	099	089	079	069	059	049	039	435.029
	Bcn		145.810 (Steady unmodulated carrier)															
RS-12/13 (Notes 2, 3 & 4)		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 10)	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											
RS-16 (Note 10)	[a]	Dn	29.415	29.425	29.435	28.445	29.448											
		Up	145.915	145.925	145.935	145.945	145.948											
	Bcn		29.408	29.451	435.504	435.548												
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-12/13 are mounted on common spaceframes, along with comunication and navagation packages.
3. 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.
4. 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.
5. Transmitters on both AO-16 & LU-19 are currently using Raised Cosine Mode.
6. 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.
7. 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.
8. 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)
9. PO-28 is available to amateurs on an intermittent, unscheduled basis.
10. Modes of operation used include: CW,/USB/FAX/Packet/RTTY
11. Modes of operation used include: FM (AFSK) & PSK Data.
12. Modes of operation used include: Packet & FM Voice.
13. Operation as a single channel narrowban d FM transponder.

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

Satellite	Mode		Frequencies										
JAS-Ib (FO-20) (Notes 8 & 10)	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 8)	[c]	Dn		435.120									
		Up	145.900		145.975								
KITSAT A (KO-23) (Note 8)	[c]	Dn		435.173									
		Up	145.850		145.900								
KITSAT B (KO-25) (Note 8)	[c]	Dn	435.175		436.500								
		Up	145.870	145.980									
IT-AMSAT (IO-26) (Note 8)	[a,c]	Dn		435.820 (Sec.)	435.867								
		Up	145.875	145.900		145.925	145.950						
EYESAT /AMRAD (AO-27) (Note 13)		Dn	436.792										
		Up	145.850										
POSAT (PO-28) (Notes 8, 9 & 10)	[c]	Dn	435.250	435.280									
		Up	145.925	145.975									
FUJI/ OSCAR 29 (FO-29) (Notes 8 &10)	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							
MIR (Note 12)	[b] FM Voice	Dn	145.800	145.550	145.485								
		Up	145.200	145.550	145.985								
SHUTTLE (SAREX) (Note 12)	[b]	Dn		145.840									
		Up	144.450	144.470									

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

Amateur and Weather Satellite Two-Line Orbital Element Sets

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

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

Catalog # | Intl. Desig. | Epoch Year | Epoch Day .Fraction | Period Decay Rate | Not used
1 14129U 83058B 94254.05030619 - .0000192 00000-0 100000-30 3080

2 14129 26.8972 308.5366 6028238 209.9975 94.5175 2.05881264 5658 5
Catalog # | Inclination | Right Asc. of Node | Eccentricity | Argument of Perigee | Mean Anomaly | Mean Motion | Revolution # at Epoch

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

AMATEUR RADIO SATELLITES
OSCAR 10 (AMSAT OSCAR 10, AO-10)
1 14129U 83058B 97277.84210603 .00000065 00000-0 10000-3 0 5088
2 14129 26.2661 123.5522 6039277 157.0705 248.6734 2.05879961 79648
OSCAR 11 (UoSAT 2, UoSAT 11, UOSAT OSCAR-11, UO-11)
1 14781U 84021B 97271.45940497 .00000222 00000-0 45283-4 0 43
2 14781 97.8451 248.6193 0012923 36.4155 323.7923 14.69589230726428
Russian Mir Space Station
1 16609U 86017A 97279.46379389 .00005167 00000-0 68195-4 0 6817
2 16609 51.6543 246.6130 0006451 184.4339 175.6604 15.60284534664393
OSCAR 16 (PACSAT, AMSAT OSCAR-16, AO-16)
1 20439U 90005D 97277.26535133 .00000017 00000-0 23224-4 0 976
2 20439 98.5324 359.7193 0010544 250.2683 109.7361 14.30020103401824
OSCAR 17 (DOVE, DOVE OSCAR-17, DO-17)
1 20440U 90005E 97277.80006711 -.00000016 00000-0 10532-4 0 959
2 20440 98.5345 1.1791 0010527 243.6965 116.3136 14.30163307401931
OSCAR 18 (WEBERSAT, WEBERSAT OSCAR-18, WO-18)
1 20441U 90005F 97276.26125508 -.00000022 00000-0 83238-5 0 1025
2 20441 98.5337 359.5551 0011140 251.5070 108.4901 14.30129954401712
OSCAR 19 (LUSAT, LUSAT OSCAR-19, LO-19)
1 20442U 90005G 97276.28977289 -.00000011 00000-0 12418-4 0 1006
2 20442 98.5379 0.3127 0011485 250.8178 109.1762 14.30246262401740
OSCAR 20 (JAS 1B, FUJI 2, FUJI OSCAR 20, FO-20)
1 20480U 90013C 97271.33809706 .00000027 00000-0 12587-3 0 9983
2 20480 99.0577 213.5801 0541474 143.8042 220.0997 12.83238966357934
RS-12/13 (Radio Sputnik 12/13, Cosmos 2123)
1 21089U 91007A 97274.31261859 .00000063 00000-0 51333-4 0 114
2 21089 82.9226 199.9309 0030181 4.8209 355.3232 13.74086451333738
OSCAR 22 (UoSAT-F, UoSAT-5, UOSAT OSCAR 22, UO-22)
1 21575U 91050B 97274.70379817 .00000035 00000-0 25913-4 0 8043
2 21575 98.2891 331.4262 0007036 299.3362 60.7121 14.37086797325784
OSCAR 23 (KITSAT-A, KITSAT-1, KITSAT OSCAR-23, KO-23)
1 22077U 92052B 97277.06107148 -.00000037 00000-0 10000-3 0 6942
2 22077 66.0805 277.2831 0004247 182.2458 177.8537 12.86303787241754
OSCAR 27 (EYESAT-A, EYESAT-1, AMSAT OSCAR-27, AO-27
1 22825U 93061C 97278.23128650 .00000043 00000-0 34879-4 0 5907
2 22825 98.5356 349.9595 0007940 284.2400 75.7898 14.27738209209773
OSCAR 26 (ITAMSAT, ITAMSAT OSCAR-26, IO-26)
1 22826U 93061D 97276.57952233 .00000034 00000-0 31261-4 0 5862
2 22826 98.5355 348.6171 0008726 288.5406 71.4853 14.27848244209556
OSCAR 25 (KITSAT-B, KITSAT-2, KITSAT OSCAR-25, KO-25)
1 22828U 93061F 97276.23744739 .00000009 00000-0 20765-4 0 5653
2 22828 98.5337 348.3753 0009444 272.6669 87.3430 14.28192714177639
OSCAR 28 (POSAT, POSAT OSCAR-28, PO-28)
1 22829U 93061G 97275.20885812 .00000104 00000-0 59084-4 0 5818
2 22829 98.5326 347.4682 0009022 270.5908 89.4238 14.28178899209402
RS-15 (Radio Sputnik 15)
1 23439U 94085A 97271.31270952 -.00000039 00000-0 10000-3 0 2497
2 23439 64.8210 346.0851 0147059 112.8459 248.8063 11.27528319113563
OSCAR 29 (FUJI 3, FUJI OSCAR-29, FO-29)
1 24278U 96046B 97276.57893614 .00000009 00000-0 48098-4 0 1110
2 24278 98.5298 302.9668 0350751 265.3677 90.7328 13.52633780 55778
RS-16 (Radio Sputnik 16)
1 24744U 97010A 97278.24339359 .00006777 00000-0 22071-3 0 868
2 24744 97.2646 181.2075 0009403 61.2371 298.9813 15.32122631 32930

WEATHER/IMAGING SATELLITES
Geostationary Satellites
GOES 7 (Standby Geostationary Spacecraft-USA)
1 17561U 87022A 97275.42719789 -.00000145 00000-0 10000-3 0 3973
2 17561 3.9761 66.0421 0001449 218.3469 142.6982 1.00274768 22043
GOES 8 (Operational East-USA)
1 23051U 94022A 97274.57637804 -.00000262 00000-0 10000-3 0 8621
2 23051 0.2355 96.8395 0004927 125.2740 280.8450 1.00264689 20095
GOES 9 (Operational West-USA)
1 23581U 95025A 97277.77665523 .00000081 00000-0 00000+0 0 6044
2 23581 0.1756 270.2633 0003327 333.2780 274.3943 1.00276462 8686
GOES 10 (Standby Geostationary Spacecraft-USA)
1 24786U 97019A 97277.54617503 -.00000102 00000-0 00000+0 0 1238
2 24786 0.1606 276.5418 0002750 352.0848 197.0789 1.00271217 1653
ELEKTRO (Operational-Russia)
1 23327U 94069A 97275.96799582 -.00000107 00000-0 00000+0 0 3307
2 23327 1.0011 90.9769 0001850 105.3812 239.9323 1.00271511 10747
Feng Yun 2B (Operational-China)
1 24834U 97029A 97274.73224537 -.00000338 00000-0 00000+0 0 681
2 24834 0.9980 260.9438 0000718 346.6109 130.4510 1.00260487 1133
Meteosat 5 (Operational ESA, aka MOP-2)
1 21140U 91015B 97274.00813657 -.00000087 00000-0 00000+0 0 3824
2 21140 1.4989 79.1537 0002370 110.0245 174.5821 1.00272914 26325
Meteosat 6 (Operational-ESA)
1 22912U 93073B 97273.83657407 -.00000020 00000-0 00000+0 0 8302
2 22912 0.3392 57.7673 0002466 90.4312 162.4396 1.00269689 12574
Meteosat 7 (Operational ESA)
1 24932U 97049B 97278.01726317 -.00000093 00000-0 00000+0 0 363
2 24932 1.7500 290.0248 0001983 294.8175 144.8592 1.00272270 348
GMS 4 (Standby-Japan, aka Himawari 4)
1 20217U 89070A 97276.75688161 -.00000370 00000-0 10000-3 0 6418
2 20217 2.7290 72.8277 0000920 246.0853 86.2095 1.00265087 30165
GMS 5 Operational-Japan, aka Himawari 5)
1 23522U 95011B 97272.12024884 -.00000303 00000-0 10000-3 0 4442
2 23522 0.4483 335.1777 0002773 255.7862 320.2333 1.00263775 9154

Near Polar/Polar Orbiting Imaging Spacecraft
NOAA 12 (Operational morning spacecraft-USA 137.500 MHz)
1 21263U 91032A 97278.07227433 .00000097 00000-0 62148-4 0 5447
2 21263 98.5368 288.9677 0012881 339.8183 20.2485 14.22753684331984
NOAA 14 (Operational afternoon spacecraft-USA 137.620 MHz)
1 23455U 94089A 97278.10059592 .00000116 00000-0 88735-4 0 2102
2 23455 99.0020 229.6919 0010052 349.6620 10.4343 14.11698038142459
Meteor 2-21(Off at last report)
1 22782U 93055A 97275.24526763 .00000025 00000-0 94838-5 0 5932
2 22782 82.5497 333.0295 0023508 92.9416 267.4435 13.83081891206384
Meteor 3-5 (Operational-Russia 137.850 MHz)
1 21655U 91056A 97276.25161837 .00000051 00000-0 10000-3 0 108
2 21655 82.5552 346.3515 0014805 69.7558 290.5154 13.16855473294939
Meteor 3-6 (Off at last report)
1 22969U 94003A 97277.59601844 .00000051 00000-0 10000-3 0 3784
2 22969 82.5590 285.7730 0016331 129.2190 231.0385 13.16747392177481
DMSP B5D2-7 (DoD meteorological polar orbiter: downlink encrypted)
1 23233U 94057A 97278.08454784 .00000092 00000-0 72628-4 0 3995
2 23233 98.7640 334.2862 0011769 274.7918 85.1913 14.12839814159888
DMSP B5D2-8 (DoD meteorological polar orbiter: downlink encrypted)
1 23533U 95015A 97278.08643393 .00000028 00000-0 38890-4 0 1450
2 23533 98.8505 280.7052 0007290 141.7417 218.4269 14.12809112130689
DMSP B5D2-9 (DoD meteorological polar orbiter: downlink encrypted)
1 24753U 97012A 97278.07599384 .00000073 00000-0 62911-4 0 1982
2 24753 98.9206 322.0494 0009651 93.9903 266.2372 14.13003227 25902

EARTH RESOURCES IMAGING SATELLITES
OKEAN 1-7 (Okean 4-Russia 137.400 MHz)
1 23317U 94066A 97278.26763196 .00000344 00000-0 48583-4 0 2732
2 23317 82.5468 341.9468 0026164 340.4072 19.6129 14.74138457160521
SICH-1 (Oceanographic satellite-Russia 137.400 MHz)
1 23657U 95046A 97278.13258223 .00000138 00000-0 17813-4 0 2018
2 23657 82.5341 123.3761 0026952 310.7349 49.1520 14.73588167112771
IRS-1C (Remote Sensing-India)
1 23751U 95072A 97276.22498060 -.00000044 00000-0 00000+0 0 2523
2 23751 98.6973 349.8527 0001212 42.6719 317.4527 14.21633104 91649
IRS-P3 (Remote Sensing-India)
1 23827U 96017A 97272.54906270 -.00000044 00000-0 00000+0 0 2154
2 23827 98.7078 349.9474 0001287 82.7753 277.3571 14.21628277 79179
TOMS-EP (Total Ozone Mapping Spectrometer-USA)
1 23940U 96037A 97274.89456470 .00002957 00000-0 12780-3 0 1575
2 23940 97.4150 180.5418 0013668 126.0692 234.1801 15.23177494 69381
IRS-1D
1 24971U 97057A 97278.71006003 .00000688 00000-0 10000-3 0 280
2 24971 98.5678 351.8499 0210018 4.4068 140.4594 14.65853122 982

El Niño: Strongest Ever!

By Hank Brandli

El Niño, the weather phenomena involving the warming of the equatorial Eastern Pacific waters, is getting stronger and could ultimately be the largest climatic event of the century.

Figure 1 is a U.S. Air Force Defense Meteorological Satellite Program (DMSP) weather satellite photo made by the spacecraft's microwave imager. It consists of images taken over 14 orbits in August 1997. This photo of the Northern Hemisphere clearly shows El Niño's geographic extent and strength.

DMSP is the only weather satellite that can take both night visual and microwave imagery. It can take Earth's surface temperatures even through clouds, though not through moisture-laden clouds.

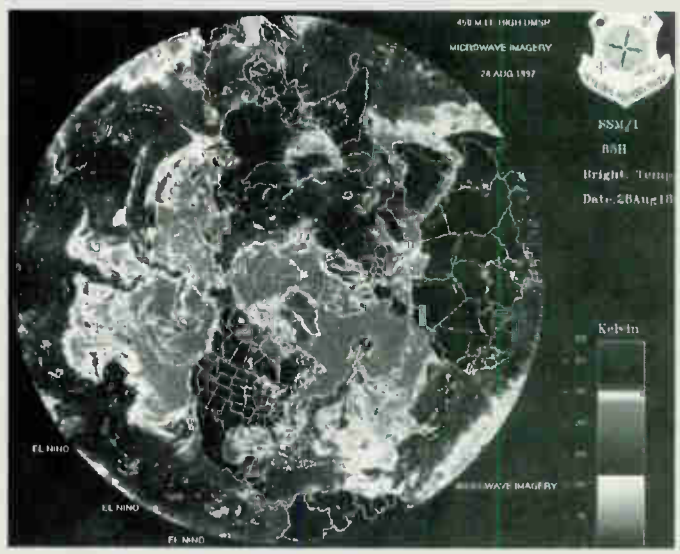
Due to El Niño, temperatures in the tropical Pacific have been running between 84 and 86 degrees, which is two to three degrees above normal.

Some of the problems expected from this unusually warm tide include:

- Increased tropical storm and hurricane activity in the eastern and northern Pacific, including Hawaii, but a diminished hurricane season in the Atlantic.

- Increased rainfall in California and along the rim of the Gulf of Mexico, including Florida.

- A relatively mild winter in Alaska and improved fishing off the California coast for tuna, mahi mahi, and other species of tropical fish.



- A drought during the coming year in Hawaii, Australia, Indonesia, and northeast Brazil.

Climatologists have linked El Niño to patterns of subsequent droughts, floods, typhoons, and other costly extremes around the globe.

El Niño is the warming of waters off equatorial South America and gets its name from the Spanish reference to the Christ child, because it usually arrives at Christmas time. The current El Niño shows all the earmarks of equaling or exceeding this century's strongest occurrence which hit in 1982 and 1983.

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-87	November 1997 Columbia*	28.5/160	16 days	USMP-4 & Spartan
STS-89	January 1998 Endeavour**	51.6/213	10+1 days	S/MM-08***

*Crew Assignment: CDR: Kevin R. Kregel, PLT: Steven W. Lindsey, MS: Winston E. Scott, MS: Kalpana Chawla, MS: Takao Doi (Japan), MS: Leonid Kadenyuk (Ukraine).

**Crew Assignment: CDR: Terrence Wilcutt, PLT: Joe Edwards, MS: Bonnie Dunbar, MS: Michael Anderson, MS: James Reilly, MS: Andrew Thomas (U), MS: David Wolf (D).

***Crew Assignment: Two Russians along with U.S. Astronaut David Wolf (D).

STS	Downlink Frequency Assignments:
VHF Voice	130.1625 MHz (STS-89 Only)
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	121.750, 143.625 MHz
VHF Voice	145.985 MHz (Amateur Radio)
UHF Voice	437.925, 437.950, 437.975 MHz (Amateur Radio)

Chinese Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
December 1997	Long March 3B	Xichang	Chinastar-1
December 1997	Long March 2C	Taiyuan	Iridium

Iridium	Downlink Frequency Assignments
L-band	1616-1626.5 MHz
Ka-band	19.4-19.6 GHz

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
November 1997	Titan 4	CCAS	DOD
November 1997	Delta II	CCAS	GPS II-28
November 1997	Delta II	VAFB	Iridium #5 (5)
November 1997	Taurus	VAFB	GEOSAT
November 1997	Athena	CCAS	Lunar Prospector
November 1997	Pegasus XL	VAFB	ORBCOMM & SNOE
December 1997	Atlas IIAS	CCAS	Galaxy-8i
December 1997	Athena	VAFB	CRSS-1
December 1997	Delta II	CCAS	Globalstar-1
December 1997	Atlas	CCAS	NRO
December 1997	Pegasus XL	VAFB	TRACE & BATSAT
December 1997	Delta II	VAFB	Iridium #6 (5)
December 1997	Athena	VAFB	CLARK
December 1997	Delta II	CCAS	GPS IIR-3
January 1998	Delta II	CCAS	Skynet-4D
January 1998	Delta II	VAFB	Iridium #7 (5)
January 1998	Atlas II	CCAS	Eutelsat W1

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

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

GPS IIR-3	Downlink Frequency Assignments
L-band	1227.6, 1381.05, 1575.42 MHz
S-band	2227.5 MHz

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

Taurus	Downlink Frequency Assignments
S-band TLM	2269.5 and 2288.5 MHz
C-band TRK	5765.0 MHz

Athena	Downlink Frequency Assignments
S-band	2208.5, and 2210.5 MHz
C-band	5765.0 MHz

Lunar Prospector	Downlink Frequency Assignments
S-band	2273.0 MHz

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

Orbcomm	Downlink Frequency Assignments
VHF-band	137.680, 137.710 MHz

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

Satellite Launch Schedules

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
November 1997	Proton	Baikonur	Kupon
November 1997	Cyclone	Baikonur	Cosmos
November 1997	Soyuz-U	Plesetsk	Cosmos
November 1997	Zenit-2	???????	TechSat-2 & Thai-microsat
December 1997	Proton	Baikonur	RadioAstron
December 1997	Proton	Baikonur	Glonass (3)
December 1997	Rockot	???????	UoSat-12
December 1997	Proton	Baikonur	Astra-2A & InSat-2E
December 1997	Start-1	Svobodnyi	Early Bird
December 1997	Soyuz-U	Baikonur	Progress M-37
December 1997	Proton	Baikonur	AsiaSat-3
January 1998	Proton	Baikonur	Gorizont-33
January 1998	Soyuz-U	Baikonur	Soyuz TM-27
January 1998	Proton	Baikonur	Raduga-1
January 1998	Soyuz-U	Baikonur	Cosmos

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
November 1997	Ariane 44L	Guiana	Sirius-2 & Indostar
November 1997	Ariane 44L	Guiana	Equator-S & JCSAT-5
December 1997	Ariane 44L	Guiana	Intelsat 804 & NileSat-1
January 1998	Ariane 44L	Guiana	Brazilsat B-3 & Inmarsat

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

Japanese Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
November 1997	H-II	Tanegashima	TRMM & ETS-7
January 1998	H-II	Tanegashima	COMETS

TRMM	Downlink Frequency Assignments
S-band	2255.500 MHz

ETS-7	Downlink Frequency Assignments
S-band	2220.000, 2276.990 MHz

List of Abbreviations and Acronyms

C-band	3700 to 6500 MHz.
CCAS	Cape Canaveral Air Station, FL
CDR	Commander
(D)	Crew member coming down from Russian Space Station MIR.
ETS-7	Engineering Test Satellite-7.
Galaxy	Hughes telecommunications satellite with principal applications including network TV, radio, VSAT, business video and data services.
GEOSAT	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.
GHz	Gigahertz
GPS	U.S. Air Force global positioning satellite for military and civilian navigation services.
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.
L-band	500 - 1549 MHz
Lunar Pro	Unmanned satellite to earth's moon.
MHz	Megahertz
MS	Mission Specialist, a member of Shuttle flight crew primarily responsible for Orbiter subsystem and payload activities.
ORBCOMM	Orbcomm will provide low-cost alpha numeric data communications and position determination for emergency assistance, data acquisition and messaging services using pocket portable and mobile subscriber terminals.
PLT	Pilot, a member of the Shuttle crew whose primary responsibility is to pilot the Orbiter.
S-band	2000 to 2300 MHz
Sirius-2	A telecommunications satellite for Nordiska Satellitaktiebolaget (NSAB) to be placed at 5 degrees East longitude.
S/MM-08	Shuttle mission to the Russian Space Station MIR to support design and assembly of the International Space Station.
SNOE	Student Nitric Oxide Explorer, University of Colorado payload; first in series of low-cost university small research/science payloads.
SPARTAN	Shuttle Pointed Autonomous Research Tool for Astronomy. X-ray astronomy, medium energy survey mission, using retrievable free flyer.
TechSat	Israeli technology satellite.
TLM	Telemetry
TRK	Tracking
TRMM	Tropical Rainfall Measuring Mission. A joint mission between NASA and the Japanese space agency (NASDA). The mission will study the distribution and variability of precipitation and latent heat release over a multi-year data set.
(U)	Crew member going up to Russian Space Station MIR.
UHF	Ultra High Frequency (390 to 499 MHz)
USMP-4	Series of flights that conduct materials processing and fundamental experiments in the microgravity environment available in the Orbiter cargo bay while in low earth orbit.
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
X-band	8000 and 10,999 MHz
XL	Extra Large

Satellite Launch Report

By Phillip Clark, *Molniya Space Consultancy*

How to Use the Satellite Launch Report

The "Satellite Launch Report" is a complete list of satellite launches which took place during July and August 1997. The format of the listing is as follows:

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

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

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

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

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1997 Jul 1/1802	1997-032A		Columbia (STS-94)	117,801 kg
1997 Jul 1.91	28.47 deg	90.57 min	300 km	304 km

Seven astronauts reflying the Microgravity Sciences Laboratory (MSL-1R) mission which as STS-83 (1997-013A) had been curtailed in April 1997: mass of the shuttle at the time of landing as quoted in the NASA press kit for the mission (and shown here) is significantly higher than for the STS-83 mission. Crew comprises: J D Halsell (commander), S L Still (pilot), J S Voss (mission specialist MS-1 and payload commander), M L Gernhardt (MS-2 and EVA crewman if required, EV-1), D A Thomas (MS-3, EV-2), R K Crouch (payload specialist, PS-1) and G T Linteris (PS-2). Payload carried MSL-1R/Spacelab module, mass 10,169 kg. Launched from KSC: landed at KSC Jul 17 at 1047 UTC. On a statistical note, this is the first time that a complete crew has reflown a mission and the shortest interval between flights for the crew members.

