Satellite Times®

$3.95 US
$6.25 CAN

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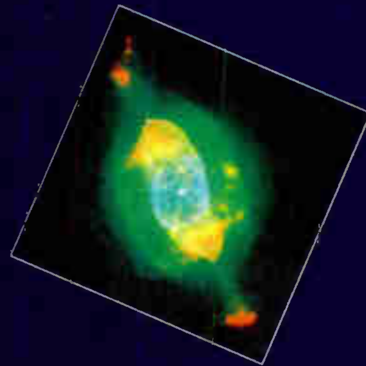


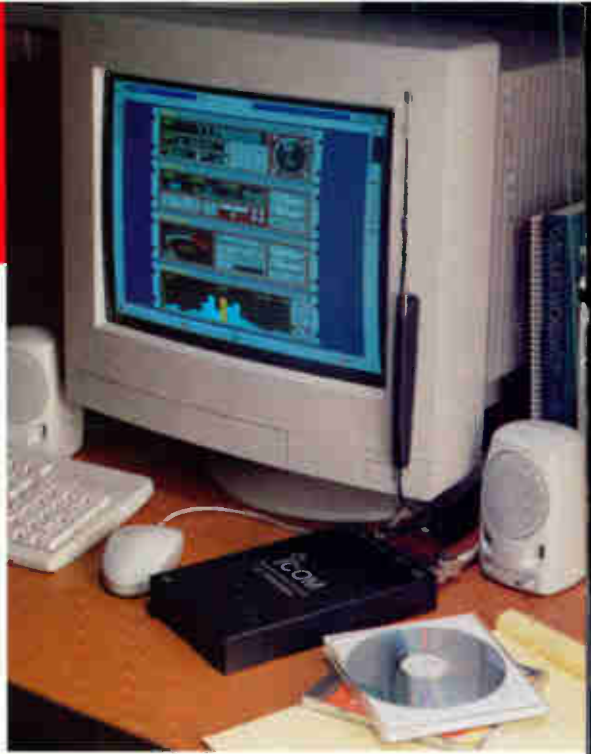
Volume 4, Number 4 February 1998

Life on the Edge

When the Sun begins its wild ride into retirement — about five million years from now — better get out of Dodge and head for Titan.

Hubble Space Telescope offers new perspectives on the death of stars.

ICOM Leads the Way with New PC Ready Scanners and Receivers



The whole world in a little black box! ICOM's newest receiver is a PC-external peripheral (no internal PC installation required). It's true plug and play world band convenience!

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- All Mode AM, FM, WFM, SSB, CW
- 3 Selectable User Screens
- Unlimited Number of Memory Channels
- Runs on Windows® 3.1 or 95

PC Ready!

NEW!

Plug and Play. Software, 6-pin RS-232C cable, antenna and AC adapter are **included**.

IC-PCR1000

External, PC-controlled Wide Band Receiver

IC-R8500

The Expert's Choice is Also Easy to Use

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Satellite Times

Cover Story

Cover Photo: Our cover photo this month is a photographic montage of dying stars taken by NASA's Hubble Space Telescope. (Photographs courtesy of NASA and STSci).

Life on the Edge

Now is a good time to buy real estate on Titan, the largest of Saturn's moons. Land there is dirt cheap right now. But when the sun swells and becomes a red giant, life on Earth might be a little uncomfortable. Of course, you will have to wait five billion years when the sun begins its wild ride into retirement before packing up the moving van. For more on this story see page 10.