1997 Jul 5/0411	1997-033A		Progress-M 35	7,250 kg?
1997 Jul 6.10	51.65 deg	90.30 min	264 km	315 km
1997 Jul 8.06	51.65 deg	92.34 min	386 km	392 km

Unmanned cargo freighter, carrying supplies to the crew aboard the Mir Complex. Docked at the rear port of the Complex (-X) Jul 7 at 0559 UTC. Undocked from -X port Aug 6 at 1146 to free the post for
Soyuz-TM 26, re-docked Aug 18 at 1253 UTC after a docking attempt the previous day had been cancelled. Launched from Baikonur using Soyuz-U vehicle.

1997 Jul 9/1304	1997-034A		Iridium 15	657 kg
1997 Jul 9.61	86.40 deg	97.29 min	619 km	639 km
1997 Aug 4.53	86.40 deg	100.39 min	774 km	780 km

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1997 Jul 9/1304	1997-034B		Iridium 17	657 kg
1997 Jul 10.46	86.40 deg	97.38 min	623 km	643 km
1997 Aug 3.55	86.39 deg	100.40 min	775 km	780 km
1997 Jul 9/1304	1997-034C		Iridium 18	657 kg
1997 Jul 10.53	86.40 deg	97.40 min	627 km	641 km
1997 Aug 2.24	86.41 deg	100.38 min	774 km	779 km
1997 Jul 9/1304	1997-034D		Iridium 20	657 kg
1997 Jul 10.46	86.40 deg	97.40 min	626 km	643 km
1997 Aug 2.03	86.38 deg	100.39 min	772 km	782 km
1997 Jul/1304	1997-034E		Iridium 21	657 kg
1997 Jul 10.80	86.40 deg	97.39 min	626 km	642 km
1997 Jul 15.47	86.40 deg	97.44 min	629 km	643 km

Third launch of a cluster of Iridium satellites. Satellites have a dry mass of 556 kg. The complete Iridium system will comprise 66 satellites spread between six orbital planes: each plane will have ten operating satellites and one spare. Dying satellites will be de-orbited: expected operational lifetime is about two years for each satellite. Iridium 21 failed to manoeuvre to its operational orbital altitude. Launched from ETR using a Delta-2 (7920).

1997 Jul 23/0343	1997-035A		Navstar 29 (USA 132)	2,032 kg
1997 Jul 23.23	39.19 deg	356.65 min	190 km	20,373 km
1997 Aug 10.62	54.93 deg	718.10 min	20,124 km	20,247 km

First successful launch of a Navstar Block 2R navigation satellite in the Global Positioning System (GPS): on station at the beginning of operations it is 1,075 kg. Launched from WTR using Delta-2 (7925).

1997 Jul 28/0115	1997-036A		Superbird C	3,130 kg
1997 Jul 29.34	27.90 deg	1,925.90 min	318 km	89,479 km
1997 Aug 24.51	0.03 deg	1,436.00 min	35,770 km	35,799 km

Telecommunications satellite launched for the Space Communications Corporation of Japan. Mass quoted is at launch. Satellite located over 143-144 deg E. Launched from ER using an Atlas-2AS.

1997 Aug 1/2020	1997-037A		SeaStar	309 kg
1997 Aug 2.01	98.28 deg	90.63 min	297 km	313 km
1997 Sep 3.83	98.22 deg	98.94 min	707 km	709 km

SeaStar (also called OrbView 2) is a remote sensing oceanographic satellite to be operated by Orbital Imaging Corp and manufactured by Orbital Sciences Corp (its parent company). It carries SeaWiFS (Sea-viewing Wide Field Sensor), originally planned to fly on Landsat 6. Launched using an L-1011/Pegasus-XL from WTR.

1997 Aug 5/1536	1997-038A		Soyuz-TM 26	7,150 kg?
1997 Aug 5.70	51.62 deg	88.69 min	188 km	232 km
1997 Aug 8.07	51.65 deg	92.33 min	386 km	392 km

Two-manned spacecraft carrying Anatoli Y Solovyov (commander) and Pavel V Vinogradov (flight engineer) to the Mir Complex. Flight of French spationaut Leopold Eyharts planned for this launch delayed until Soyuz-TM 27 in early 1998 due to conditions on board Mir. Spacecraft docked at the -X (Kvant 1) port of the Mir Complex Aug 7 at 1702 UTC: after the return of Soyuz-TM 25, Solovyov, Vinogradov and Foale (NASA astronaut) undocked spacecraft from Mir Aug 15 at

1329 and re-docked at the front longitudinal port (+X) at 1413. Solovyov and Vinogradov should remain on board Mir until early 1998. Spacecraft launched from Baikonur using a Soyuz-U.

Launch Date/Time Epoch	Int Des Incl	Satellite Period	Perigee	Mass Apogee
1997 Aug 7/1441	1997-039A	Discovery (STS-85)		98,843 kg
1997 Aug 7.63	57.00 deg	90.43 min	290 km	301 km
1997 Aug 17.53	56.99 deg	89.62 min	250 km	261 km
1997 Aug 19.42	56.99 deg	87.31 min	229 km	254 km
1997 Aug 7/1441	1997-039B	CRISTA-SPAS 2		3,504 kg
1997 Aug 7.93	57.00 deg	90.44 min	291 km	301 km

Piloted mission carrying six astronauts: C L Brown (commander), K V Reminger (pilot), N J Davis (mission specialist, MS-1), R L Curbean (MS-2 and EVA astronaut if required, EV-1), S K Robinson (MS-3, EV-2) and B V Tryggvascon (payload specialist, PS-1, Canadian Space Agency). Main payload is CRISTA-SPAS 2 (Cryogenic Infra-red Spectrometer and Telescopes for Atmosphere—Shuttle PAllet Satellite): deployed from the orbiter's payload bay Aug 7 at 2227 and recaptured Aug 16 at 1514 UTC. Other payloads (not separated while in orbit) were: IEH 2 (International Extreme ultra-violet Explorer), mass 1,461 kg: TAS 1 (Technology Applications and Science), mass 2,517 kg: and NASDA's remote manipulator test article, mass 1,647 kg (planned for later use on Japanese JEM module for International Space Station). Launched from and landed at KSC, the latter coming on Aug 19 at 1108.

1997 Aug 8/0646	1997-040A	PAS 6		3,420 kg
1997 Aug 8.79	7.02 deg	630.90 min	175 km	35,803 km
1997 Aug 20.19	0.05 deg	1,436.10 min	35,774 km	35,799 km

Direct broadcast television satellite, launched for PanAmSat Corporation. Mass quoted for the satellite is at launch: on-station and the beginning of operations the mass is 2,050 kg and the dry mass is 1,285 kg. Satellite deployed over 316.5 deg E. Launched from Kourou using an Ariane-44P.

1997 Aug 14/2049	1997-041A	Cosmos 2345		2,500 kg?
1997 Aug 15.10	53.16 deg	88.27 min	184 km	195 km
1997 Aug 15.16	49.95 deg	622.14 min	233 km	35,292 km
1997 Aug 20.14	1.33 deg	1,444.13 min	34,290 km	37,598 km
1997 Aug 29.88	1.30 deg	1,435.98 min	34,295 km	37,274 km

Early warning satellite in the Prognoz series. Satellite deployed over 336 deg E. Launched from Baikonur using a four-stage Proton-K. Unusually the orbital inclination of the low parking orbit was 53.2 deg rather than the standard 51.6 deg: some unofficial Russian sources have suggested that this was due to a trajectory programming error. Fourth stage burn to geosynchronous transfer orbit took place at the time of the fifth pass through the ascending node of the orbit, rather than the first which is standard: this is the fourth time that the transfer orbit burn was thus delayed, and it resulted in the payload being injected into geosynchronous drift orbit close to 0 deg E rather than the normal ~90 deg E.

1997 Aug 19/1750	1997-042A	Mabuhay Agila 2		2,560 kg
1997 Aug 20.32	24.63 deg	807.02 min	171 km	44,499 km
1997 Sep 2.41	0.26 deg	1,435.97 min	35,777 km	35,791 km

Communications satellite launched for Mabuhay Philippine Satellite Corporation. Mass quoted is at launch. Satellite to be operated over 147 deg E. Second launch of CZ-3B ("Chang Zheng"—Long March) from Xi Chang, first vehicle to reach orbit.

Launch Date/Time Epoch	Int Des Incl	Satellite Period	Perigee	Mass Apogee
1997 Aug 21/0038	1997-043A	Iridium 26		657 kg
1997 Aug 21.13	86.69 deg	95.66 min	544 km	557 km
1997 Sep 10.47	86.43 deg	100.22 min	765 km	773 km
1997 Aug 21/0038	1997-043B	Iridium 25		657 kg
1997 Sep 5.89	86.40 deg	100.40 min	775 km	780 km
1997 Aug 21/0038	1997-043C	Iridium 24		657 kg
1997 Sep 8.53	86.39 deg	100.40 min	774 km	781 km
1997 Aug 21/0038	1997-043D	Iridium 23		657 kg
1997 Sep 9.15	86.38 deg	100.39 min	775 km	780 km
1997 Aug 21/0038	1997-043E	Iridium 22		657 kg
1997 Sep 8.87	86.39 deg	100.39 min	775 km	780 km

Fourth launch of a cluster of Iridium satellites: dry mass of each is 556 kg. Launched from WTR using Delta-2 (7920).

1997 Aug 23/0651	1997-044A	Lewis (SSTI)		386 kg
1997 Aug 23.32	97.57 deg	90.47 min	289 km	306 km
1997 Aug 25.59	97.57 deg	90.70 min	298 km	320 km

Lewis is the first flight of the TRW Space and Electronics Group Small Spacecraft Technology Initiative (SSTI) satellite, and it is an experimental satellite carrying two hyperspectral radiometers. The TRW hyperspectral imager can use 384 spectral bands while the Goddard Space Flight Center's Linear Etalon Imaging Spectral Array (LEISA) can use 256 spectral bands. Lewis also carries the Ultraviolet Cosmic Background instrument, an astrophysics payload built by the University of California at Berkley. Satellite planned to manoeuvre to a Sun-synchronous 517 km circular orbit and operate for a minimum of three years (minimum, goal—five years), but after deployment the satellite was found to be spinning at 2 revs/minute and this could not be countered. Second launch of LMLV-1 (Lockheed Martin Launch Vehicle from WTR: first launch was as LLV-1 (Lockheed Launch Vehicle) and failed to reach orbit.

1997 Aug 25/1439	1997-045A	ACE		752 kg
1997 Aug 26	28.7 deg	95,140 min	177 km	1,367,769 km

ACE (Advanced Composition Explorer) is a science satellite, launched to determine and compare the elemental and isotopic composition of samples of matter from the solar corona and from interplanetary, local interstellar and intergalactic media. The satellite should enter a halo point around the L1 Lagrangian libration point between the Earth and the Sun, some 1.4 million km from the Earth. Mass quoted is at launch, dry mass is approximately 560 kg. Launched from ETR using Delta-2 (7920). Approximate orbital data are shown which are from Boeing Delta-2 launch information booklet.

1997 Aug 28/0033	1997-046A	PAS 5		3,720 kg
1997 Aug 28.07	51.57 deg	635.87 min	215 km	36,018 km
1997 Sep 9.29	0.06 deg	1,436.15 min	35,745 km	35,830 km

PAS 5 is a telecommunications satellite launched for the PanAmSat Corporation and built by Hughes Space and Communications: this is the first launch of an HS-601HP (high power) satellite: it is also the first commercial satellite to use an xenon ion propulsion system. Mass quoted is at launch. Satellite to be located over 302 deg E. Launched by a four-stage Proton-K from Baikonur.

1997 Aug 29/1502	1997-047A	FORTE (P94-1)		215 kg?
1997 Aug 30.02	69.96 deg	101.22 min	800 km	834 km

FORTE (Fast On-orbit Recording of Transient Events) satellite is sponsored by the US Department of Energy and jointly undertaken by the Los Alamos and Sandia National Laboratories. Satellite is intended to detect and characterise advanced radio frequency pulses. Launched from WTR using L-1011/Pegasus-XL.

Updates For Previous Launches

International Designation	Comment
1983-059B	Anik-C 2 had its location stabilised over 245 deg E approximately 1997 Aug 6.
1984-114A	Spacenet 2 was manoeuvred off-station over 290 deg E in mid-July 1997.
1985-109D	Satcom-K 2 was manoeuvred off-station over 274 deg E approximately 1997 Jul 6 and was apparently re-located over 278-279 deg E in mid-

	July.
1986-003B	Satcom-K 1 was manoeuvred off-station over 273 deg E approximately 1997 Jul 2.
1986-026A	GStar 2 was manoeuvred off-station over 235 deg E approximately 1997 Aug 20.
1989-052A	The last set of orbital data to be issued for Gorizont 18 was dated 1997 Apr 1, and the satellite was shown in a drift orbit. It seems likely that the satellite has been retired and possibly "lost" by USSPACECOM.
1989-062A	The orbital data suggesting that TVSat 2 had manoeuvred off-station in May 1997 were in error: the satellite is still operating over 359-0 deg E.
1989-100A	Cosmos 2053 decayed from orbit 1997 Sep 2.
1990-063A	Some confusing orbital data have been issued during August 1997 for TDF 2. On Jul 29 the satellite was shown to be stationary over 341-342 deg E. On Aug 4 and Aug 12 the satellite was shown to be stationary over 35-36 deg E and then data issued starting Aug 20 have shown the satellite drifting to the east.
1992-021B	INMARSAT-2 4 was manoeuvred off-station over 305 deg E approximately 1997 Jul 17.
1993-078B	The Two-Line Orbital Elements showed THAICOM 1 stationed over 78 deg E on 1997 Jul 30, but data for the following day and during August showed the satellite located over 119-120 deg E. Since it is unlikely that a relocation over more that 40 deg of longitude could take place during one day, it would appear that the satellite was not tracked during the actual relocation (planned once THAICOM 3—1997-016A—became operational) and the immediate pre-manoeuvre data are in error.
1995-028A	The major piece following the Cosmos 2313 break-up decayed from orbit 1997 Jul 11.
1995-052A	Cosmos 2321 decayed from orbit 1997 Aug 21.
1996-021A	The Two-Line Orbital Elements suggest that Astra 1F was relocated from 21 deg E to 19 deg E during the second half of July 1997.
1996-062A	On 1997 Sep 12 at 0117 UTC spacecraft time) the orbit injection motor on Mars Global Surveyor fired to place the spacecraft into orbit around Mars. The spacecraft entered an orbit with a period of ~1,500 minutes, closest approach ~250 km, most distant point ~56,000 km. The initial orbital inclination is not available at the time of preparing this entry. The first aerobraking manoeuvre is planned for Sep 17. (In calculating the orbital period a martian radius of 3,397 km and a martian mass 0.107 times that of the Earth have been used.)
1997-003A	Soyuz-TM 25 carrying cosmonauts Tsibliev and Lazutkin undocked from the front (+X) port of the Mir Complex 1997 Aug 14 at 0855 UTC and landed 170 km south-east of Dzezkazgan at 1217 UTC.
1997-025A	The launch date for Thor 2 should be 1997 May 20 and not 1997 May 21.
1997-027A	Add the following orbital data for INMARSAT-3 4: 1997 Jul 24.73 0.27 deg 1,435.56 minutes 35,763 km 35,789 km The satellite is stationed over 306 deg E.
1997-030A	Add the following orbital data for Iridium 14: 1997 Jul 10.92 86.40 deg 100.39 minutes 775 km 779 km
1997-030B	Add the following orbital data for Iridium 12: 1997 Jul 8.88 86.41 deg 100.39 minutes 772 km 782 km
1997-030C	Add the following orbital data for Iridium 10: 1997 Jul 7.54 86.39 deg 100.39 minutes 773 km 781 km
1997-030D	Add the following orbital data for Iridium 9: 1997 Jul 13.13 86.40 deg 100.38 minutes 775 km 779 km
1997-030E	Add the following orbital data for Iridium 13: 1997 Jul 8.19 86.40 deg 100.39 minutes 773 km 781 km
1997-030F	Add the following orbital data for Iridium 16: 1997 Jul 7.58 86.39 deg 100.39 minutes 774 km 779 km
1997-030G	Add the following orbital data for Iridium 11: 1997 Jul 7.13 86.40 deg 100.39 minutes 776 km 778 km
1997-031A	Add the following orbital data for INTELSAT 802: 1997 Jul 17.54 0.03 deg 1,436.15 minutes 35,777 km 35,798 km The satellite was initially located over 165 deg E, but it was manoeuvred off-station approximately Aug 13 and relocated to 174 deg E approximately Aug 23.

Orbital Planes For Iridium Deployments

To the end of August 1997 there had been four deployments of Iridium satellites, three using the United States Delta-2 (7920) launch vehicles (each with a cluster of five satellites) and one using the Russian Proton-K with a Block DM-5 fourth stage (carrying seven satellites). Of the 22 satellites launched, only Iridium 21 (1997-034E/24873) has failed to operate. The orbital planes which have been used are:

30.3 deg	1997-043	Iridium Cluster 4 (61.9 deg)
93.5 deg	1997-020	Iridium Cluster 1
125.1 deg	1997-030	Iridium Cluster 2
156.6 deg	1997-034	Iridium Cluster 3

The orbital planes are defined by the right ascension of the ascending node of the first satellite in each cluster, and the planes are separated by 31.6 deg (rather than 30 deg which one would expect for a system with six orbital planes—giving planes covering 180 deg). The orbital plane corresponding to an ascending node of 61.9 deg was filled with the Iridium cluster launched on September 14: at present it is not clear whether the sixth orbital plane will correspond to an ascending node of 358.7 deg or 188.2 deg.

ST SPECIAL REPORT

By Philip Chien

Ultra-Low Frequency Radio in Space

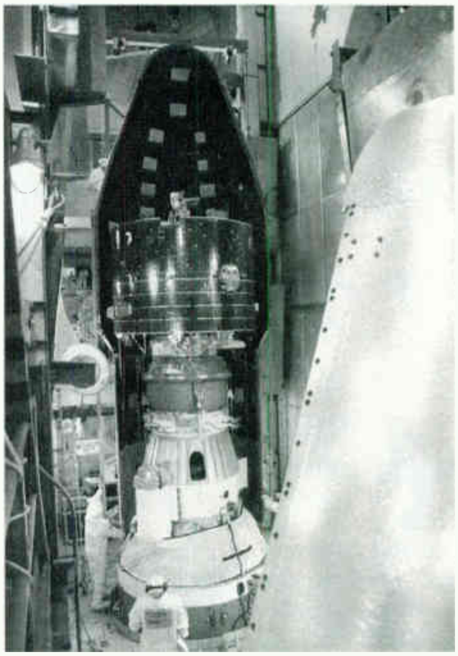
Normally we think of radio waves as artificial signals, generated purposely for communications, radar, and other applications. But there are natural radio waves, caused by the Earth's environment, the Sun, Jupiter, and the interactions of different magnetic fields.

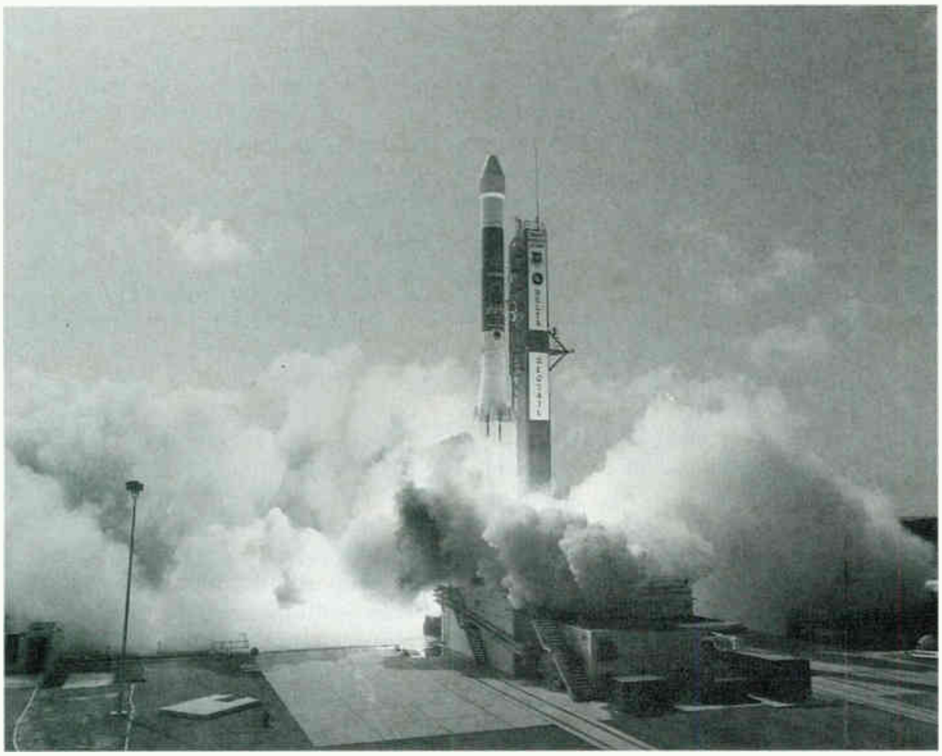
NASA, the European Space Agency, the Japanese space agency NASDA, and other space faring nations have been participating in the multinational International Solar-Terrestrial Program (ISTP). The primary spacecraft in this series are *Geotail*—a joint U.S Japanese effort, *Polar* and *Wind*—U.S. spacecraft, *SOHO*—a joint U.S/European effort, and *Cluster*—an European effort. Other parties also participate in each of these spacecraft. The Cluster series was lost in the Ariane 501 accident but the other spacecraft are all in operation. In addition, over twenty other spacecraft have contributed useful data.

While Earth observation satellites like Landsat and Spot monitor the Earth's environment, the ISTP satellites monitor the Sun-Earth environment.

Many different space physics spacecraft were launched before the ISTP project was established. The first U.S. satellite, *Explorer 1*, detected the Earth's magnetic fields. An Explorer-class satellite launched in the 1970s, *IMP-8* remains in operation returning valuable data.

ISTP was conceived in the 1970s, planned in the 1980s, and launched in the 1990s. *Geotail* was launched in 1992, followed by *Wind* in 1994, *SOHO* in 1995, and *Polar* in 1996. The original plan called for the spacecraft to be launched about a year apart. But cost overruns on the Polar and Wind spacecraft caused them to be delayed, eliminating some of the original goals to have the spacecraft in simultaneous operation during their primary periods.





Unlike most other satellite programs where satellites use one or two very well defined types of orbits, the ISTP series uses rather unique one-of-a-kind orbits to accomplish its objectives.

Geotail—literally the Earth's tail—has to fly through the region behind the Earth as viewed by the Sun. The Sun causes the Earth's magnetic field to form a tear-drop shaped pattern with the tail pointing away from the Sun. If *Geotail* relied on using its thrusters to stay in position it could only carry enough propellant to remain in place for a couple of years. Instead the spacecraft controllers developed a unique orbit which uses the moon's gravitational pull to keep its orbit in check. Each time the moon comes around it's used to deflect the *Geotail* spacecraft in to a new slightly different orbit. It's similar to the way *Galileo* spacecraft is using the gravitational pull from Jupiter's moons to aim it at its next target.

Wind requires a high altitude orbit on the Sunward side to monitor the magnetopause, the place where the Earth's magnetic fields deflect the Solar Wind. Its orbit gradually changed over time, with apogees (the high point in the satellite's orbit) on the day side of its orbit and magnetotail perigees, and lunar swingbys to take it towards the gravitationally stable libration points.

Continued on page 93

THE BEGINNER'S COLUMN

By Ken Reitz, KS4ZR
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Expanding Your Satellite TV Horizons

Terrestrial TV signals don't tend to travel very far. At VHF and UHF frequencies, there's not a lot of refracting or bouncing of the signal to allow for long distance reception. Strange events in the atmosphere sometimes allow a VHF or UHF-TV signal to travel considerable distances but these instances are rare and fleeting. For the most part TV viewers have to be content to watch their own local stations for whatever pleasure that might bring.

The advent of satellite television changed that whole concept forever. Perched 23,000 miles above the Earth, these transmitters (often with outputs of less than 10 watts) cover entire continents. As long as you have an unobstructed view to the Clarke Belt (that imaginary line along which all the geostationary satellites orbit) you can receive dozens of satellites.

Crossing the Border

Over North America there are domestic broadcast satellites from Galaxy 6 at 74 degrees west to Satcom C5 at 139 degrees west. In between are some thirty C and Ku-band satellites with over 500 channels of video and hundreds of audio channels. But, east and west of the edge of our domestic satellite range are dozens more satellites. The only thing stopping you from seeing them is that nagging line-of-sight problem. You have to be able to see the satellite to receive it. For instance, living in the U.S. there's no way that I am going to be able to receive satellites directly over Russia or Australia. Those satellites are too far away.

The closer you are to the edge of the East Coast of the U.S., the more likely you'll be able to see satellites parked over the Atlantic ocean. And, the closer to the edge of the West Coast of the U.S. you are, the more likely you'll be able to see satellites over the Pacific. Since the U.S. is so wide, there is no chance of East Coast viewers seeing West Coast satellites or vice versa. There is a chance that folks living in the middle of the country with large (i.e. 15-foot and up) dishes might be able to see some satellites from each side.

What You'll Need

Any C-band satellite TV system can be used to receive Atlantic or Pacific satellites, subject to a long list of caveats and limitations. First, since you'll be operating on the fringe of the satellite signals for the most part, you'll need as big a dish as you can put up. Standard 10-foot mesh dishes will do a better job than 6- or 7.5-foot dishes in most cases. If you're thinking about buying a dish and reception of Atlantic satellites is a must, consider buying a 12- or 15-foot dish. Be prepared to pay a premium price for an extra large dish: Orbitron makes a 11.7-foot polar mount dish which sells for about $700. Their 16 foot dish retails for around $2,900 (plus shipping).

Transmissions on Atlantic satellites are in both C and Ku-bands; therefore it's a good idea to have a C/Ku-band feed horn and the best low-noise LNBs you can afford. Combined C/Ku-band feed horns with top grade LNBs cost about $350. U.S. domestic satellites are transmitted with vertical or horizontal polarity (called linear polarization), while European satellites are transmitted with circular polarity (right hand or left hand circularly polarized). A linear polarity feed horn will still receive circularly polarized transmissions, but some loss will be noticed in the signal. To offset that loss linear polarized feeds can be fitted with an insert which allows circularly polarized signals to be received. These devices are called "dielectric inserts" and are available from Skyvision, a mail order company (800-543-3025), for about $20. You may also buy a circular polarity feed horn, but this would inhibit reception of linear polarized signals and cost considerably more.

You will also need a longer motor drive to allow you to view satellites far to the east. Most satellite systems are sold with 18-inch actuator arms (this is the motorized device which turns the dish). Viewers on the East Coast will have trouble seeing Satcom C5 (our western-most satellite) because it will be so far on our western horizon that there may be trees, buildings or hills in the way. The same holds true for viewers on the West Coast in which G6 is on the eastern horizon and obstacles may be in the way.

Some satellite TV systems are sold with 24-inch actuators and these have no trouble seeing our domestic satellites. However, they will not be able to see beyond that. A 36-inch actuator will easily do the job and will cost about $250. The one thing you need to know about using a long actuator and cranking your dish from horizon to horizon, is that when it's furthest east the geometry of the installation puts the actuator arm at a mechanical disadvantage. My experience is that a 36-inch actuator will be able to bring back a 10-foot aluminum dish from such a position but not a fiberglass or solid aluminum dish. You may have to have someone out at the dish site helping the dish up. It's also a good idea to lubricate the pivot points on your dish to ease operation.

There is a different type of mount called a "horizon-to-horizon" mount which can be installed to access these satellites. These cannot be used with a polar mount and add considerably to the expense.

What You'll See, What You Won't

From my location, using a 10 foot mesh dish, a 36-inch actuator, a 40 degree C-band LNB, and a .8 dB Ku-band LNB, I can see as far west as Satcom C5. There are a number of trees in the way but enough signal gets through to allow me to listen to the SCPC signals, mostly radio networks for sports, news, and music. To the east I can see as far as Intelsat 601 which is at 27.5 degrees west: That's when the trees get in the way and I come near the end of my actuator arm. It's possible—with a horizon-to-horizon mount, no obstruction in the way, a big enough dish, and decent LNB—to see as far as Express 2 at 14 degrees west.

What's actually out there? In North

America we use a system of transmitting known as NTSC, but, in Europe there are several other types of transmission modes in current use. PAL is the system used most in England and SECAM is used in France and Russia. Neither of the other two are compatible with NTSC. In addition, many of the signals use encryption systems such as MAC or Leitch and will not be viewable even if you could see the satellites. And, finally, the day of digital transmission is upon us and many channels are sent via a digital data stream and it will appear on your screen as just another empty channel.

As if that weren't enough to deter you, you should also know that most of these satellites have transponders which are "spot beamed." This means that certain channels are actually aimed at different parts of the western hemisphere. Spot beams are narrowly focused transmissions which cannot be received outside of the intended reception area. Because the beam is concentrated, the signal level to those areas is very strong. Conversely, wide or hemispheric beams are intended for reception in a broad area of the hemisphere. These beams are spread over an enormous area and consequently the signal is considerably weakened. The upshot is that what you're looking for is an unencrypted, NTSC feed, spot beamed to your location. There aren't many of those.

There are several full time channels such as USIA/World Net seen on Intelsat 601 at 27.5 degrees west. This is the same feed which used to be on Spacenet 2, channel 3. There are no additional subcarriers to this channel. There are numerous news feeds for ITN (Independent Television News from London) and Reuters (another Euro-news service). You'll also see occasional video from CNN, NBC, ABC, and CBS. BBC used to have feeds of their World Service Television but these are now sent in a digital format.

The best pictures I've seen are from Hispasat, a relatively new satellite launched in 1992, at 30 degrees west. The Ku-band signals from TV Espana Internacional and Hispavision are as good as many Ku signals from our local birds. In addition there are two audio subcarriers: Radio Nacional de Espana and Radio Exterior both with news, sports, and talk shows from Spain. Spanish speakers in North America will really enjoy the non-commercial movies, sports, and news on these channels. I believe that, as strong as this signal is, an unobstructed view will yield good results on Ku-band dishes as small as 6 feet. Maybe less.

Tuning in to the Internationals

This business of seeking out new satellites is not for the complacent and satisfied. You'll be required to reconfigure your dish and spend hours scanning the eastern or western horizons with little result. But, it is interesting and you'll learn a little about satellite technology along the way.

The first thing you should know is that extending your actuator arm to its limit may damage or bend the arm. If it's bent you'll have to replace it. The next thing you'll find out is that your receiver's memory may already have all satellite slots filled. In this case, you'll have to assign the new satellites to existing names. You'll also have to re-set the eastern (or western) limits on your receiver so that it will allow the extra travel. Your actuator arm should have internal limits which will prevent overextending.

Since these satellites appear to be mostly vacant it won't be easy to just cruise east and hope to land on an active transponder. The chart below shows how to determine where the satellites are. Each receiver uses a different set of numbers to determine where it is in the Clarke Belt. Take the known positions of two satellites, say Satcom F3 and Galaxy 1. Since these satellites are 2 degrees apart you can find out exactly how many counts your actuator must see to move 2 degrees. Subtract the number for F3 from G1, divide by two, and you'll know how many counts your dish must move to travel 1 degree in the Clarke Belt. Mine takes six counts. Armed with this information, you can determine how many counts away the satellites east of Galaxy 6 are. If your receiver displays the number on the front of the receiver or on the screen you'll search much faster.

Keep in mind that Ku-band channels will appear as different numbers on different receivers and that you may have to adjust the video tuning and skew to peak the signal. Audio subcarriers are not standard frequencies. One count on your receiver will be enough to lose a signal, so tune carefully and watch for anything in the snow such as sync bars which might indicate a channel nearby.

For more information on all the world's satellites, including footprint charts and video and audio listings, get a copy of *Satellite & TV Handbook* from *Grove Buyer's Guide.*

International Satellites

Satellite	Location	Band
Intelsat 706	53 deg west	C-band
Intelsat 709	50 deg west	C-band
Panamsat F1	45 deg west	C/Ku-band
TDRSS	41 deg west	C-band
Orion F1	37.5 deg west	Ku-band
Hispasat	30 deg west	Ku-band
Intelsat 601	27.5 deg west	C-band
Intelsat 605	24.5 deg west	C-band
Intelsat K	21.5 deg west	Ku-band
Express 2	14 deg west	C-band
Gorizont 26	11 deg west	C-band

ST

By Steve Dye, *gpsyes@aol.com*

GPS and GLONASS on the Web

Without doubt the worldwide web (WWW) has become one of the most accessible sources of information for any conceivable subject. If you want it, it's there. The web is available from anywhere in the world as long as you have internet access, and it serves us 24 hours a day. So what has this to do with GPS? Well, the level of available information regarding GPS on the internet is one step short of infinite.

The columns I write for *ST* and the book I wrote (available from Grove) contain plenty of information regarding GPS and GLONASS. However, if you want to know what the latest results are from the University of Southern California's GPS-seismic experiments, or where each satellite is exactly, then you could not do better than to jump to the appropriate web address and take a peek, since that information is continually updated and as close to real-time as you can get.

The worldwide web is an information resource for GPS unsurpassed by any other means. In this issue's column we will show you how cruising the web will assist you in learning about areas of GPS and GLONASS that are constantly changing. Such items as product lines, prices, stock prices of GPS companies, satellite constellation status, published results of recent experiments, and users' experiences with GPS on their home pages are just a few of the many areas of interest for GPS alone.

Let's start off with companies and their products. When we think of GPS, names such as Trimble, Magellan, Garmin, and Ashtech come to mind, but other companies such as Motorola, Hughes, and Racal are also in the business, to name a few. The WWW is aptly named—it really is a web—you go to one address, and click on a link to another page or address that may take you to another, and before you know it, you are a long way from your original start page. GPS is one subject that will certainly take you to enormous depths in the internet!

Companies Involved in the GPS Industry

Who are some of the major players in the industry? Try these addresses :

http://www.trimble.com
http://www.magellan.com
http://www.garmin.com
http://www.ashtech.com

This is all I need to say about these pages. The well designed layout will tell you all you ever needed to know about their product lines, the companies areas of interest, as well as a few things about GPS itself. These pages are but a few of the many web sites created for the hundreds of companies involved in the industry and science.

Research Institutions and Experiments

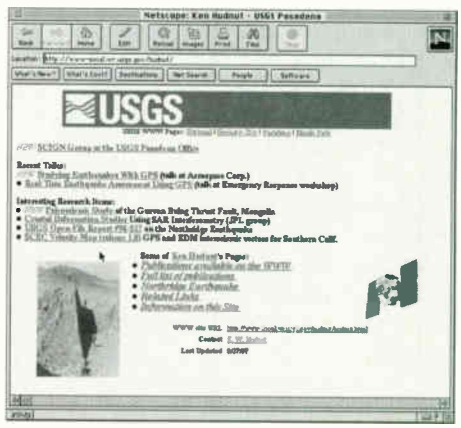
Research using GPS and other navigation technologies is featured on the WWW as much as commercial information.

URL address **http://www.dur.ac.uk/~dgl0grf/gps.html** is one of the several web addresses of the University of Durham in England. This site looks at a graduate student's project researching crustal spreading cycles on Iceland using GPS and the East Pacific rise.

http://www-gpsg.mit.edu/

This site from MIT looks at GPS and geodynamics and provides information regarding the research of this subject.

http://www-socal.wr.usgs.gov/hudnut/

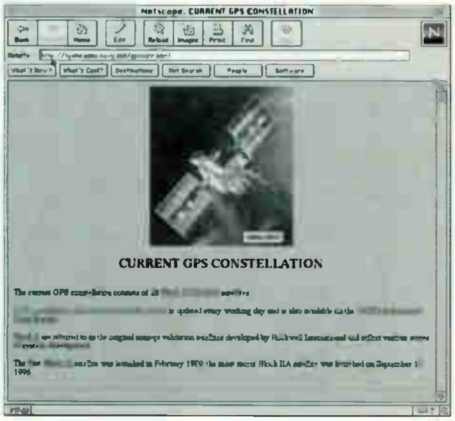


No GPS enthusiast's visit to the WWW is complete without a visit to Dr. Ken

Hudnut's page to see what we are learning about earthquakes and how GPS can be used to accurately measure the movement of the Earth's crust due to seismic activity with blinding precision!

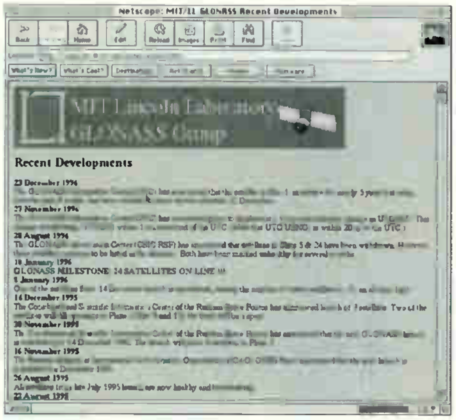
GPS and GLONASS Information Resources

The MIT Lincoln Laboratory has an excellent GLONASS page at URL: **http://satnav.atc.ll.mit.edu/**. This page will provide a host of information regarding GLONASS constellation status (health / availability), position estimates, local-area differential, wide-area differential, velocity estimates, almanac data, and satellite visibility. For information about the GPS constellation, I recommend going to **http://tycho.usno.navy.mil/gpscurr.html**, then navigate yourself to the page that indicates the GPS constellation status and health.



The U.S. Naval Observatory Home Page is at **http://tycho.usno.navy.mil/gps.html** and is an excellent source of information, as is the U.S. Coast Guard's home page, found at: **http://www.navcen.uscg.mil/**. These latter two pages are well designed, professional, highly informative pages that really reflect the level of service provided by these government agencies whose services we take for granted. For more information about GLONASS, go to **http://www.nz.dlr.de/gps/glonass.html**. or **http://vega.atc.ll.mit.edu/notes/recent.html**.

Another site that caught my eye was **http://info.hut.fi/Units/Geodesy/links.html**. This site contains tens of links to other GPS sites for a variety of topics. Go there—you will be glad you're paying for unlimited access!



Home pages

There are hundreds of GPS enthusiasts and professionals who just have to share their GPS knowledge and experience with the rest of the world via their home page—one of them being myself. Pay me a visit at: **http://sdye.home.mindspring.com/**. Visit this site to learn a little about my book, my GPS links, and to email me any question you have about GPS.

Websites for Serious GPS Users

From my extensive research of the WWW, there seem to be very few sites geared towards the serious or professional GPS user. Of these, one site that is fully committed and oriented toward this goal is at **http://www.gpsindustry.com**. This is a small company dedicated to providing an information and advertising resource site for the entire GPS community, be it for corporate, military, professional, or private users of GPS. Online tutorials, GPS constellation updates, industry news, technology updates, articles, and a locator guide are samples of what you will find there. This is where visitors can post questions and engage in a

professional exchange about GPS-related topics. A visit to this URL is certainly worth your time for updates on professional GPS issues.

Finding More GPS Related Material.

Using a search engine, information can be found for 1001 GPS topics. Try using the following addresses :

http://www.yahoo.com
http://www.excite.com
http://www.altavista.com
http://www.infoseek.com
http://www.lycos.com

Once you arrive at these sites (which are really directories and search engines) just enter GPS and any other key word relating to your search, and wait for hundreds of WWW addresses for you to visit to appear..

Until next edition of the Navigation Satellite column, I wish you happy cruising on the net. If you have a question about GPS or GLONASS, please email me at **gpsyes@aol.com** ST

Satellite Times Tests

By Steven J. Handler

OmniQuest, Mitsubishi's New Satellite Telephone

Welcome to the new generation of portable satellite phones now appearing on the scene. Although still not as featherweight and compact as cellular phones, these laptop, commuter sized portables are much lighter than their 25-30 pound predecessors.

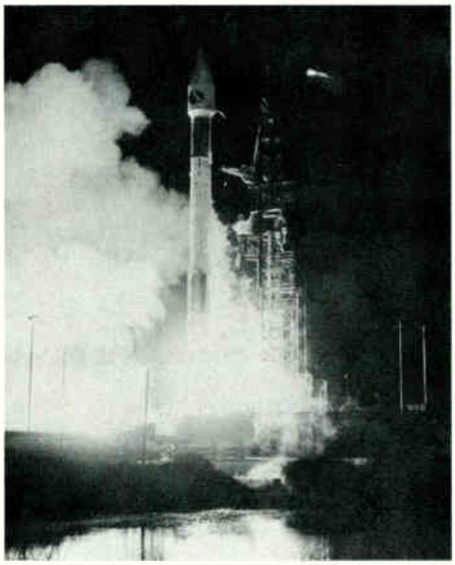
Satellite Times tested one of the first arrivals to the marketplace, Mitsubishi's new ST-251 OmniQuest satellite phone that handles voice, data, and fax.

OmniQuest consists of several components all stored in a nylon carrying case about the size of a briefcase. The base unit contains the transceiver. Attached is a movable lid that contains the phone's antenna. Together they measure 11.3"(W) x 2.2"(H) x 8.3"(D), about the size of a laptop computer. A telephone handset measuring 8" (L) x 2.2" (W) x 1.3" (D) plugs into one of the ports on the base unit, allowing voice calls to be made.

Included with the phone is a 3100-mAh nickel metal hydride battery that Mitsubishi rates at one hour of talk time or eight hours of standby while using the most conservative power options. With handset and battery (sans case), the phone weighs 5.3 pounds.

Artist's rendering of AMSC-1 in orbit 22,300 miles above the earth (Photo Credit: AMSC)

OmniQuest operates on American Mobile Satellite Corporation's Skycell system. It communicates up to AMSC-1—a satellite located at 101 degrees West in a geostationary orbit 22,300 miles above the Earth—which relays the call down to AMSC's Reston, Virginia, earth station and into the public telephone system. Incoming calls to OmniQuest take the reverse path. Coverage includes most of North and Central America, Alaska, Hawaii, parts of the Caribbean, and the northern portion of South America.



Launch of AMSC-1 April 7, 1995 from Cape Canaveral. (Photo Credit: AMSC)

American Mobile Satellite Corporation (AMSC) was established in 1988. In 1989, the FCC awarded them the license to provide mobile satellite service to the United States, Alaska, Hawaii, Puerto Rico, the U.S. Virgin Islands, and coastal waters up to 200 miles offshore. Besides the laptop sized phones such as the OmniQuest, AMSC supports other configurations including marine, aircraft, and vehicle-mounted phones.

AMSC-1, launched April 7, 1995, from Cape Canaveral, is one of two similar satellites, the other being MSAT. Both are based on the Hughes Space and Communications Company's HS-601 3-axis stabilized satellite bus. AMSC-1's payload was built by Spar of Canada. Although Hughes was the prime contractor for AMSC-1, Spar Aerospace, Ltd. of Canada was the prime contractor for MAST, which was built for TMI Communications of Ottawa, Canada.

Hughes' HS-601 spacecraft debuted in 1987 and is no small bird. AMSC-1 and MSAT measure approximately 62 feet across with both antennas deployed and 68 feet, 9 inches from the tip of one three panel solar wing to the tip of the other. The HS-601 has been one of the major birds launched into geosynchronous orbit for use in the C-band satellite television market.

Designed for a 12 year life, AMSC-1 and MSAT were the first satellites to use Hughes graphite Springback antennas. Lightweight at 45 pounds each, they are rolled together into a 16 foot cone and located in the normally unused space found in the top of the rocket fairing. AMSC-1 is designed to have 56.5 dBW (equivalent to about 457,000 watts) of power to provide communications for its users. The satellite varies the power used by each voice channel depending on the gain of the mobile antenna being used.

Communications between mobile users and the satellite take place in the L-band. The satellite receives signals from the ground station and relays them down to the mobile customer, using channels between 1530-1559 MHz. The mobile customer's phone transmits its signals up to the satellite using the 1631.5-1660.5 MHz band. Communications with the ground station which controls the satellite takes place in the Ku-band.

Mitsubishi's OmniQuest laptop sized satellite telephone (Photo Credit: AMSC)

Using any of the current generation of satellite phones is more complicated than operating a cellular phone. We were pleased that OmniQuest was relatively easy to set up and operate. Although reading the product manual is often the last resort for a consumer, we think OmniQuest's large and detailed manual is a "must read" for those who wish to properly operate the phone.

To make or receive calls, the phone's

American Mobile
SATELLITE

Credit: American Mobile Satellite Corporation

lid (which contains the antenna) is raised and (in North America) pointed southward in the general direction of the satellite. Two angle guide markings located on the unit's base, help set the proper angle of the lid to maximize the satellite signal.

For those who harken back to their days as a boy or girl scout, a compass that's (included) lets the user know which direction is south, allowing the antenna to be properly pointed. A word to the wise: don't wing it, use the compass to establish which direction is south. Using the compass and the angle guide, we had no trouble in aligning the direction and angle of the phone to establish contact with the satellite.

One word of warning, though; we found the compass does not provide accurate readings when in close proximity to the phone. This should be no shock to those proficient in using a compass, which is often influenced by metal objects. The common sense solution is to move away from the unit and other metal or magnetic objects when using the compass.

The phone's antenna requires a clear, unobstructed view to the south. Walls, trees, buildings, and other objects that block the southerly path may prevent signals from the satellite reaching the phone and vice versa. Not surprisingly, we found that best performance was obtained outdoors. OmniQuest also performed very well when placed on the dashboard, inside a stationary vehicle. Be aware, however, that the phone is not designed to be used in moving vehicles. To our surprise, the phone delivered acceptable performance used inside a house (wood construction) about 6 feet from a southerly facing window.

We find OmniQuest's voice quality generally good. At times voices had a digital, unnatural sound but not enough to inhibit the conversation. Although our calls were connected almost instantantly, we noticed a slight delay during phone calls. The delay is caused because radio waves traveling at the speed of light take about a quarter of a second to travel the 22,300 miles up to the satellite and then 22,300 miles back down again to the phone network. To compensate for this slight delay, we waited until the other party finished talking before we started, so as not to miss what they were saying.

For those tired of carrying around an address/phone directory, OmniQuest's 99 memory slots and three additional one-touch memory slots can store important names and numbers. Each slot holds numbers up to 32 digits in length and name tags up to 11 characters long. When recalling names and numbers from memory, only the last seven digits of a number and the first four letters of a name tag appear on the two line LCD display. The remainder must be viewed sequentially. OmniQuest also allows you to recall and display the last three numbers dialed.

SkyCell offers rate plans (both include an incoming toll free phone number). Plan TS1 costs $25 for a monthly access fee and $1.49 a minute for airtime on calls made in the continental United States to locations in the continental U.S., Alaska, or Hawaii. Plan TS2 has a $100 a month access fee that includes 80 minutes of airtime and $1.35 per minute for airtime thereafter. Skycell's airtime is inexpensive compared to other satellite telephone alternatives such as Inmarsat-M or Inmarsat Mini-M. However, Skycell, unlike Inmarsat, does not provide global coverage.

Besides the nickel metal hydride battery and handset, OmniQuest comes with a nylon carrying case, detachable handset cradle that snaps into the side of the base, battery charger and AC adapter, and compass. Packed up in the nylon case, the phone and these accessories weigh about 9.9 pounds.

For those looking for the ability to talk longer without having to recharge a battery, PowerLink, from AER Energy Resources, might provide a solution. Although not tested by *Satellite Times*, PowerLink is an extended life air-zinc battery for the OmniQuest. At 3.4 pounds, it's 2.3 pounds heavier than the nickel metal hydride battery supplied with the OmniQuest, but promises much better talk and standby times of up to eight hours or 50 hours respectively. It's scheduled to be available before this issue reaches the newsstand.

OmniQuest, one of the new generation of satellite telephones, is still not at the size and weight to which cellular users have become accustomed. However, it's lighter and easy to use compared to prior generations of satellite phones.

What type of customer might find the OmniQuest a solution to their communications needs? Disaster relief workers, insurance adjusters working in disaster areas, reporters traveling to remote areas, military and government agents and others who want the ability to communicate without being dependant on the availability or operational status of local landline and cellular communications. It also may fill a niche for those people located or traveling in remote areas not served by landline or cellular service.

With a suggested list price of $4,499.00 the OmniQuest is not inexpensive. However, for those who desire communications without dependance on local conditions, it may be the solution.

Regular *Satellite Times* columnist Steven J. Handler covers the wireless communications industry for a number of publications. He can be reached by e-mail at: **ontheair@grove.net**

For more information about the OmniQuest ST-251 contact:
American Mobile Satellite Corporation
10802 Parkridge Blvd
Reston, VA 20191
800-872-6222
http://www.skycell.com

ST

ST ON THE AIR

By Steven J. Handler
ontheair@grove.net

The Death of C-band

Is the delivery of programming to consumers via C-band satellite dying a slow death?

Although the patient is not yet terminal, I think it's only a matter of time before C-band's heartbeat goes flatline. Worse, there may be nothing we as C-band viewers can do to stop it.

I normally dedicate this column to reviewing interesting and exciting channels available to satellite viewers. However, sadly, I feel compelled to touch upon what I believe is a monumental trend that potentially will have a dramatic effect on all C-band viewers.

Recently I toured the rural Midwest including Michigan, Wisconsin, Minnesota, Iowa, and Illinois. During my travels I noticed that not only are small dishes for DIRECTV, PRIMESTAR and others becoming more plentiful, but in many areas they now outnumber the larger C-band dishes. Quite a change from several years ago, when only large C-band dishes dotted the landscape.

I suspect that the migration of rural C-band users to small dish systems will continue. In some cases the low cost of small dish systems has empowered those who previously could not afford the $2000 plus installed C-band system to participate in satellite TV entertainment. Others, such as my in-laws, found their older C-band systems in need of replacement. Rather than purchase another C-band system, they opted for the simpler-to-use small dish system.

Small dish popularity doesn't end in rural America. With the cost declining, small dishes now inhabit many rooftops in urban America, providing serious competition for local cable systems.

Why are DIRECTV, ECHOSTAR, and PRIMESTAR successful? Perhaps it's because America, the most technologically advanced country in the world, still has a vast majority of its population that is not comfortable with technology. Households whose VCRs still flash 12:00 are plentiful. Enter small dish systems—whose simple-to-use remote control resembles that long-familiar, conventional TV remote—and you can see why these systems beckon to those wanting ease of use with a good selection of programming.

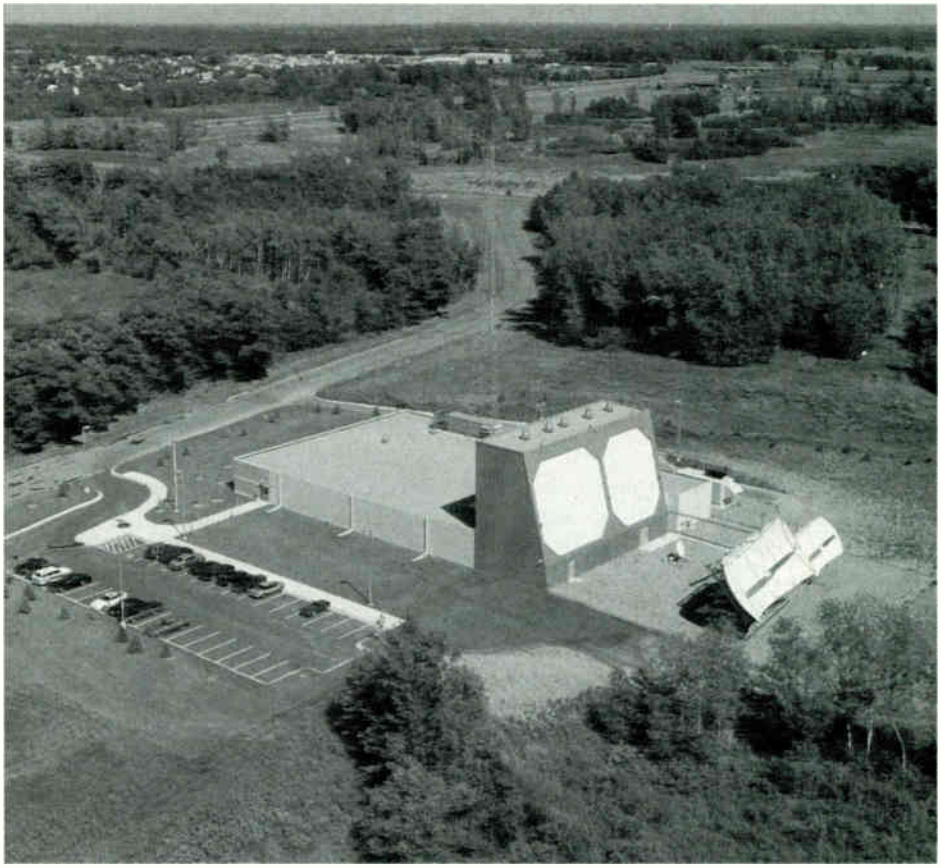
The bottom line is simple: Consumers want programming. How it gets to their television set is irrelevant. The simpler the delivery system, the better. C-band, unlike the small dish systems, is neither simple to setup nor to operate.

Can it be that C-band manufacturers have forgotten that in the marketplace consumers are the king? Have they forgotten the KISS (keep it simple stupid) war cry? Will C-band be knocked out of the marketplace by small dish alternatives that stress ease of use? I think so.

The C-band Advantage

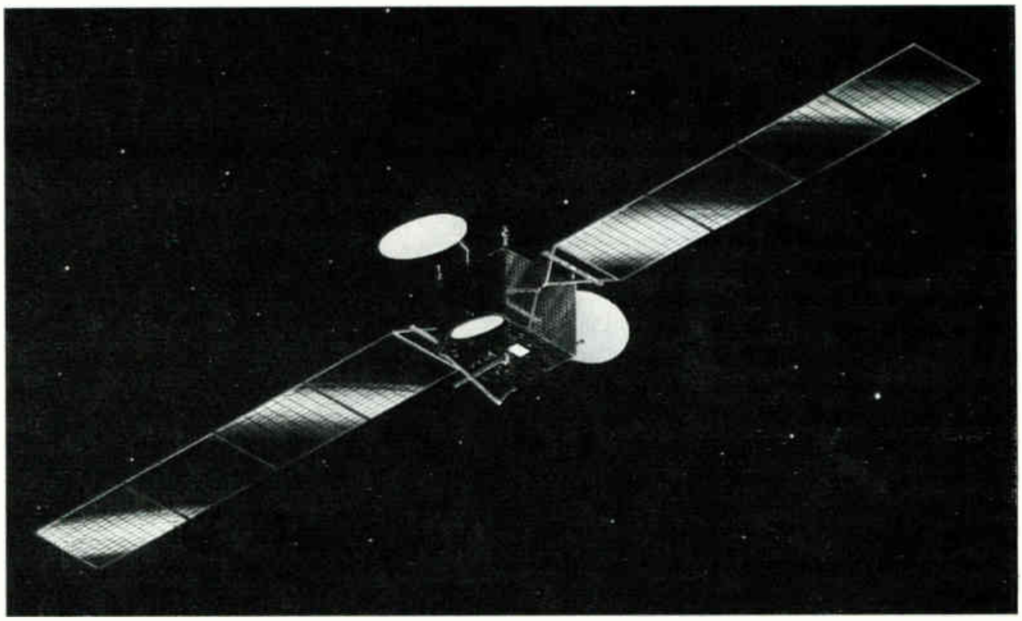
DIRECTV™

PRIMESTAR®



Aerial View of DIRECTV's Castle Rock, Colorado broadcast. (Photo Credit: DIRECTV)

C-band manufacturers may have been lulled into a false sense of security. With three million plus users in America, they may believe that their products are meeting consumer demand and enjoy popular support. If so, I think they are wrong and have perhaps made a fatal mistake. The mainstay of C-band viewers—rural America—in many cases turned to C-band not because it was their first choice among television delivery systems, but rather because it was the only way to receive television programming in many rural and remote communities.



Artists drawing of DIRECTV's DBS-1 satellite (Photo Credit: DIRECTV)

In urban areas, the cable television industry, long accustomed to its monopoly position, is now facing a formidable challenge by small dish satellite delivery systems. In the urban slugfest, I believe the winner will be whoever offers the best selection of programming at reasonable prices, packaged through a cost effective and easy to use delivery system.

What's so good about C-band? Aficionados point to the 500 plus channels of programming versus the under-200 television channel selection offered by small dish systems. I use a C-band system and enjoy television as well as the next viewer. Besides all of the free channels available via my C-band dish, I subscribe to a programming package that includes around 50 subscription channels. Still, even with that theoretical "500 plus" channel selection, I find that many times there is still nothing worthwhile to view. The simple fact is that for most people 200 or 100 channels is probably overkill. I would venture to say that the average C-band or small dish viewer concentrates viewing to less than a dozen different channels.

Is C-band better than small dishes? Ardent C-band supporters will be quick to brag that when viewing C-band you are watching first generation signals. Their theory may be correct, however in reality, I find no perceivable difference between the quality of signals offered by C-band and small dish systems. If there is a difference, I believe it is so small that the average viewer will find it insignificant.

So what if some of the small dish signals were originally received by the providers on C-band and then retransmitted by another satellite to the consumer? So long as the small dish viewer receives excellent quality signals, whether they are first generation or second generation makes no difference.

Another advantage C-band proponents may tout is the availability of free programming. That's true. C-band still has many channels that may be viewed for free, unlike the small dish that requires subscription for viewing any channels. However, many of the more popular channels, including CNN, HBO, Family Channel, Disney, and scores of others, require a subscription whether viewed on C-band or via a small dish system.

Worse, I think the number of quality free channels available to C-band viewers is declining. Don't take my word for it: consult the grid that appears in each issue of this magazine and compare the current grid to the first issue of *Satellite Times.* Those who enjoyed excellent programming provided by formerly free channels may now—or may soon—find their favorite fare available only by subscription. Even worse, some formerly free offerings now use digital signals, placing them beyond the reach of the vast majority of C-band consumers.

I see the eyes of C-band proponents light up as they insist that C-band programming is less expensive than small dish programming. In general, this may be true. However, it's time for a reality check. Consumers are rational: Given a choice between plunking down $2500 or more for an installed C-band system that includes an IRD, dish, and related components or $200 for a small dish system, which is going to be more popular? Worse yet, those seeking the latest in C-band digital IRD technology may find the cost of an installed system over $3000.

The difference in cost to purchase a small dish and C-band system will go a long way toward paying for the difference in programming costs. For example, those who purchase a $200 small dish system and place $2300 (the potential difference in cost between a small dish and C-band system) in a five percent savings account can receive over $100 a year in interest.Enough to put a big dent in the cost of programming.

Programming Cutoff at the Source

The trend is not in C-band's favor. C-band may be devastated by simple economics. The target audience for these channels are cable TV subscribers. C-band viewers are simply an added bonus, are able to tune in because of the mere happenstance that C-band is the method by which these channels deliver their signals to cable systems. The cost to each of these channels for their protected C-band transponder is typically well over $100,000 a month. In the past there was no effective alternative for delivery of their signals. However, new digital technology and compression systems now allow several channels to be delivered via a single transponder.

It doesn't take much imagination to figure out that the more channels you fit onto one transponder the less the cost becomes for each channel. In today's corporate downsizing and cost cutting environment, slicing a $1,200,000 a year bill in half or more is very attractive. As these channels go digital, even if they elect to allow viewing by subscription (and there is no guarantee that they will) most of today's C-band equipment used by consumers may be incapable of receiving and decoding their digital signals.

How long before death's rigor mortis sets in on your C-band dish? My prognosis: C-band will die a slow and lingering death. As more and more C-band users face the prospect of replacing their aging systems, defection to the smaller dish will take place. As the number of C-band viewers dwindles, the cost of serving them will increase and C-band's lower programming cost advantage may potentially disappear. My bet is that within five years C-band could be in trouble; within a decade, it may go the way of the telegraph key, vacuum tube, and the dinosaur.

Don't Shoot the Messenger

Before you label me as some fanatic trying to bash C-band, please recognize that I own a C-band system and not a small dish. I love being able to watch the flights of the space shuttle over NASA TV—a channel that is not available on a small dish systems. However, as a professional observer of the satellite television industry, you don't have to hit me over the head to spot a trend. Simplicity and a good selection of programming will continue to spur the growth in popularity of small dish systems.

Small dish owners don't have to worry about rotators or activator arms that require lubrication and maintenance. In the colder climates there are no moving parts to freeze, preventing the dish from rotating. And let's face it, large dishes are about as attractive as a giant 10 foot garbage can in your front yard.

As for me, when my C-band system dies or when the defection of programmers to digital compression gets too severe, I will shed a tear, but my next system will be one of the small dish offerings. That's how I will watch what's on the air.

To contact the author, Steve Handler, e-mail him at: **ontheair@grove.net**

The opinions expressed in this column are not necessarily those of *Satellite Times*, its management, or staff. We welcome your comments. All correspondence received, by e-mail, postal service, or otherwise shall become the property of *Satellite Times*, who in its sole discretion may print, in whole or part, any of such correspondence.

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Inside DIRECTV's Castle Rock Broadcast Center (Photo Credit: DIRECTV)

10.974 GHz.

CNN International has moved to a new transponder on Intelsat 707 at 11.485 GHz (replacing NRK 2, which has moved to 11.325). Norway's TV Norge ended its clear PAL transmissions from Intelsat 707 on 11.016 GHz on September 30. Transmmissions continue via Thor 2 at the same orbital position on 11.421 GHz, also in clear PAL.

On September 1 Scandinavia's FilmNet officially changed its on-the-air name to Canal Plus, to reflect its new French ownership. FilmNet 1 Nordic on 12.092 GHz is now Canal Plus Sverige ("Sweden"). Canal Plus Danmark ("Denmark") is on 11.261 GHz, while Canal Plus Norge ("Norway") is on 11.293 GHz.

FilmNet 2 Nordic on 12.015 GHz is now the pan-Nordic Canal Plus Gul ("Yellow"). All are in Eurocrypt M/S2-encoded D2-MAC. (The yellow and Swedish channels are on Thor 1, the Danish and Norwegian channels on Thor 2.)

Nokia's new digital satellite receiver for Scandinavia, the Mediamaster 9610S, is ready to be sold in stores. But as Canal Plus is apparently delaying the launch of its Canal Digital package to Scandinavia, Nokia and the shops are reluctant to do any marketing. The Canal Digital package on 1 degree West on 11.174 GHz carries Norway's NRK 1 and TV Norge, and TV Finland. The package at 11.278 GHz carries the pan-Nordic Canal Plus service, as well as the separate Canal Plus channels to Sweden, Finland, Norway, and Denmark, the Hallmark Channel, and Finland's Nelonen.

If Canal Plus/Digital is slow off the mark, it may be out-flanked by Rupert Murdoch. Now that the first Scandinavia channels from Murdoch's British Sky Broadcasting are on the air, BSkyB is considering launching digital channels to Scandinavia. BSkyB's head of international distribution, Kirsten McConnell, has been in Scandinavia negotiating with cable companies, and says Sky may concentrate even more on Scandinavia.

There's a new radio station covering the Nordic region, which besides Sweden Norway, and Denmark, also includes Iceland and Finland, and Denmark's semi-autonomous possesions Greenland and the Faroe Islands.

Radio Sweden primarily covers Sweden, but also takes up important stories in the other Nordic countries. Radio Finland does the same from the Finnish horizon, and both broadcast in English daily. Radio Norway International, on the other hand, only carries English once a week.

Radio Denmark had an English program last year, when Copenhagen was the European Cultural Capital. That was discontinued at the end of the year, but former Radio Denmark presenter Julian Isherwood started his own weekly program called *Copenhagen Calling*, available not on shortwave, but on satellite and the Internet via the World Radio Network. Now Julian has done it again, with a new weekly program called *Norden This Week*. ("Norden" is the Scandinavian word for the region.)

Norden This Week is carried on the World Radio Network to Europe, Africa, Asia and the Pacific, and North America Sundays at 1700 UTC, which is 1200 Eastern Time in North America.

The IFA Show in Berlin also saw the official launch of a new service from the World Radio Network, the WRN3 network in German. German programs from YLE Radio Finland, Radio Prague, Deutsche Welle, Radio Vlaanderen International, ORF Radio Austria International, the Voice of Russia, Vatican Radio, Radio Budapest, Radio Sweden and Polish Radio Warsaw are taking part. WRN3 will be carried in Europe on Astra, analog on Sky Movies transponder 16, audio 7.38 MHz, and via Astra Digital Radio on ZDF's transponder 33.

ASIA

According to the Egyptian newspaper *al-Usba*, Moslem militant leader Ayman al-Zawahi will launch a satellite television channel with Islamic fundamentalist billionaire Ossama Ben Laden. The channel will broadcast for 10 hours a day beginning in December, and will be seen in both Europe and the Arab world.

India's Information and Broadcasting Minister S. Jaipal Reddy says the current ban on direct to home broadcasting is likely to be removed by the end of the year. On the first day of the winter session of parliament, the Joint Parliamentary Committee's report on broadcasting will be ready, he says, and the Broadcast Bill will be passed. Once the Bill is passed, Reddy says the Authority would be constituted without much delay.

The sudden introduction of the ban came as a great surprise to Rupert Murdoch, who was poised to launch his India Sky Broadcasting system. To add insult to injury Murdoch and a senior official from his Star television network have been summoned by an Indian court for broadcasting four "obscene" films. According to the *Statesman* newspaper, on September 25 a Delhi court ordered Murdoch and the chief of Star's operations in India, Rathikanata Basu, to appear in court on October 27 to answer the allegations.

NBC announced on September 23 that it had reached more than 3 million homes in India during its first year of broadcasting on the sub-continent. Besides the information channel NBC Asia, NBC also broadcasts the business channel CNBC to India. There are plans to launch several new India-specific shows on both channels next year. NBC has also inaugurated its new studio in Bombay. But there are no plans to dub American serials into Indian languages, as Rupert Murdoch's Star-TV has done, as NBC is targetting the "international Indian" (i.e. one who speaks English).

DirecTV Japan has applied for Posts and Telecommunications Ministry approval for its 91 channel digital satellite TV service, set to begin test broadcasts at the end of November. DirecTV Vice President Akira Yoshigi says the service will include more than 30 channels not aired by its rival, PerfecTV. DirecTV will carry movie programming on eight channels. DirecTV will also provide seven music channels, which PerfecTV does not carry.

DIRECTV™

According to the Japanese Posts and Telecommunications Ministry, all three major digital satellite TV rivals in Japan have agreed to share the same set-top receivers. PerfecTV (which began operating last November), DirecTV (which starts this November), and Japan Sky Broadcasting (which starts next April), will all use a new system developed by the Association of Radio Industries and Businesses that can receive data sent from any of the broadcasters and convert it into suitable analog signals, providing viewers with up to 350 channels.

This followed Japan's first digital satellite television broadcaster, PerfecTV, announcing it would tie up with Murdoch's JSkyB in a move which could possibly lead to their merger. The tie-up would have allowed viewers to choose among 200 channels from both broadcasters. They were also considering unifying their systems and jointly collecting subscription fees.

However, in what must be a major setback for proponents of unified digital broadcasting standards, the Ministry of Posts and Telecommunications later said that the digital broadcast system committee of its Telecommunications Technology Council has suggested that more than one method be used for transmission of digital signals from broadcast satellites. On September 24 the committee released a list of five tentative transmission methods.

Sony Pictures Entertainment is launching a new Pan-Asian satellite TV service. By early next year, the AXN channel will broadcast four customized feeds covering Taiwan, the Philippines, Thailand, Hong Kong, Malaysia, Singapore, Indonesia, and Japan. The only Pan-Asian channel dedicated to action/adventure programming, AXN will offer a wide variety of feature films, series, and extreme sports. It will launch on the Apstar 1A satellite.

Indonesia's only pay-TV company, Datakom, plans to put up its own satellite with 40 digital channels by the end of the year. After launch by Ariane, Indostar-1 will be broadcasting 40 channels of Western and Indonesian movies, news, soaps, and financial information to dishes as small as one meter in diameter.

Datakom's current pay-TV system, Indovision, uses the Palapa-C1 satellite for its 19 channels (which include CNN, TNT, five of Rupert Murdoch's Star-TV channels, the BBC, HBO, and ESPN), as well as six terrestrial Indonesian channels. All of these will shift to Indostar, and the additional channels will be filled by PPV programs, home shopping, financial news, educational programs, and a music channel.

Datakom (which is one-third owned by President Suharto's second son) has been allotted slots to launch three more satellites. Another satellite will be orbited in 1999, with further launches planned for 2001 and 2003.

The Philippines' Agila 2 satellite was launched successfully on a Chinese Long March on August 20. It carries 30 C-band and 24 Ku-band transponders and is now located at 144 degrees East. CNBC has started transmissions on the new satellite on 4.165 GHz in PAL.

Intelsat 801 has taken over from Intelsat 701 at 174 degrees East. Intelsat 701 is moving to 180 degrees.

INTELSAT

Launches and Musical Chairs

Ariane successfully launched its 100th satellite flight on September 24. Flight 100 carried into orbit Intelsat 803. Only eight of Ariane's 100 launches have failed, giving the European commercial launcher one of the best records in the world.

Meanwhile, Intelsat has been playing musical chairs in the Clarke Belt. The international satellite operator says there is an anomaly in its Intelsat 605 satellite at 24.5 degrees West. Intelsat 803 is being placed at 27.5 West degrees initially, freeing Intelsat 601 to move to 34.5 degrees West. From that position, Intelsat 603 will be moved to replace the malfunctioning satellite at 24.5 degrees West.

Eventually, Intelsat 803 will replace Intelsat 515 at 21.3 degrees West. The new satellite will have better coverage and significantly higher power, and Intelsat says it will offer the greatest coverage of Africa by any spacecraft. C-band reception will be possible with antennas as "small" as 1.8 meters. There are programming commitments from Discovery, TV5 Afrique, MCM Africa, CFI, Canal Plus Horizons, RTP International, and RTP Africa. Others planning on transferring to the 803 include the Portuguese broadcasters RTP1, RTP2, SIC, and TVI.

Intelsat 804 (to be launched on December 16) will be located at 64 degrees East, and not 29.5 West degrees as previously reported. It will be tested for about five weeks at the test location at 47 degrees East, then move to the final location.

The launch of Egypt's Nilesat has been moved back from November this year to January.

Turkey's third satellite, Turksat 2A, will be launched in 1999, and will, together with the previous satellites, cover the range from "Western Europe to the Great Wall of China". Considering that the first two Turksats put a terrible signal into northern Europe, despite the many Turkish immigrants there, any such claims will have to be taken with a large grain of salt.

China is to launch the U.S.-made ChinaSat-8 in the fourth quarter of 1998. The 52 (?!) transponder satellite was ordered from Loral Space and Communications Co.

Thanks as usual to Curt Swinehart, Richard Karlsson, Frank Oestergren, James Robinson, *The Satco DX Chart*, *Tele-satellit News*, and *What Satellite TV*. ST

By Doug Jessop

Don't You Just Love Satellite Technology?

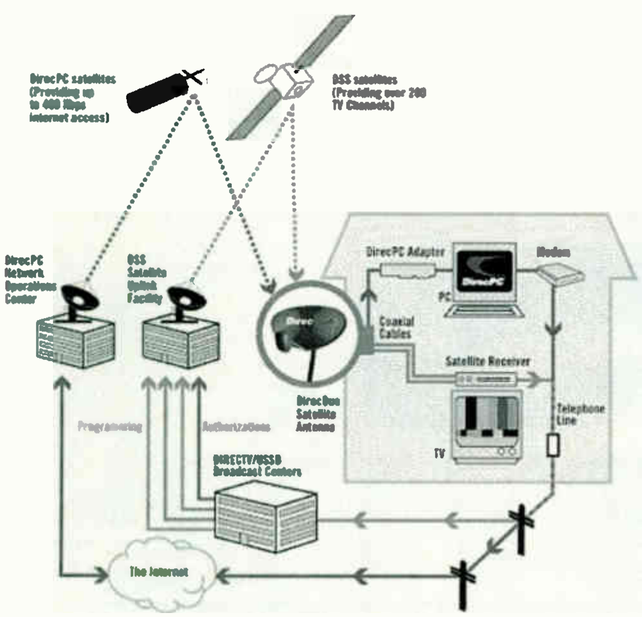
I have to admit I'm a gadget guy. I truly enjoy my given profession of television broadcasting. I also spend a fair amount of time (according to my wife I spend more than I realize, but that's another conversation) managing about a dozen websites on the Internet. So when I heard about a product that mixes both I had to take a peek.

DirecPC is an advanced satellite antenna which enables you to receive DirecTV/USSB programming and high-speed Internet access at up to 400 kbps. All you need is the DirecPC 21-inch elliptical dish, a receiver that sits on your TV, a PC adapter, their software, and opposable thumbs.

The Digital Satellite System (DSS) signal originates at the broadcast center for your satellite television service provider—DirecTV and/or USSB. From the broadcast center, your TV signals are transmitted to a satellite 22,300 miles up in space (geostationary orbit), which beams the signals back to dishes across the country. From the dish, it's a short trip down a cable and into your set-top receiver.

Turbo Internet uses a high speed satellite link to turbocharge Internet access. Working in conjunction with your Internet Service Provider (ISP), your request is forwarded through your modem to the DirecPC network operations center and routed to the Internet. When the remote server responds to your request, the file is sent to DirecPC's operations center, where the file is transmitted to the DirecPC satellite 22,300 miles up in space. The signals are then blasted back to your DirecPC dish at up to 400 kbps. To envision how incredible this speed is, imagine your 1983 Pinto winning the Indy 500.

Both the Digital Satellite System and DirecPC components share a single telephone line for requisite monthly receiver billing "phones-ins" and Internet navigation.



According to Paul Gaske, senior vice president for broadcast products and services at HNS, the new product confirms the company's "rock-solid" commitment to the modern American multimedia family. Gaske said that DirecDuo answers a question customers have been asking since DirecPC was introduced to the consumer marketplace last year.

"People have wanted to know: When can I get Turbo Internet and DirecTV on the same dish?" said Gaske. "Well, the simple answer to that question is right now. With DirecDuo," Gaske continued, "one dish really does do it all—a daughter does research for a homework assignment on the worldwide web while mom and dad enjoy a top hit movie on DirecTV or USSB. Meanwhile, their son is watching the NBA playoffs in digital clarity with his buddies in the den. And all of this comes into the home through a single, discreet satellite dish."

The antenna is capable of supporting multiple Digital Satellite System set-top boxes for television programming, as well as a DirecPC card installed in a computer for Turbo Internet access. Both the TVs and the PC can be located in different rooms on separate floors.

For Hughes, the biggest challenge in developing the DirecDuo dish was designing a stationary antenna capable of receiving signals from two separate satellites—those used for DirecPC and those employed by DirecTV and USSB. To accomplish this, HNS engineers packed two low-noise amplifiers (LNB's) inside the housing at the end of the antenna's arm.

"While DirecDuo is an amazing feat of engineering, the consumer will be unaware of the fact that the dish points to different satellites," said Gaske. "For such a sophisticated piece of satellite hardware, the dish is surprisingly easy to install. The customer's main focus will be on enjoying satellite television and Turbo Internet in their home."

Existing DirecTV and USSB customers can upgrade their systems by purchasing a DirecPC card and DirecDuo antenna for $599 (MSRP). These customers will simply replace their existing 18-inch dishes with a DirecDuo dish while keeping their set-top box, regardless of its brand. These customers may also elect to purchase the fully functional DirecDuo kit if they wish to add a second Digital Satellite System receiver to their home, thereby giving them the ability to independently watch DirecTV and USSB on separate TVs.

The complete DirecDuo hardware/software package, ranging in price from $899 to $999 (MSRP), includes a 21-inch elliptical dish with a "tri-mode" LNB and a universal mount, a 16-bit PC card, Microsoft Windows-95-based software and one of three Hughes-brand Digital Satellite System receivers.

Existing DirecPC customers can upgrade their systems to receive satellite television by adding a simple enhancement to their LNB configuration and a DSS receiver, for a total cost ranging from $599 to $699.

Okay, so now you have the dish...how much is the programming and Turbo Internet going to set me back? The basic package lets you surf at speeds of up to 200 kbps for $19.95 per month (80 cents per MB from 6 a.m. to 6 p.m. weekdays). In addition, HNS offers two unlimited Turbo Internet packages at up to 400 kbps: the Moon Surfer Plan at $39.95 per month (6 p.m. to 6 a.m. weekdays and all day on weekends; 80 cents per MB from 6 a.m. to 6 p.m. weekdays); and the Sun Surfer Plan at $129.95 per month (6 a.m. to 6 p.m.weekdays, and 60 cents per MB from 6 p.m. to 6 a.m. weekdays and all day on weekends). DirecTV and USSB pricing will depend on the programming packages purchased by the consumer.

Granted, with the performance of the new DirecDuo product (not to mention the investment) you may have to be reminded that the little gold orb in the sky is the sun, but you have to admit that this is a multimedia junkie's ultimate toy.

Another One Bites the Dust

The Alphastar direct-to-home (DTH) satellite service has closed, court-appointed receiver and manager Ernst & Young announced. After offering the service for sale, the receiver did not receive any acceptable bids to acquire the business as a going concern, it said.

As a result, the previously announced backstop deal with Loral SpaceCom Corporation will be completed and AlphaStar Canada Inc, and its U.S. counterpart, AlphaStar Television Network Inc., will have no alternative but to stop broadcasting effective 3:00 a.m., Thursday, August 7, 1997, said Ernst & Young.

Sports.

ESPN Inc. said that it has reached an agreement to acquire Classic Sports Network (Galaxy 7, transponder 13). The transaction, under which CSN becomes a wholly owned subsidiary of ESPN, is expected to be completed within two months. A purchase price was not divulged, but was reported by the *Wall Street Journal* to be $175 million. ESPN is 80 percent-owned by ABC Inc., an indirect subsidiary of the Walt Disney Co. The Hearst Corp. holds the remaining 20 percent. The owners of CSN include Allen & Co. Inc., AT&T Ventures, Warburg Pincus Ventures, and Mass Mutual Life Insurance.

Rupert Murdoch's Fox Group has announced an agreement to purchase the Los Angeles Dodgers, a deal that gives the media mogul control of baseball's last family-owned team. "I believe Fox Group will be an outstanding owner of the Dodgers," said Peter O'Malley, who has agreed to remain president of the team. "Their support of major league baseball and their commitment to the community is extraordinary." Owning the Dodgers puts Murdoch well on his way to, with Tele-Communications Inc. (TCI), form a sports network that would challenge Walt Disney's ESPN (Galaxy 5, transponders 9/14). The agreement is still subject to approval by baseball team owners. The purchase price, which was rumored to be $350 million, was not disclosed.

Executives at News Corp. announced that the company intends to purchase a major stake in FiT TV (Satcom C3, transponder 1), the health and fitness cable channel created by Jake Steinfeld. Just what the company will pay for its portion of the network was not disclosed. The 24-hour fitness channel will be run through the Fox/Liberty Networks and International Family Entertainment, both of which are run by News Corp. Minority stakes in FiT TV will be maintained by Body by Jake Enterprises and Reebok International.

DirecTV filed a complaint with the FCC against Comcast Corp. wherein it was alleged that, by refusing to grant DBS distribution rights to its new regional sports network, the cable TV giant had engaged in unfair methods of competition. Both parties compete for subscribers in the Philadelphia area, where Comcast not only owns the programming (SportsNet), but holds a majority interest in two of the area's strongest professional sports franchises (the NBA's Philadelphia 76ers and the NHL's Philadelphia Flyers) as well as some of its most desirable cable TV franchises.

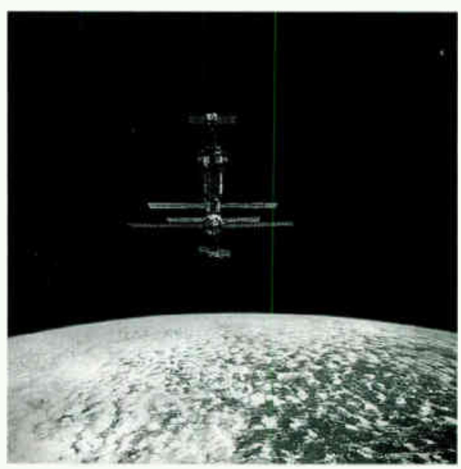
Close Call

This summer I took the opportunity of the nice weather to do a little casual stargazing. I noticed a slowly moving light that was way too far away to be a plane, and much too slow to be a shooting star. That of course leaves only two options, an alien vechicle or a satellite moving in its ceaseless orbit. It brought to the forefront the question of what happens to old satellites, a.k.a. "space junk."

The United States Space Command, which tracks space objects for the military from Colorado Springs, says 614 satellites populate the areas in and around geostationary orbit (22,300 miles in space), with roughly half of them dead or drifting uselessly.

On September 17, 1997, the problem-plagued Russian space station *Mir* narrowly avoided a collision with a U.S. military satellite. In a case of "what now" the crew members were in the midst of fixing their central computer when the errant satellite came within 500 to 1,000 yards of colliding with the *Mir*. The *Mir* survived without any damage. But the satellite came close enough that the three crew members, including U.S. astronaut Michael Foale, sealed themselves into the Soyuz re-entry capsule to make a fast getaway in case the space station was going to get hit.

The *Mir*'s latest adventure began Sun-



day, September 16. The Pentagon's Space Command, which routinely identifies potential collision paths, sent out warnings that a 220-pound U.S. military reconnaissance satellite would fly within one kilometer, or about 1,090 yards, of the *Mir* about 9:30 p.m. Monday.

NASA officials identified the satellite Tuesday as a *MSTI-2*, known as "Misty," one of a series of small and inexpensive satellites. The satellite was launched in May 1994 to do research and was taken out of service in September that year, said Nicholas L. Johnson, NASA's chief scientist for orbital debris at the Johnson Space Center in Houston.

Details of how to get on the Satellite Observer Mail List, elements, prediction programs and other satellite information are at the Visual Satellite Observers Home Page: **http://www2.plasma.mpe-garching.mpg.de/sat/vsohp/satintro.html**

Program Notes

OPRAH
THE OPRAH WINFREY SHOW

As her fans held their collective breath, Oprah Winfrey announced that she will continue her reign over daytime television for at least several more seasons. The queen of talk TV said she decided to commit to doing the *Oprah Winfrey Show* (feeds Monday-Friday 1000 ET GE1, transponder 1 and at 1600 on G4, transponder 12) through the 1999-2000 season in order to help people "lead better lives." Winfrey, whose show got its start in 1984, is one of only three women in TV and film to have her own production studio (the other two are Lucille Ball and Mary Pickford). HARPO Entertainment Group is reportedly worth close to $420 million. The show is distributed via satellite by King World.

King World Productions Inc. reports that it has cleared *The Roseanne Show* (no feed information available at presstime) set to debut in fall 1998, in all top-10 markets, and 29 of the top 30. Overall,

101 stations representing 80 percent of the nation are now committed to carrying the entertainment/talk show.

It is a reality in the TV business that will surely become the bane of online show producers as well: the mid-season cancellation, the non-renewal, even the passed-over pilot. That was the fate recently of Ziff-Davis' *The Site* TV show as executives from MSNBC (G1, transponder 10) and ZD announced that the plug had been pulled on the two-time Emmy award winner. MSNBC said the move came about as the result of its continuing focus on hard news content, while the feature-like *The Site* focused mostly on societal effects of the digital revolution. Still, *The Site* had garnered among the highest ratings on the network in its nightly 7-8 p.m. (EST) time slot. Ziff-Davis plans to launch ZDTV, a 24-hour cable network, in the first quarter of 1998.

Ohio News Network (ONN), the first statewide cable news service in the U.S., has announced a new affiliation agreement with Satellite Services, Inc., the program arm of TCI, the nation's leading cable operator. The agreement opens the door for individual TCI-owned and affiliated operators throughout Ohio to provide ONN's unique brand of 24-hour statewide news coverage in their local areas. "We are extremely pleased to be working with TCI," said John Butte, Vice President and General Manager of ONN. "Providing subscribers 24-hour access to news and information they can't get anywhere else on cable is evidence of TCI's commitment to high quality service."

Star Search, everybody's favorite talent competition, is on its way to a small screen near you. The syndicated series, which launched the careers of stars like Sinbad and Martin Lawrence, will return in full force next summer with *Star Search 2000*, a 100-city talent scouting that will culminate in a televised final competition. Although Ed McMahon has left the franchise, sources said that 14 celebrities including Whoopi Goldberg, Dustin Hoffman, David Copperfield, Gregory Hines, Marvin Hamlisch, Carl Reiner and Robert Goulet, have signed on as advisory board members.

Variety reported this week that Mills Lane, the Nevada judge and part-time boxing referee who disqualified Mike Tyson for biting off a piece of Evander Holyfield's ear, may get to host his own syndicated TV show. According to sources, the show, currently being shopped around Hollywood, is similar to *People's Court* and *Judge Judy* (Monday-Friday at 0730/1500 ET on G4, transponder 14). The push to get Mills on the air is being spearheaded by veteran producers John Tomlin and Bob Young, whose credits include *A Current Affair, Inside Edition* (Monday-Friday at 1500 on G4, transponder 12 and 1600 on GE1, transponder 1), and *Day & Date.*

Goodbye England's Rose

In a final note, satellites certainly helped make the world seem a bit smaller with the broadcast of the funeral of Princess Diana. The number of satellite feeds during the week leading up to Princess Diana's funeral was astounding. Chances are that you probably even saw a couple of wildfeeds from England. She will truly be missed.

Sources: *Cowles/Simba Media Daily, LA Times, NY Post, SF Chronicle, TELE-satellite News, Wall Street Journal.*

Doug Jessop has been in the broadcasting industry since 1979 and was the creator of the Keystone Communications *North American Satellite Guide*. He welcomes your comments at: **http://www.searcher.com/STcomments.html**

ST

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SI FINAL FRONTIER

By Philip Chien

A Look Back at the Saturn V

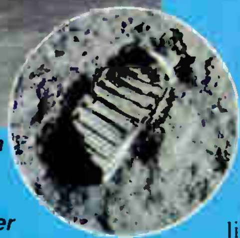
November 9 marks the 30th anniversary of the first flight of the Saturn V. December 7th marks the 25th anniversary of the final use of the three-stage Saturn V, carrying the final lunar landing mission, Apollo 17.

In that short five-year period two unmanned test flights, three rehearsals to test out the Saturn V and Apollo spacecraft, and seven successful launches of missions towards the moon occurred. All of the missions were highly successful, with the exception of the Apollo 13 mission—which was a failure of a heating element in the service module, not the Saturn's fault. After Apollo 17 completed the final moon landing a two-stage Saturn V was used to launch Skylab in May 1973. The remaining Saturn V components became outdoor displays at NASA's Kennedy, Johnson, and Marshall Spaceflight Centers, and the Michoud facility where the engines were tested.

The Saturn V has been described as the most incredible machine ever built. If anything, that's an understatement. Each of the five F-1 engines in the first stage generated 6.6 million Newtons (1.5 million pounds) of thrust—for a total of 33.3 million Newtons (7.5 million pounds) of thrust when the Saturn roared off the launch pad. Each F-1 generated as much power as all three shuttle main engines put together. At launch a fully fueled Saturn V weighed 2.8 million kg (6.2 million pounds) and stood 110 meters (363 feet) tall. It could place 122,500 kg (270,000 pounds) in to orbit, or 45,300 kg (100,000 pounds) on a lunar trajectory.

Altogether the Saturn Vs carried 30 passengers into space, with four astronauts having the opportunity to fly multiple Saturn V

Huge first stage of the Apollo launch vehicle is ready to be moved to its new home.



Symbolizing the dawn of a new era in human history, astronauts of the Apollo flights were the first to ever witness an earthrise or leave their footprints on the surface of an extraterrestrial globe.

missions. Jim Lovell was the first to fly two Saturn V missions—Apollo 8 and Apollo 13. He's the only astronaut to go close to the moon twice without making a lunar landing. John Young flew the Saturn V on Apollos 10 and 16 (first to fly from both pads). Gene Cernan flew on Apollo 10 and Apollo 17. Dave Scott flew on Apollo 9 and Apollo 15.

Much of the equipment used to launch the Saturn V remains in use, adapted for the shuttle program. The vehicle assembly building, launch control center, crawler/transporters, mobile launch platforms, and launch pads are all legacies from Apollo.

Preserving the Past

For many years the Kennedy Space Center displayed its Saturn V components outdoors, next to the vehicle assembly building. But the oceanside environment had taken its toll and it was clear that major measures would be required to prevent further damage. The decision was made to build the Apollo/Saturn V center to house the stages in an indoor climate controlled display.

There was one major problem to obtain investments to fund the facility. As a national historic landmark all of the Saturn V components and spacecraft are owned by the Smithsonian Institution and technically on loan to the various NASA centers and other museums where they're displayed. In theory the Smithsonian could ask for the centers to return their displays. So NASA's visitor center had to obtain a letter from the Smithsonian promising that the Saturn V would remain at the Kennedy Space Center for at least 25 years—the period to pay off the bond.

With that hurdle out of the way construction began on the museum and renovation of the stages. The old decaying paint was removed and new paint was applied. To minimize traffic congestion the components were moved to their new location on weekends. It was rather amazing to see a tractor normally used to move houses dragging the 130,000 kg (287,000 pound) Saturn I-C first stage down the road!

Taking the Revamped Tour

When the center opened a year ago there were a couple of minor mistakes and incongruities. The most glaring error had the narrator describing the failure of the U.S. Explorer satellite—with the video showing a Vanguard failure. Explorer was actually the successful U.S. satellite which followed the Vanguard failure. These mistakes have been corrected.

It must be remembered that the Apollo/Saturn V center is primarily a tourist attraction—not a historical record or an attempt to be completely factual. Certainly there are many things in the displays which didn't occur exactly as portrayed.

The museum is more of a "broad-brush" look at the Apollo program than any serious attempt to document the Apollo or Saturn programs. The shows features Apollo 8 and Apollo 11 and barely mention the other missions. Skylab is completely ignored, and the only indication of the Apollo-Soyuz mission is the Apollo command module on display. Only the Saturn V is showcased; the smaller Saturn 1B which was used to launch Apollo 7, Skylab crews, and the U.S. portion of Apollo-Soyuz is nowhere to be seen.

The self-guided tour starts with a film showing the historic context of the Apollo program—the cold war, space race, U.S. trying to catch up with the Soviet Union, and President Kennedy's inspiring speech to send Americans to the moon by the end of the decade. The first "show" is a fairly faithful recreation of the launch control center, featuring many of the actual consoles used in the Apollo era. Many retired Apollo engineers were consulted to ensure the accuracy of the layout. The show is just the final three minutes of the countdown but gives an excel-

The new Apollo/Saturn V facility at the John F. Kennedy Space Center.

lent sense of the excitement at the time.

The main hall was designed to simulate the inside of the massive vehicle assembly building. While it isn't as large, it does give a sense of the gigantic scale of the project. A complete set of Saturn V components is on display, compiled from the Apollo era's left-overs.

The S-IC first stage on display is the original "all systems test stage" used for check-outs, not an actual flight-ready vehicle. It was officially designated S-IC-T, but became affectionately known as "T-Bird." It was used to test out ground facilities at the Kennedy Space Center before the actual flight components arrived. It originally had a large band of black paint on top of the stage. Workers complained about how hot it got working inside the stage and later versions of the S-IC stage had the more familiar alternating white and black pattern. When the stage was cleaned and repainted the design was updated to match the Apollo 11 configuration.

The S-II second stage was the one which would have flown Apollo 18 to the moon before it was canceled. It's the only "flight qualified" component of the three on display in Florida.

The S-IVB third stage was the test unit which was used for Skylab dynamics testing.

The instrument unit is located at ground level, permitting close inspection of its various boxes. With today's computer technology it seems hopelessly out-dated—almost like it belongs in a Flash Gordon movie. But it had enough computing power to send the Saturn V towards the moon.

Also on display is the lunar module which was originally intended for Apollo 15 and as the backup Apollo command/service module for Skylab and the Apollo-Soyuz missions, and the actual Apollo command module which was flown in July 1975 on the first joint U.S.-Soviet manned spaceflight.

A second show begins with a film showing the world-wide excitement and interest before the Apollo 11 landing. The show features a full-scale mockup of the lunar module landing on a simulated lunar landscape, astronauts reminiscing about the Apollo program, and kids talking about their wishes for the future.

The lunar landing simulation ends up with an out-of-place plug for the upcoming international space station. While space station certainly is justified in terms of learning how to live in space for long periods and science, it has very little to do with exploring the solar system.

Naturally, the Apollo/Saturn V center includes a cafeteria and souvenir stands. It's a fantastic place to watch shuttle launches from, but access is limited to the families of the astronauts and VIPs.

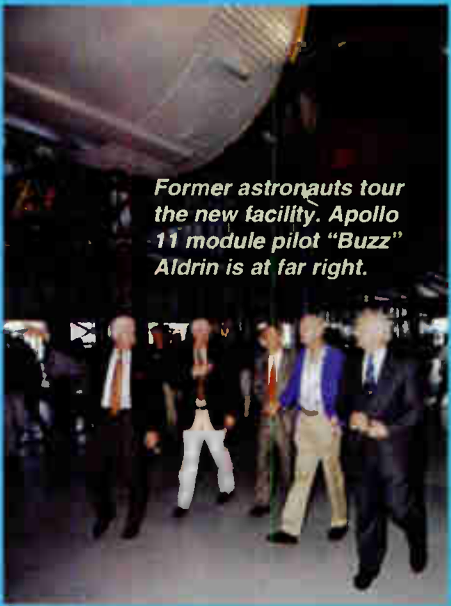
One feature I would certainly enjoy would be a small library with technical documentation for those who wish to browse and take the time to find out more about the actual history of the Apollo program.

There is no separate fee to enter the museum, but you do have to take the KSC bus tour to get there. Current rates are $10 for adults, and $7 for children from 3 to 11. You can spend as much or as little time as you want at the museum before taking another bus to continue your tour of the space center or to return directly to the main visitor's center.

Two new stops on the bus tour are scheduled to open in December, the International Space Station center and the LC-39 observation gantry. The space station center will have simulated space station modules on display, similar to the actual units in the adjacent building. A window will permit tourists to peek into the giant cleanroom where the American, European, Canadian, and Japanese space station elements are prepared for flight. The LC-39 observation gantry is actually a misnomer. It's located just 800 meters (half a mile) from launch complex 39A—well within the range safety limits for a shuttle launch. So nobody is allowed to view a launch from that building! It would be more accurate to call it the launch pad viewing area.

In the 1970s the American public lost interest in the space program. We beat the Russians to the moon and Apollo was winding down. But interest in Apollo and space exploration in general is rising again. The public is conscious that there are Americans in space aboard the Russian space station *Mir*, and the shuttle flying on a regular basis. The 1995 movie *Apollo 13* brought about a new surge of interest in the Apollo program, and the Apollo Saturn V Center reflects this interest. Ron Howard and Tom Hanks, two of the key creative minds behind the *Apollo 13* movie, are now working on an HBO series *From the Earth to the Moon* which chronicles the entire Apollo program in a series of 12 one-hour episodes. It's scheduled to premiere in April 1998.

The astronauts who flew on Saturn V



Former astronauts tour the new facility. Apollo 11 module pilot "Buzz" Aldrin is at far right.

While thousands of people worked on the Saturn V and dozens of astronauts were involved in preparing and supporting the flights, only 26 lucky people got to fly on the most powerful rocket ever to be man-rated. Four of them were lucky enough to be chosen to make an additional Saturn V mission. Three additional Saturn Vs flew without people onboard—the Apollo 4 and 6 test flights and the two-stage vehicle which launched Skylab.

Apollo 8	Frank Borman, Bill Anders, Jim Lovell
Apollo 9	Jim McDivitt, Rusty Schweickart, Dave Scott
Apollo 10	Tom Stafford, Gene Cernan, John Young
Apollo 11	Neil Armstrong, Buzz Aldrin, Mike Collins
Apollo 12	Pete Conrad, Al Bean, Dick Gordon
Apollo 13	Jim Lovell, Fred Haise, Jack Swigert
Apollo 14	Al Shephard, Ed Mitchell, Stuart Roosa
Apollo 15	Dave Scott, Jim Irwin, Al Worden
Apollo 16	John Young, Charlie Duke, T.K. Mattingly
Apollo 17	Gene Cernan, Jack Schmitt, Ron Evans

ST

by Wayne Mishler, KG5BI

Radio Shack adds new satellite system to product line

The demand for direct satellite systems (DSS) is increasing and RadioShack is meeting the demand with a new line of DSS products.

In August they introduced their new Optimus 5100 digital satellite system available at more than 6,800 RadioShack stores and participating dealers nationwide.

The Optimus is a single output system. RadioShack continues to offer a dual output RCA-brand system for consumers who wish to add a second receiver for independent DSS viewing in another room.

RadioShack says the new system provides CD-quality sound and laserdisc-quality reception. Programming options include access to premium channels, pay per view movies, sports, and specials. Parental channel lockout and StarSight Direct Tuning by program title are included.

The user-installable Optimus DSS System 5100 is capable of receiving DirecTV and USSB programming with more than 200 channels.

The suggested retail price of $299.99 includes an 18-inch mini-dish, set-top receiver, and remote.

Information is available from RadioShack via their toll-free number: 800-THE-SHACK.

World Radio Network announces satellite channels

World Radio Network has announced a new German-language service, WRN3, transmitted to listeners throughout Europe.

"We know that people across Germany, Austria and Switzerland were looking forward to the start of WRN3," says Karl Miosga, managing director of World Radio Network.

"We are making this service truly future-proof. The service is being transmitted via Astra Digital Radio, and we will provide a live relay on the Internet using RealAudio."

WRN3 includes programs from the leading international radio stations in Europe which broadcast German-language services. Listeners will be able to hear a global perspective in the programs of YLE Radio Finland, Radio Budapest, Vatican Radio, the Voice of Russia, Radio Sweden, ORF Radio Austria International, Deutsche Welle, and Radio Vlaanderen International.

The final schedule was to be announced at the launch of WRN3 at the launch of WRN3 in Berlin, August 31.

The service will be available for direct to home reception via two simultaneous channels on the Astra satellite. One is a traditional analogue service via an audio subcarrier on transponder 16 (Sky Movies television) at 7.38 MHz. The other is a digital service via the new Astra Digital Radio service.

Tune to transponder 33 and look for WRN3 in the receiver display.

GPS-based vehicle navigation coming of age

Today's worldwide demand for GPS-based vehicle navigation products is estimated by the U. S. GPS Industry Council to be $1.1 billion, and that sum is expected to top $3 billion in the year 2000.

Markets for driver information systems include private passengers, motoring tourists, field sales and service personnel, government agencies, public safety departments, utilities, real estate professionals and others who use an automobile in the course of their work.

These include systems like the new PathMaster, formerly produced by Rockwell International Corporation, recently purchased by Magellan Systems Corporation. PathMaster is currently installed in more than 8,000 Hertz rental cars under the name "NeverLost," and sold to consumers through a nationwide network of dealers.

Drivers use the system to program to program a travel route. They set a route by selecting from hundreds of local destinations, including hotels, ATMs, airports, points of interest, hospitals, tourist attractions, and individual street addresses. Once the route is set, PathMaster uses GPS satellites, dead-reckoning, and map-matching to precisely locate the vehicle. Visual and voice prompts guides the driver turn by turn to the destination.

Japan is currently leading this industry, with over 1.5 million vehicle navigation units installed. The United States is next, followed by Europe, according to a recent communique from Magellan.

Using their new acquisition as a "launch platform," Magellan is working on the next generation of affordable GPS-based vehicle navigation systems. This will include a range of driver information services, destined to become a part of the nation's Intelligent Transportation System, being promoted by the U. S. Department of Transportation.

"Two excellent examples of space-based, information superhighway technologies

with potential to help people navigate are the new ORBCOMM global satellite data communications service and the emerging digital radio broadcast services—both of which could be linked to the PathMaster to provide real-time driver information for more efficient travel management," says Magellan President Randy Hoffman.

Magellan acquired Rockwell's intellectual property and core technology for vehicle navigation including existing and developmental products. They also received Rockwell's experienced engineering team with strengths in vehicle positioning, guidance and tracking, GPS, dead reckoning and map matching, display electronics, digital mapping, design, and human factors for drivers and vehicles.

The former Rockwell driver information systems unit also becomes a part of Magellan. The 33-employee product development group will remain in Troy, Mich., but will relocate to new facilities.

Magellan Systems is headquartered at 960 Overland Ct., San Dimas, CA, 91773, telephone 909-394-5000.

Industry preparing for era of digital broadcasting

Mitsubishi Electric America, Inc., is commercializing and marketing strategies for what they call the "forthcoming era of digital broadcasting."

"For broadcasters and manufacturers, the reality of digital television has arrived, and Mitsubishi Electric Corporation is leveraging its core competencies to bring advanced products to market," says Y. Yamaguchi, a senior managing director of that company.

The Digital Broadcasting Business America (DBBA) Division, headquartered in New Providence, N.J., has been chartered to formulate business strategies and to market selected products to manufacturers of broadcast and receiver equipment conforming to digital television standards.

The transition from analog to digital broadcasting, as mandated by the Federal Communications Commission, has been anticipated for several years by various R&D laboratories and business units of Mitsubishi, according to Tommy Poon of DBBA.

"Our mission is to consolidate the marketing and support of their products in the U.S.," Poon says.

New RV satellite systems announced

MOTO-SAT, a subsidiary of Pen Interconnect, Inc., broke new ground in the recreational vehicle industry with a new series of satellite television positioners for RVs that work with all DSS and DISH network receivers.

The company says its Executive series of positioners is compatible with all satellite receivers currently available from major manufacturers.

The Executive package includes the positioner, motorized mount with mounting plate, antenna reflector, LNB (low-noise-block) and easy-installation kit.

You can telephone the company at 800-247-7486, or e-mail them at **info@pen-interconnect.com**.

Trimble announces computer-based training

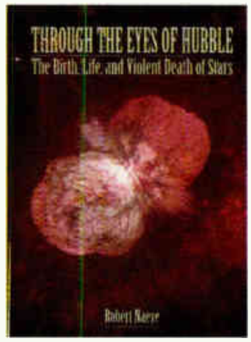
At the National Business Aircraft Association Convention in Dallas, September 23, the Trimble company announced new computer-based training systems for its "Plus" product line.

The NavTutor and Trimble Trainer are comprehensive Instrument Flight Rules (IFR) GPS training systems for general aviation. They are CD-ROM programs that allow users of Trimble GPS to learn and maintain proficiency with the 2000 Approach Plus, 2101 Approach Plus, and 2101 I/O Approach Plus, at home, in a low stress environment, using a standard PC with multi-media capability.

For information call Trimble at 800-827-8000.

Through the eyes of Hubble: the birth, life, and violent death of stars

The title of this new book by Robert Naeye sends one's imagination soaring into the depths of space for an up-close encounter with stars.



More than that, its 100 color photographs and illustrations brings you face to face with events you never dreamed existed.

Distributed by Kalmach Publishing Company, this 8 x 11 inch, 112-page, hardcover book with dust jacket became available in October. The suggested retail price is $29.95.

Robert Naeye (pronounced noy-ah) is an associate editor for *Astronomy* magazine. He is a science journalist, writer, and amateur astronomer. He has an M.S. in science journalism from Boston University.

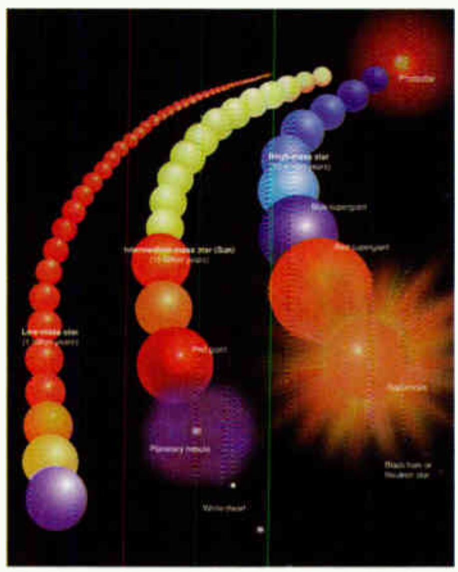
In his book, Naeye takes you on a fascinating voyage through the life cycle of stars with stunning photographs from the Hubble Space Telescope.

You'll visit nurseries where new stars are born. You'll trace the life of a star. And you'll see the dramatic aftermath of exploded stars.

The book presents detailed images of stellar nurseries, spectacular jets, protoplanetary disks, exploding stars, and the shrouds of dead stars.

It features seven original paintings by renowned space artist Michael Carroll, never published before, and explains stars in a way that everyone can understand.

You can order the book from Kalmbach at 800-533-6644. The Internet address is **www.kalmbach.com**.



The illustrations in this book are top notch, complementing the beautiful Hubble space images.

By Larry Van Horn

This space radar image (this is not a visual image) shows the area surrounding the Dead Sea along the West Bank between Israel and Jordan. This region is of major cultural and historical importance to millions of Muslims, Jews, and Christians who consider it the Holy Land.

The yellow area at the top of the image is the city of Jericho. A portion of the Dead Sea is shown as the large black area at the top right side of the image. The Jordan River is the white line at the top of the image which flows into the Dead Sea. Jerusalem, which lies in the Judaean Hill Country, is the bright, yellowish area shown along the left center of the image. Just below and to the right of Jerusalem is the town of Bethlehem. The city of Hebron is the white, yellowish area near the bottom of the image. The area around Jerusalem has a history of more than 2,000 years of settlement and scientists are hoping to use these data to unveil more about this region's past.

The Jordan River Valley is part of an active fault and rift system that extends from southern Turkey and connects with the east African rift zone. This fault system has produced major earthquakes throughout history and some scientists theorize that an earthquake may have caused the fall of Jericho's walls. The Dead Sea basin is formed by active earthquake faulting and contains the lowest place on the Earth's surface at about 400 meters (1,300 feet) below sea level. It was in caves along the northern shore of the Dead Sea that the Dead Sea Scrolls were found in 1947. The blue and green areas are generally regions of undeveloped hills and the dark green areas are the smooth lowlands of the Jordan River Valley.

This image is 73 kilometers by 45 kilometers (45 miles by 28 miles) and is centered at 31.7 degrees north latitude, 35.4 degrees east longitude. North is toward the upper left. The colors are assigned to different radar frequencies and polarizations as follows: red is L-band, horizontally transmitted and vertically received; green is L-band, horizontally transmitted and horizontally received; and blue is C-band, horizontally transmitted and vertically received. The image was acquired by the Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR) on October 3, 1994, onboard the space shuttle *Endeavour*.

SIR-C/X-SAR, a joint mission of the German, Italian, and United States space agencies, is part of NASA's Mission to Planet Earth. Each flight of SIR-C/X-SAR collected data at more than 400 sites around the globe. The science team is using images like this one to help answer various scientific questions about the condition of ecosystems, the extent of snow and ice packs, geologic activity such as volcanoes and earthquakes, and measurement of ocean waves and currents.

By Larry Van Horn

Hubble Uncovers Brilliant Star in Milky Way's Core

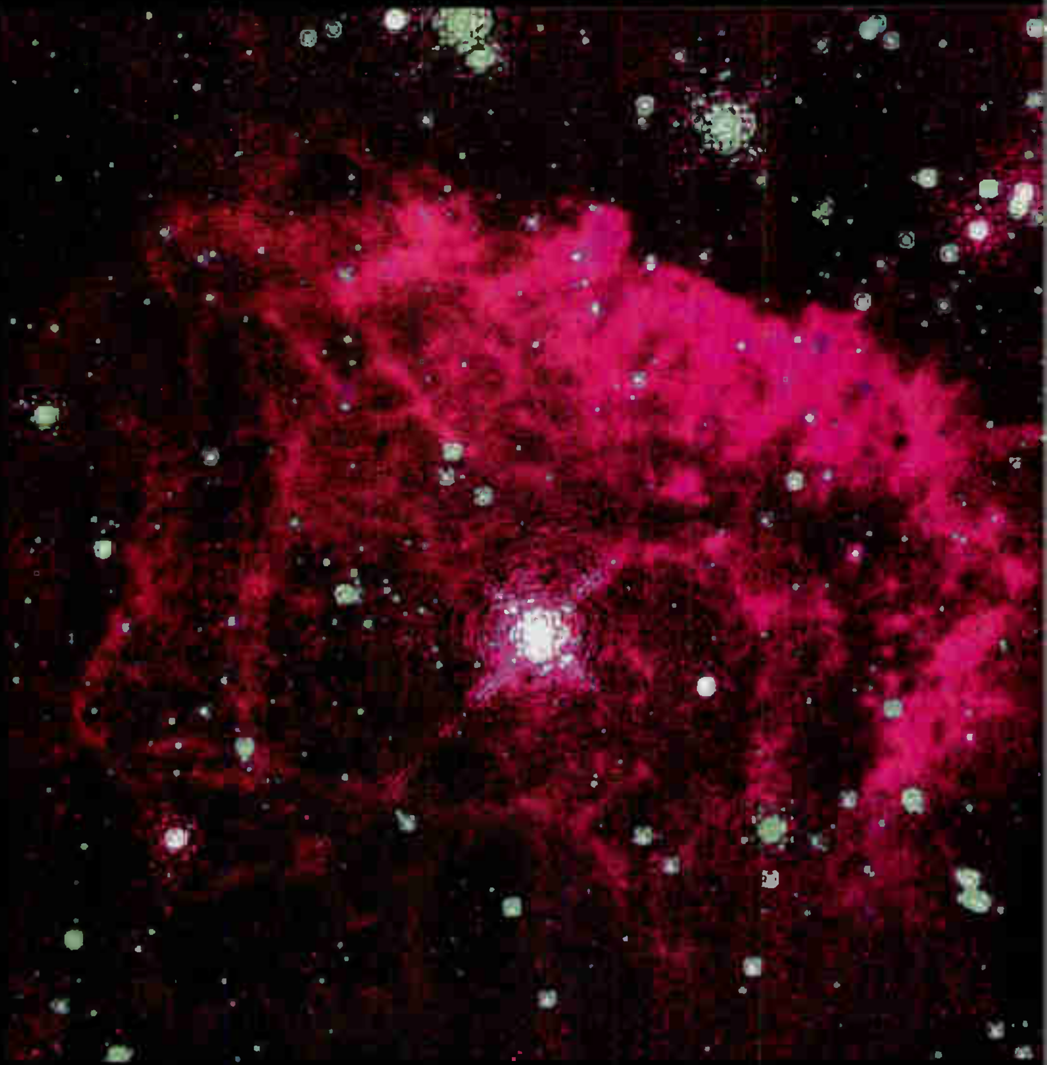
Astronomers using NASA's Hubble Space Telescope have identified what may be the most luminous star known—a celestial mammoth which releases up to 10 million times the power of the Sun and is big enough to fill the diameter of Earth's orbit.The star unleashes as much energy in six seconds as our Sun does in one year.

The star appears as the bright white dot in the center of this image taken with NASA's Hubble Space Telescope. Hubble's Near Infrared Camera and Multi-Object Spectrometer (NICMOS) was needed to take the picture, because the star is hidden at the galactic center, behind obscuring dust. NICMOS' infrared vision penetrated the dust to reveal the star, which is glowing with the radiance of 10 million suns.

The image also shows one of the most massive stellar eruptions ever seen in space. The radiant star has enough raw power to blow off two expanding shells (magenta) of gas equal to the mass of several of our suns. The largest shell is so big (four light-years) it would stretch nearly all the way from our Sun to the next nearest star. The outbursts seen by Hubble are estimated to be only 4,000 and 6,000 years old, respectively.

Despite such a tremendous mass loss, astronomers estimate the extraordinary star may presently be 100 times more massive than our Sun, and may have started with as much as 200 solar masses of material, but it is violently shedding much of its mass.

The star is 25,000 light-years away in the direction of the constellation Sagittarius. Despite its great distance, the star would be visible to the naked eye as a modest fourth magnitude object if it were not for the dust between it and the Earth.



This false-colored image is a composite of two separately filtered images taken with the NICMOS, on September 13,1997. The field of view is 4.8 light-years across, at the star's distance of 25,000 light-years. Resolution is 0.075 arc seconds per pixel (picture element). (Photo: Don F. Figer, UCLA and NASA)

Two Voyager Spacecraft Are Still Going Strong...

The incredible portfolio of the Voyager missions includes the first-ever close-up photos of Neptune (below), Jupiter and its moons (below, left, grouped electronically for impact), and Saturn (right and lower right).

... at the Edge of the Solar System After 20 Years

Twenty years after their launch and long after their planetary reconnaissance flybys have been completed, both Voyager spacecraft are now gaining on another milestone—crossing that invisible boundary that separates our solar system from interstellar space, the heliopause.

Since 1989 when Voyager 2 encountered Neptune, both spacecraft have been studying the environment of space in the outer solar system. Science instruments on both spacecraft are sensing signals that scientists believe are coming from the heliopause—the outermost edge of the Sun's magnetic field that the spacecraft must pass through before they reach interstellar space.

"During their first two decades, the Voyager spacecraft have had an unequaled journey of discovery. Today, even though Voyager 1 is now more than twice as far from the Sun as Neptune, their journey is only half over, and more unique opportunities for discovery await the spacecraft as they head toward interstellar space," said Dr. Edward Stone, the Voyager project scientist and director of NASA's Jet Propulsion Laboratory, Pasadena, CA. "The Voyagers owe their ability to operate at such great distances from the Sun to their nuclear electric power sources which provide the electrical power they need to function."

The Sun emits a steady flow of electrically charged particles called the solar wind. As the solar wind expands supersonically into space, it creates a magnetized bubble around the Sun, called the heliosphere. Eventually, the solar wind encounters the electrically charged particles and magnetic field in the interstellar gas. The boundary created between the solar wind and interstellar gas is the heliopause. Before the spacecraft reach the heliopause, they will pass through the termination shock—the place where the solar wind abruptly slows down from supersonic to subsonic speed.

Reaching the termination shock and heliopause will be major milestones for the spacecraft because no one has been there before and the Voyagers will gather the first direct evidence of their structure. Encountering the termination shock and heliopause has been a long sought-after goal for many space physicists, and exactly where these two boundaries are located and what they are like still remains a mystery.

"Based on current data from the Voyager cosmic ray subsystem, we are predicting the termination shock to be in the range of 62 to 90 astronomical units (AU) from the Sun. Most 'consensus' estimates are currently converging on about 85 AU. Voyager 1 is currently at about 67 AU and moving outwards at 3.5 AU per year, so I would expect crossing the termination shock sometime before the end of 2003," said Dr. Alan Cummings, a co-investigator on the cosmic ray subsystem at the California Institute of Technology.

"Based on a radio emission event detected by the Voyager 1 and 2 plasma wave instruments in 1992, we estimate that the heliopause is located from 110 to 160 AU from the Sun," said Dr. Donald A. Gurnett, principal investigator on the plasma wave subsystem at the University of Iowa. (One AU is equal to 93 million miles (150 million kilometers), or the distance from the Earth to the Sun.)

Voyager 2 was launched first on Aug. 20, 1977, and Voyager 1 was launched a few weeks later on a faster trajectory on Sept. 5. Initially, both spacecraft were only supposed to explore two planets—Jupiter and Saturn. But the incredible success of those two first encounters and the good health of the spacecraft prompted NASA to extend Voyager 2's mission to Uranus and Neptune. As the spacecraft flew across the solar system, remote-control reprogramming has given the Voyagers greater capabilities than they possessed when they left the Earth.

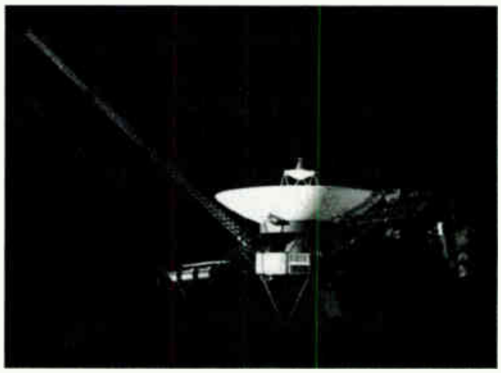
There are four other science instruments that are still functioning and collecting data as part of the Voyager Interstellar Mission. The plasma subsystem measures the protons in the solar wind. The magnetometer instrument onboard the Voyagers measures the magnetic fields that are carried out into interplanetary space by the solar wind. Other science instruments still collecting data include the planetary radio astronomy subsystem and the ultraviolet spectrometer subsystem.

Voyager 1 encountered Jupiter on March 5, 1979, and Saturn on Nov. 12, 1980, and then, because its trajectory was designed to fly close to Saturn's large moon Titan, Voyager 1's path was bent northward by Saturn's gravity sending the spacecraft out of the ecliptic plane, the plane in which all the planets but Pluto orbit the Sun.

Voyager 2 arrived at Jupiter on July 9, 1979, and Saturn on Aug. 25, 1981, and was then sent on to Uranus on Jan. 25, 1986, and Neptune on Aug. 25, 1989. Neptune's gravity bent Voyager 2's path southward sending it also out of the ecliptic plane and on toward interstellar space.

Both spacecraft have enough electrical power and attitude control propellant to continue operating until about 2020 when the available electrical power will no longer support science instrument operation. Spacecraft electrical power is supplied by Radioisotope Thermoelectric Generators (RTGs) that provided approximately 470 watts of power at launch.

The Voyagers are now so far from home that it takes nine hours for a radio signal traveling at the speed of light to reach the spacecraft. Science data are returned to Earth in real-time to the 34-meter Deep Space Network antennas located in California, Australia and Spain. Voyager 1 will pass the Pioneer 10 spacecraft in January 1998 to become the most distant human-made object in our solar system. ST



By Jeff Lichtman
jmlras@juno.com

Radio Astronomy in the Low Bands?

There has always been an interest in the lower frequencies in the area of radio astronomy and communications. On a recent trip throught the web, I came accross some interesting information that I thought you would enjoy. While not purely radio astronomy, it does represent some of the work done by our own U.S. Navy in the area of ELF (Extremely Low Frequencies). The range is 30-300 Hz. I will also cover the VLF and HF areas.

ELF is one of a number of band designators defined by the Institute of Electrical and Electronics Engineers (IEEE) to name bands or ranges of the electromagnetic frequency spectrum.

The Navy's ELF Communication System

The ELF frequency range is critically important to the Navy because of its value in providing a way to communicate with submerged submarines. As a result of the high electrical conductivity of sea water, signals attenuate (or decrease) rapidly as they propagate downward through it. In effect, the sea water "hides" the submarine from detection while simultaneously preventing it from communicating with the outside world through normal radio transmissions.

The degree to which a signal is attenuated depends on its frequency, however. The lower the frequency, the deeper a signal can be received in sea water. In order to receive conventional radio transmissions a submarine must travel at slow speeds and be near the surface of the water. Both of these situations make a submarine more susceptible to enemy detection. Frequencies in the ELF range, however, can be received considerably deeper, and broadcasts using this mode provide a primary link between the nation's commander-in-chief and the submarine force.

One of the great difficulties associated with the use of ELF for communication purposes is the problem of generating a useful signal. The physical size of an antenna that can produce a usable signal with reasonable efficiency is inversely proportional to the frequency. For example, an antenna useful for cellular telephone frequencies need only be several inches long to be completely effective. At ELF, on the other hand, a reasonably efficient antenna must be quite large.

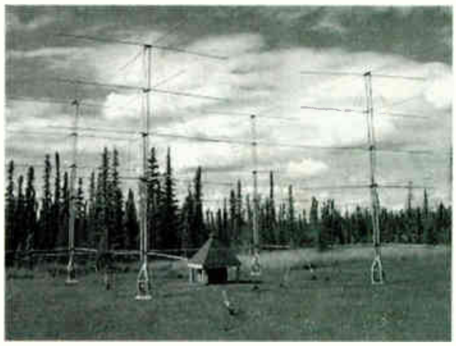
The ELF system, which became operational in 1989, uses two transmitting antennas, one in Wisconsin and one in Michigan. The two sites must operate simultaneously to meet worldwide coverage requirements. Each antenna looks like a power line, mounted on wooden poles. The Wisconsin antenna consists of two lines, each about 14 miles long. The Michigan antenna uses three lines, two about 14 miles long and one about 28 miles long. Each site has a transmitter building near the antenna. The transmitter facility in Michigan uses about six acres of land and the one in Wisconsin about two acres. The operating frequency is 76 Hz.

The construction required no relocation of people or buildings. The antenna location in state and national forests avoided buildings, historic sites, villages, and towns. Construction contractors coordinated extensively with the Michigan Department of Natural Resources and the U.S. Forest Service to avoid rare vegetation and to repopulate the easement with local flora.

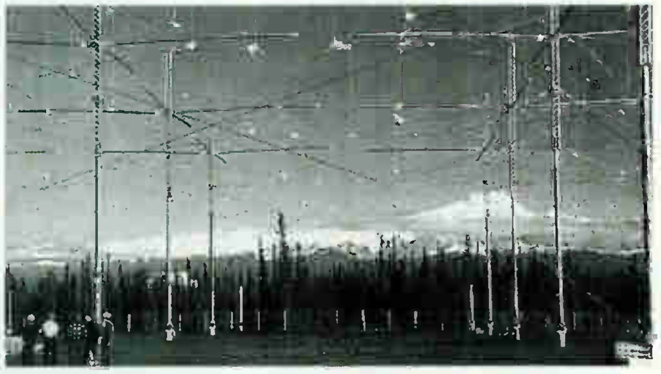
The National Academy of Sciences reviewed the ELF program in 1977 for possible ecological effects. While it found none at that time, the study did recommend that the Navy conduct an ecological monitoring program. As a result, in the last 10 years, several universities, funded by the Navy, conducted independent studies to look for ecological effects of ELF. The studies found no adverse effects on animals, plants, or micro-organisms at the ELF system test sites. Much of this research has already been published in scientific journals. The National Academy of Sciences (NAS) is reviewing the results for proper data analysis and scientific procedure.

HAARP

HAARP (High frequency Active Auroral Research Program) is a major Arctic facility for upper atmospheric and solar-terrestrial research. HAARP was built on a DoD-owned site near Gakona, Alaska. Principal instruments include a high power, high-frequency (HF) phased array radio transmitter (known as the Ionospheric Research Instrument, or IRI), used to stimulate small, well-defined volumes of ionosphere, and an ultra-high frequency (UHF) incoherent scatter radar (ISR), used to measure electron densities, electron and ion temperatures, and Doppler velocities in the stimulated region and in the natural ionosphere. To further the scientific capabilities and usefulness of the IRI and ISR, HAARP is supporting the design and installation of the latest in modern geophysical research instruments, including an HF ionosonde, ELF and VLF receivers, magnetometers, riometers, a LIDAR (Light Detection And Ranging), and optical and infrared spectrometers and cameras which will be used to observe the complex natural variations of Alaska's ionosphere as well as to detect artificial effects produced by the IRI.



One of the research areas for HAARP will be the study of methods and techniques for the generation of extremely low frequencies (ELF) through ionospheric heating. Background on the value



HAARP engineers (lower left) examine the main antenna array.

of this important frequency range to the Navy, how an ionospheric heater might be used to produce ELF signals, and a comparison of the strength of ELF signals generated by HAARP to other more common sources of ELF in the common environment.

There is a lot more on this subject, too numerous to list. For those of you interested in this subject, I will list a few web sites at the end of this article.

74 MHz at the VLA: Breaking the Ionospheric Barrier

A new observing system operating at 74 MHz and providing an angular resolution of 20 seconds is currently online at the VLA. This system is successfuly demonstrating that ionospheric limitations to baseline lengths less than five kilometers need no longer limit the angular resolution of ground based, low frequency less than 100 MHz observations, thereby opening up a new high resolution window on the very poorly explored region of the electromagnetic spectrum.

The system comprises a prime-focus dipole feed and amplifier installed on eight of the VLA's 25 meter antennas. Although the system is of low efficiency, it works well for imaging strong more than 100 Jy sources on long five kilometer or more baselines since self-calibration has sufficient signal to noise to remove phase errors on the short about 10 second timescales characteristic of ionospheric fluctuations. Maps of a few strong, well known radio sources imaged in most cases with unprecedented angular resolution at this frequency have now been produced.

A few interesting scientific results have already benefited from this new capability:

- Evidence for thermal absorption inside Cas-A.
- Absorption by thermal filaments in front of the Crab Nebula Supernova remnant.

The 74 MHz VLA system has demonstrated that the ionosphere is no longer a barrier against long baseline more than a five kilometer ground-based observations below 100 MHz. In light of this we are now designing a Very Large Low Frequency Array (VLLFA) over a several hundred km aperture. The VLLFA would open up a previously unexplored high resolution window on the electromagnetic spectrum.

VLF Lightning Research

Great science is being done by at the Space, Telecommunications and Radioscience (STAR) Laboratory in the Department of Electrical Engineering at Stanford University, as witnessed on their web page. STARLab Very Low Frequency (VLF) Research Group investigates the earth's electrical environment, its upper atmosphere, lightning discharges, radiation belts, and the ionized regions of the earth's upper atmosphere known as the ionosphere and magnetosphere. Much of our work involves the use of very low frequency (VLF) electromagnetic waves which are generated by lightning discharges, by man-made transmitters and by the energetic radiation belt electrons.

Scientists have investigated the generation of these waves and the manner in which they propagate in and scattered from various regions of the upper atmosphere. They use VLF waves as diagnostic tools to investigate physical processes in the vicinity of the Earth's low and high altitude plasma environment.

Under the direction of Professor Umran Inan, the VLF group carries out extensive observational programs at multiple sites across the continental United States, in Antarctica, in Alaska, and on satellites. In addition, extensive theoretical modeling and interpretation work is carried out on quantitative modeling of high-altitude optical emissions known as sprites, blue jets, and elves, on modeling the propagation and scattering of electromagnetic waves in the earth-ionosphere waveguide: and on other related electromagnetic wave and plasma physics problems. Dr Steve Reising also displays some of this science on his web page.

More information may be obtained by contacting the following:

Office: Durand Building, Room 323,
Lab: Main Quad, Building 360
Phones: (650) 725-8446, (650) 725-3580, (650) 723-9251 (Fax)

US Mail: STAR Lab, Durand 323, Stanford University, Stanford, CA 94305-4055
or P.O. Box 13355, Stanford, CA 94309-3355

E-mail: **scr@nova.stanford.edu**
Advisor: Prof. Umran S. Inan

For additional information of the material presented in this column, check out the following worldwide web sites:

http://server5550.itd.nrl.navy.mil/projects/haarp/haarpFactSheet.html
http://rsd-www.nrl.navy.mil/7214/weiler/74MHz.html
http://www-star.stanford.edu/~vlf/
http://www-star.stanford.edu/-scr/Welcome.html

Finally, Radio Astronomy Supplies has some interesting equipment for use in the VLF field and lightning detection studies. We offer a 40-kHz radio telescope and two types of lightning detection devices. One of these even includes software.

For more information see the web page: **http://www.nitehawk.com/rasmit/ras.html** or contact Radio Astronomy Supplies, 190 Jade Cove Drive, Roswell, GA 30075 (770) 992-4959. ST

World Radio Network Schedules

WRN 2 North American Multilingual Program Schedule
Galaxy Five (125 deg West) transponder 6-3.820 GHz (TBS) vertical polarization, audio subcarrier 6.2 MHz. Please note that programs listed below are subject to pre-emption without notice. All times Eastern Daylight (UTC +4 hours).

0030	WRN Announcements, until....
0200	YLE Radio Finland (Mon-Sat)
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	Radio Netherlands in Dutch
1400	WRN Announcements, until....
1500	Radio Vlaanderen International in Dutch
1530	WRN Announcements, until....
1630	ORF Radio Austria International in German
1700	Radio Budapest in Hungarian
1800	Polish Radio Warsaw in Polish
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 (Sunday)
2130	YLE, Easy Listening Music in Finnish
2230	YLE, News in Finnish
2300	WRN Announcements, until....
2330	ORF Radio Austria International in German

WRN 1 European English Program Schedule
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 BST/CET (British Summer Time/Central European Time). For UTC, subtract one hour from BST.

BST/CET	
0000/0100	Radio Budapest
0030/0130	Radio Netherlands
0127/0227	*Earth and Sky* (Daily Science Series)
0130/0230	ORF Radio Austria International
0200/0300	NPR *All Things Considered* (repeat)
0300/0400	CBC *As It Happens* (Tue-Sat)
	RCI News, and Features (Sun and Mon)
0400/0500	Polish Radio Warsaw
0430/0530	*BBC Europe Today* (Mon-Fri)
	Glenn Hauser's *World of Radio* (Sat)
	UN Radio From New York (Sun)
0500/0600	PRI *Market Place* (Tue-Sat)
	SABC Channel Africa-Johannesburg (Sun)
	UN Radio from New York (Mon)
0530/0630	ORF Radio Austria International
0600/0700	Voice of America World Wide (Mon-Fri)
	VoA Saturday (Sat)
	VoA Sunday (Sun)
0700/0800	NPR *All Things Considered* (repeat)
0800/0900	ABC Radio Australia
0900/1000	Polish Radio Warsaw (Mon-Sat)
	C-Span Weekly Radio Journal (Sunday)
0930/1030	Radio Canada International (Mon-Fri)
	UN Radio (Sat)
1000/1100	Radio Prague
1030/1130	Radio Netherlands
1127/1227	*Earth and Sky* (Daily Science Series)
1130/1230	SABC Channel Africa-Johannesburg (Mon-Sat)
	Glenn Hauser's *World of Radio* (Sun)
1200/1300	NPR *Morning Edition* (Monday-Friday)
	NPR *Fresh Air* (Sat)
	NPR *Car Talk* (Sun)
1300/1400	NPR *Morning Edition* (Monday-Friday)
	NPR *Weekend Edition* (Saturday and Sunday)
1400/1500	Radio France International
1500/1600	Voice of Russia (Mon-Fri)
	UN Radio from New York (Sat)
	Voice of America-*Communications World* (Sun)
1530/1630	ORF Radio Austria International
1600/1700	ABC Radio Australia
1700/1800	Caribbean Tempo from CANA Radio (Mon-Fri)
	Glenn Hauser's *World of Radio* (Sat)
	Copenhagen Calling (Sun)
1715/1815	Vatican Radio World News (Mon-Fri)
1730/1830	ORF Radio Austria International
1800/1900	SABC Channel Africa-Johannesburg (Mon-Sat)
	UN Radio and Health Watch (Sun)
1830/1930	RTE News at Six
1900/2000	Radio Vlaanderen International
1930/2030	Radio Netherlands
2025/2125	News in Esperanto from Polish Radio Warsaw
2030/2130	Radio Sweden
2100/2200	YLE Radio Finland
2130/2230	Polish Radio Warsaw
2200/2300	Voice of America *World Report* (Mon-Fri)
	VoA *Today* (Sat and Sun)
2300/0000	PRI *The World* (Mon-Fri)
	NPR *All Things Considered* (Sat and Sun)

WRN2 Multilingual European Program Schedule
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 British Summer Time (BST). For Central European Time (CET) add 1 hour

BST	
0000	*WRN1 (Mon-Fri)
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	Radio Prague

WRN Asia-Pacific English Program Schedule
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 +10 hours).

UTC/AET	
0000/1000	YLE Radio Finland (Mon-Fri)
	UN Radio (Sat)
	Copenhagen Calling (Sun)
0030/1030	ORF Radio Austria International (Mon-Fri)
	Radio Sweden (Sat)
	Polish Radio Warsaw (Sun)
0100/1100	NPR *All Things Considered*
0200/1200	PRI *The World* (Tue-Sat)
	PRI *The Best of Our Knowledge* (Sun and Mon)
0300/1300	RTE Dublin *Irish Collection*
0400/1400	PRI *Market Place* (Tue-Sat)
	UN Radio from New York (Sun)
	Copenhagen Calling (Mon)
0430/1430	ORF Radio Austria International
0500/1500	NPR *All Things Considered* (Repeat)
0600/1600	Polish Radio Warsaw
0630/1630	Radio Vlaanderen International
0700/1700	RTE Dublin
0900/1900	Voice of Russia
0930/1930	Radio Netherlands
1030/2030	YLE Radio Finland
1100/2100	Radio Australia
1200/2200	Radio Canada International
1300/2300	RTE Dublin
1400/0000	Radio Sweden
1430/0030	ORF Radio Austria International
1500/0100	Radio France International
1600/0200	Caribbean Tempo from CANA Radio (Mon-Fri)
	Glenn Hauser's *World of Radio* (Sat)
	Copenhagen Calling (Sun)
1615/0215	Vatican Radio World News (Mon-Fri)
1630/0230	ORF Radio Austria International
1730/0300	Channel Africa (Mon-Sat)
	Glenn Hauser's *World of Radio* (Sun)
1730/0330	RTE Dublin
1800/0400	Radio Vlaanderen International
1830/0430	Radio Netherlands
1927/0527	*Earth and Sky*
1930/0530	Polish Radio-Warsaw
2000/0600	Radio France International
2100/0700	RTE Dublin
2200/0800	RTE Dublin *Ireland Tonight*
2300/0900	Radio Netherlands
2357/0957	*Earth and Sky* (Daily Science Series)

WRN Middle East and Africa English Program Schedule
Intelsat 707 (1 deg West) 3.9115 GHz, right-hand circular-polarization, Symbol Rate 8.022 Mbaud, FEC 3/4, MPEG2 Audio Stream "WRN1." WRN can be heard in South Africa on the MultiChoice digital direct-to-home service on PanAmSat 4 at 68.5 degrees West, audio channel 51. CAT-Central African Time (UTC +2 hours).

UTC/CAT
Next five hours can be heard in South Africa on SAfm 104-107

2200/0000	RTE Dublin *Ireland Tonight*
2300/0100	Radio Netherlands
2357/0157	*Earth and Sky* (Daily Science Series)
0000/0200	YLE Radio Finland (Mon-Fri)
	UN Radio (Sat)
	Copenhagen Calling (Sun)
0030/0230	ORF Radio Austria International (Mon-Fri)
	Radio Sweden (Sat)
	Polish Radio Warsaw (Sun)
0100/0300	NPR *All Things Considered*
0200/0400	PRI *The World* (Tue-Sat)
	PRI *The Best of Our Knowledge* (Sun-Mon)
0300/0500	RTE Dublin *Irish Collection*
0400/0600	PRI *Market Place* (Tue-Sat)
	UN Radio from New York (Sun)
	Copenhagen Calling (Mon)
0430/0630	ORF Radio Austria International
0500/0700	NPR *All Things Considered* (repeat)
0600/0800	Polish Radio Warsaw
0630/0830	Radio Vlaanderen International
0700/0900	RTE Dublin
0900/1100	Voice of Russia
0930/1130	Radio Netherlands
1030/1230	YLE Radio Finland
1100/1300	Radio Australia
1200/1400	Radio Canada International
1300/1500	RTE Dublin
1400-1600	Radio Sweden
1430/1630	ORF Radio Austria International
1500/1700	Radio France International
1600/1800	Caribbean Tempo from CANA Radio (Mon-Fri)
	Glenn Hauser's *World of Radio* (Sat)
	Copenhagen Calling (Sun)
1615/1815	Vatican Radio World News (Mon-Fri)
1630/1830	ORF Radio Austria International
1700/1900	SABC Channel Africa (Mon-Sat)
	Glenn Hauser's *World of Radio* (Sun)
1730/1930	RTE Dublin
1800/2000	Radio Vlaanderen International
1830/2030	Radio Netherlands
1927/2127	*Earth and Sky*
1930/2130	Polish Radio Warsaw
2000/2200	Radio France International
2100/2300	RTE Dublin

Continued from page 93

SOHO—the Solar and Heliospheric Observatory—is positioned close to the libration point between the Earth and the Sun. The L1 point is where the Sun and Earth's gravitational forces balance out. In practice it's more desirable to have *SOHO* in an elliptical, halo-shaped orbit around the L1 point for several reasons. The halo orbit results in placing *SOHO* on the side of the Earth-Sun line which minimizes noise from the Sun for its Earth stations, and the Earth stations don't have to point their antennas directly at the Sun.

Polar uses a highly elliptical orbit to get a "big picture" view of the North Pole from an extremely high altitude. It's used to take photos of the aurora borealis.

While these satellites were designed to look at the "big picture," the *Cluster* group of four satellites was designed to look in fine detail. The four satellites were supposed to fly in formation, a first for non-classified spacecraft. *Cluster* was supposed to look at how minor distances between the spacecraft would result in different measurements.

Three of the spacecraft featured instruments which were basically very sensitive, ultra-low frequency radio receivers to listen to natural radiations. *Wind*'s instrument measures from 100 Hz to 14 MHz, and *Polar* and *Geotail* have instruments which measure from 100 Hz to 1 MHz.

The ISTP project is one of the most open about sharing data throughout the scientific community. Unlike astronomical spacecraft where the scientists jealously guard their observations for as long as NASA will permit (and who, even after their proprietary periods are over will only release the raw uncalibrated data), ISTP goes the extra step to encourage distribution of data to anybody who's interested.

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

An excellent educational outreach page is located at **http://www-spof.gsfc.nasa.gov/istp/outreach/**. It includes explanations about the ISTP program and its objectives, photos, and a place where you can ask the scientists about the ISTP program.

After the original four *Cluster* spacecraft were lost in the Ariane 501 accident, ESA decided to fund a series of replacements. The *Phoenix* spacecraft will be built out of the spare parts for the original *Cluster* series. An additional three identical smaller satellites are being built
by DASA/ Daimler Benz Aerospace in Germany. The four satellites will be launched by two Russian Soyuz launchers in the year 2000.

The next ISTP spacecraft scheduled for launch is ESA's *Equator-S* spacecraft. It's scheduled for launch in November on a commercial Ariane 4 launch vehicle with the Japanese *JCSAT-5* comsat. *Equator-S* will be placed in an elliptical orbit with apogee of 70,158 km and perigee at 500 km.

The spacecraft was originally intended to be launched in early 1997 as an auxiliary passenger on an Ariane 4. However, *Equator-S* was supposed to use a flight-spare Cluster instrument. With the decision to rebuild and refly the *Cluster* series the *Equator-S* mission was delayed until its own instrument could be built.

Sunspots were first detected by Galileo Galilei with his first crude telescopes. Until then it was thought that the Sun—as a heavenly body—had to be perfect. But telescopes showed sunspots on its surface. Tracking the spots as they traveled around the Sun gave its average period of 11 hours, and also showed that it didn't have a solid surface since spots at different latitudes took different lengths of time. The number of sunspots also varied in an eleven year cycle. When there are more sunspots, the Sun is more active, which affects shortwave communications and long term climate changes.

When President John Kennedy announced that the U.S. would put a man on the moon by the end of the decade solar physicists privately swore. The end of the 1960s would be at the solar maximum, and based on the previous couple of solar cycles it would be an extremely active cycle—certainly not the conditions suitable for astronauts in a lightly shielded spacecraft outside of the safety of Earth's magnetic field. It turned out that 1969 was one of the smallest solar maximums on record, so the astronauts were safe and the solar physicists went back to their slide rulers.

The 1970s brought Skylab with its extremely sophisticated telescopes. The Sun didn't disappoint and produced many extremely impressive flares. NASA launched the Solar Maximum Mission in time for the next solar maximum. Several fuses were blown shortly after launch, but fortunately Solar Max was the first spacecraft designed to be serviceable by astronauts in orbit. At the time it was hoped that making satellites serviceable would reduce their costs, but that has turned out to be a myth. Servicing spacecraft does have benefits in terms of space experience, though, which will certainly be beneficial for future long term space exploration.

The 41-C shuttle mission in 1984 featured the capture of Solar Max, replacement of several modules and repair of one instrument, and redeployment back into orbit. Solar Max remained in orbit until late 1989 when its orbit naturally decayed. NASA briefly considered using a shuttle mission to raise its orbit for a second extension to its already productive mission, but couldn't find enough funding. Solar Max ended up reentering the Earth's atmosphere on December 2, 1989.

The only other major solar spacecraft was the Spacelab 2 mission in 1985. The shuttle *Challenger* carried several large telescopes which were pointed towards the Sun during the eight day mission.

Regrettably most of the ISTP research is occurring during a period of solar minimum. Most of the satellites are aging and reaching the ends of their planned lifetimes—not for any technical reason but because they're running out of funds. Currently NASA and its partners have funded ISTP through 1998. The scientists would like to extend the spacecrafts' lifetimes through 2000-2002 to collect data through the next solar maximum and are hopeful that enough additional funding can be obtained.

Other web pages of interest:

LANL WW page for space weather: **http://leadbelly.lanl.gov/lanl_ep_data/campaigns_projects/space_weather.html**
NOAA space weather page: **http://www.sel.noaa.gov/today.html**
Real time solar wind data: **http://www.sel.noaa.gov/wind/rtwind.html**
10 cm solar radio noise: **http://www.drao.nrc.ca/icarus/www/sol_home.shtml**
A fascinating web page describing how amateur radio operators helped
set up an IMP-8 ground station in Antarctica: **http://webhost.gsfc.nasa.gov/nasamike/essays/imp/imp.htm**

Table 1 - Earth-Sun environmental satellites

1973-78A	IMP-J	Delta 97	Oct 26, 1973
1992-44A	GEOTAIL	Delta 212	Jul 24, 1992
1994-71A	Wind	Delta 227	Nov 1, 1994
1995-65A	SOHO	AC-121	Dec 2, 1995
1996-13A	Polar	Delta 233	Feb 24, 1996
————	Cluster (x4)	Ariane V 88 (501)	Jun 4, 1996

* Note: additional sensors are flown on geosynchronous weather satellites and military DSP observation satellites. In addition many other scientific satellites are involved in complementary studies.

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SPACE GLOSSARY

The following are some terms used in the satellite business and are described in layman's terms.

ALTITUDE (ALT): The distance between a satellite and the point on the earth directly below it, same as height.

AQUISITION OF SIGNAL (AoS): The time at which a particular ground station begins to receive radio signals from a satellite.

APOGEE: The point in a satellite's orbit farthest from the Earth's center.

ARGUMENT OF PERIGEE: This value is the number of degrees from the ascending node the perigee point occurs. The perigee point is the point where the satellite is the closest to the earth (assuming an orbit which is elliptical to some degree). This number may be entered as a real value between 0.0 and 360.0.

ASCENDING NODE: Point at which the satellite crosses the equatorial plane from the southern hemisphere to the northern hemisphere. (See RIGHT ASCENSION OF THE ASCENDING NODE.)

AZIMUTH (AZ): The angle measured in the plane of the horizon from true North clockwise to the vertical plane through the satellite.

CATALOG NUMBER: A 5-digit number assigned to a cataloged orbiting object. This number may be found in the NASA Satellite Situation Report and on the NASA Two Line Element (TLE) sets.

COORDINATED UNIVERSAL TIME (UTC): Also known as Greenwich Mean Time (GMT). Local time at zero degrees longitude at the Greenwich Observatory, England. Uses 24 hour clock, ie. 3:00 pm is 1500 hrs.

CULMINATION: The point at which a satellite reaches its highest position or elevation in the sky relative to an observer. (Known as the Closest Point of Approach)

DECAY RATE: This is the rate of decay of the orbital period (time it takes to complete one revolution) due to atmospheric friction and other factors. It is a real number measured in terms of Revolutions per Day (REV/DAY).

DECLINATION (DEC): The angular distance from the equator to the satellite measured positive north and negative south.

DIRECT BROADCAST SATELLITE (DBS): Commerical satellite designed to transmit TV programming directly to the home.

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.

DOWNLINK: A radio link originating at a spacecraft and terminating at one or more ground stations.

DRAG: The force exerted on a satellite by its passage through the atmosphere of the Earth, acting to slow the satellite down.

EARTH-MOON-EARTH (EMR): Communications mode that involves bouncing signals off the moon.

ECCENTRICITY (ECC): This is a unitless number which describes the shape of the orbit in terms of how close to a perfect circle it is. This number is given in the range of 0.0 to less than 1.0. An perfectly circular orbit would have an eccentricity of 0.0. A number greater than 0.0 would represent an elliptical orbit with an increasingly flattened shape as the value approaches 1.0.

ELEMENT SET: (See ORBITAL ELEMENTS.)

ELEVATION (EL): Angle above the horizontal plane.

EPHEMERIS: A tabulation of a series of points which define the position and motion of a satellite.

EPOCH: A specific time and date which is used as a point of reference; the time at which an element set for a satellite was last updated.

EPOCH DAY: This is the day and fraction of day for the specific time the data is effective. This number defines both the julian day (the whole number part of the value) and the time of day (fractional part of the value) of the data set.
The julian day figure is simply the count of the number of days thatparticular date is from the beginning of the year. (January 1 would have a julian day of 1. Feb 28 would be 59.) This number may range from 1.0 to 366.999999999 (taking into account leap years).

EPOCH YEAR: This is the year of the specific time the rest of the data about the object is effective.

EQUATORIAL PLANE: An imaginary plane running through the center of the earth and the Earth's equator.

EUROPEAN SPACE AGENCY (ESA): A consortium of European governmental groups polling resources for space exploration and development.

FOOTPRINT: A set of signal-level contours, drawn on a map or globe, showing the performance of a high-gain satellite antenna. Usually applied to geostationary satellites.

GROUND STATION: A radio station, on or near the surface of the earth, designed to receive signals from, or transmit signals to, a spacecraft.

INCLINATION (INC): The angle between the orbit plane and the Earth's equatorial plane, measured counter-clockwise. 0 (zero) degrees inclination would describe a satellite orbiting in the same direction as the Earth's rotation directly above the equator (orbit plane = equatorial plane). 90 degrees inclination would have the satellite orbiting directly over both poles of the earth (orbit plane displaced 90 degrees from the equatorial plane). An inclination of 180 degrees would have the satellite orbiting again directly over the equator, but in the opposite direction of the Earth's rotation. Inclination is given as a real number of degrees between 0.0 and 180.0 degrees.

INTERNATIONAL DESIGNATOR: An internationally agreed upon naming convention for satellites. Contains the last two digits of the launch year, the launch number of the year and the piece of the launch, ie. A-indicates payload, B-the rocket booster, or second payload, etc.

LATITUDE (LAT): Also called the geodetic latitude. the angle between the perpendicular to the Earth's surface (plane of the horizon) at a location and the equatorial plane of the earth.

LONGITUDE (LONG): The angular distance from the Greenwich (zero degree) meridian, along the equator. This can is measured either east or west to the 180th meridian (180 degrees) or 0 to 360 degrees west. For example, Ohio includes 85 degrees west longitude, while India includes 85 degrees east longitude. But 85 degrees east longitude could also be measured as 275 degrees west longitude.

LOSS OF SIGNAL (LoS): The time at which a particular ground station loses radio signals from a satellite.

MEAN ANOMALY (MA): This number represents the angular distance from the perigee point (closest point) to the satellite's mean position. This is measured in degrees along the orbital plane in the direction of motion. This number is entered like the argument of perigee, as a value between 0.0 and 360.0.

MEAN MOTION (MM): This is the number of complete revolutions the satellite makes in one day. This number may be entered as a value greater than 0.0 and less than 20.0. (See DECAY)

NASA: U.S. National Aeronautics and Space Administration.

ORBITAL ELEMENTS: Also called Classical Elements, Satellite Elements, Element Set, etc. Includes the catalog Number; epoch year, day, and fraction of day; period decay rate; argument of perigee, inclination, eccentricity; right ascension of ascending node; mean anomaly; mean motion; revolution number at epoch; and element set number. This data is contained in the TWO LINE ORBITAL ELEMENTS provided by NASA.

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.

POSIGRADE ORBIT: Satellite motion which is in the same direction as the rotation of the Earth.

RETROGRADE ORBIT: Satellite motion which is opposite in direction to the rotation of the Earth.

REVOLUTION NUMBER: This represents the number of revolutions the satellite has completed at the epoch time and date. This number is entered as an integer value between 1 and 99999.

REVOLUTION NUMBER AT EPOCH: The number of revolutions or ascending node passages that a satellite has completed at the time (epoch) of the element set since it was launched. The orbit number from launch to the first ascending node is designated zero, thereafter the number increases by one at each ascending node.

RIGHT ASCENSION OF THE ASCENDING NODE (RAAN): The angular distance from the vernal equinox measured eastward in the equatorial plane to the point of intersection of the orbit plane where the satellite crosses the equatorial plane from south to north (asecending node). It is given and entered as a real number of degrees from 0.0 to 360.0 degrees.

SATELLITE SITUATION REPORT: A report published by NASA Goddard Space Flight Center listing all known man-made Earth orbiting objects. This report lists the Catalog Number, International Designator, Name, Country of origin, launch date, orbital period, inclination, beacon frequency, and status (orbiting or decayed).

TLM: Short for telemetry.

TRANSPONDER: A device aboard a spacecraft that receives radio signals in one segment of the radio spectrum, amplifies them. translates (shifts) their freuency to another segment and retransmits them

TELEVISION RECEIVE ONLY (TVRO): A TVRO terminal is a ground station set up to receive downlink signals from 4-GHZ or 12-GHZ commerical satellites carrying TV programming.

TWO LINE ORBITAL ELEMENTS (TLE): See ORBITAL ELEMENTS.

UPLINK: A radio link originating at a ground station and directed to a spacecraft.

VERNAL EQUINOX: Also known as the first point of Aries, being the point where the Sun crosses the Earth's equator going from south to north in the spring. This point in space is essentially fixed and represents the reference axis of a coordinate system used extensively in Astronomy and Astrodynamics.

By Bob Grove, Publisher
E-mail address: st@grove.net

Techno-Evolution: Is the Cellular Dinosaur Heading for Extinction?

Over the last couple of years, we have witnessed an unprecedented growth in speculative investments in low earth orbiting (LEO) satellites and the Personal Communications Services (PCS). With such confidence in the new generation of portable and mobile telecommunications worldwide, what will become of the old generation—cellular telephones?

Although cell phones have been around since the early '80s, their operational cost, vulnerability to eavesdropping, unsightly towers, roaming problems, landscape attenuation, service variability, widespread dead spots, and vacant foreign countries, are legend.

Yet even with the emergence of superior, lower cost, digital PCS/LEOs in our imminent future, and the prospect of cell phones' consequent obsolescence soon after, the Cellular Telecommunications Industry Association (CTIA) can't agree on a digital protocol to protect their subscribers. Instead, over the years, they have relied on political action committees (PACs) to buy protective legislation..

The Head-in-the Sand Solution

Most recently, CTIA has been desperately trying to outlaw radio scanners capable of listening to their conversations; the embarassment of Newt Gingrich's cell phone call being heard has drawn the attention of legislators.

Intercepting cellular telephone calls carries penalities, resulting from successful conviction, which are severe, even for a first time offender—up to five years in jail and a fine of $100,000! The minimum fine is $500 with no prison sentence.

A new Bill before Congress (HR2369), prompted by CTIA and released by Congressman Billy Tauzin (R-LA), proposes a five year prison term and a $500,000 fine for anyone who:

> "manufacturers, assembles, modifies, imports, exports, sells, or distributes any electronic, mechanical, or other device or equipment ... intended for any receipt, interception, divulgence, publication, or utilization of any communications in violation of subsection (A)." (*Editor's note: this section includes reception of the domestic cellular telephone service*).

Compare this penalty with those imposed against *real* criminals, and you have a right to be incredulous—or even outraged! Hasn't Congress anything better to do?

Survival of the Fittest

So just what does telecomm's future hold? It is impossible to say which systems will eventually grasp the public's acceptance, and there are many to choose from. Most imminent are Motorola's 66-satellite Iridium, due late 1998, Qualcomm/Globalstar's 48 bird constellation, also slated for late 1998, and Orbcomm's 25 satellites, due possibly even sooner.

Just after the turn of the millenium, expect an alphabet soup of launches including ECCO, Ellipso, ICO, Odyssey, and Teledesic (Bill Gates' project). Virtually every imaginable telecommunications service is being promised by these forward-looking companies, including Internet access, paging, voice communications, worldwide telephone, data processing, signaling, security, navigation and location, and... you name it. It has been estimated that nearly 2000 satellites will be needed within the next two years to handle the exponential demand for services!

As technology moves forward, we may well witness the gradual decay of the cellular landscape blight, rusting fossils of a bygone era, abandoned in the clamor of a technosociety rushing to keep up with the frantic pace of telecommunucations. ST

IC-821H

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AO-27 Control Operator

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"(The IC-821H) is a terrific dual-band multimode transceiver for all applications. Not only is the IC-821H an excellent VHF/UHF weak signal or contest radio, it is the cornerstone of a high-performance satellite station (digital or analog). Hams who have the Phase 3D satellite in mind will want to give serious consideration to the IC-821H. It also offers superb FM-voice and 9600-baud packet performance. Combine all of these features with the IC-821H's go-anywhere size and you have a radio that's ideal for almost any application above 144 MHz!"

– QST Magazine, March 1997
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