Vol. 4, No. 4

CONTENTS

February 1998

Cheap Weather Satellite Reception

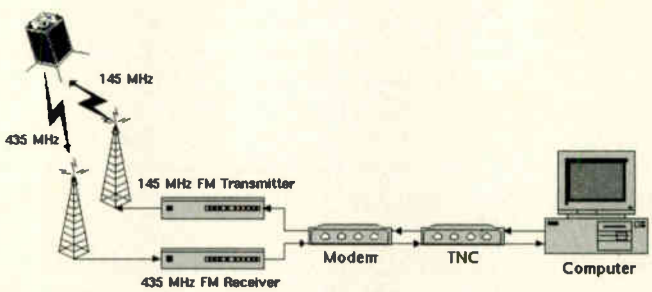
By Philip Chien, KC4YER

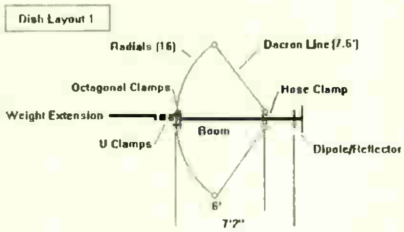
"Everybody talks about the weather but no one does anything about it." You might not be able to change the weather, but you surely can observe it from a view on high. *ST* staffer Philip Chien, in the story starting on page 14, tells you how to get started and do it inexpensively.

Under Construction: The KB2BD 9600 Baud Modem

By John A. Magliacane, KD2BD

More and more amateur radio pacsats are moving to higher and higher speeds. *ST* staffer John Magliacane offers a low cost, high-performance construction project to help the ham communicate through the newer amateur satellites. Dust off those soldering irons and turn to page 20 for part one of this two part series.





Do you like to homebrew your own equipment? Do you like to roll your own antennas from scratch? Then turn to page 76 and build your own 12-foot dish in this month's *Radio Astronomy* column.

DEPARTMENTS

ST

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

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

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

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

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Order the Feature-Packed New Magellan GPS 4000!

For the outdoor enthusiast who wants more in a GPS—more memory for landmarks and routes, more navigation screens, more features like landmark messaging, map projection, sunrise/sunset times, moon phase and real-time plotter with more functions—the GPS 4000 delivers it all in a 10-ounce package!

While the GPS 3000 excels in marine conditions, the 4000 is a winner for land-based functions. Customizable navigation screens display your most often-used readouts, while experienced map readers will appreciate the map projection and triangulation features which permit them to create new landmarks by estimating distance and location.

All units shown enable you to establish your exact location to within 100 yards in as little as 2-1/2 minutes from a cold start (35 seconds warm start), even your altitude, and allow you to plot and track your course as well, so you can find your way back if necessary. Ideal for pinpointing campsites, fishing holes, boating, travelers, trailheads, map locations, landmarks. Selectable graphic screens assist you in tracking and plotting where you've been, where you're going, and where you *ought* to be going! Show distances, directions, times, speed, course corrections, latitude/longitude coordinates, all on a backlit LCD display.

These Magellan navigational satellite receivers are ruggedly built and waterproof, and they provide up to 17 hours of continuous use on one set of standard alkaline AA cells. Operate over a 14 to 140 degree Fahrenheit temperature range. Lanyard strap included. Accessories available (please call).

ORDER GPS 4000 (above) or GPS 3000 (right)

$249.95 ea.

Hear Nature's Radio on the exciting WR-3E VLF Receiver!

Even the Earth's electrical disturbances which produce the auroras (shown here in this NASA photo) can be monitored by the WR-3E VLF receiver.

Now you can hear the ethereal sounds of the earth and its environment. Distant lightning discharges, the aurora borealis, and even solar winds produce "whistlers," "hisses," "wavers," "tweeks," "swishers," and even a medley called the "dawn chorus!" And with the solar cycle on the increase, these radio phenomena are on the increase! Electrical applicances produce a symphony of their own, and even swarms of insects can be detected by this sensitive receiver!

Since its development in 1991, many of these tiny receivers have been used by universities for atmospheric ("sferics") and geological research. As you walk through sand or over gravel, you will hear the piezoelectric discharges of the granuals as they rub together. Strolling through your home or office, you can audibly detect the panorama of electromagnetic radiations from nearly anything with a power cord on it!

You can even use this unique product as an electrical interference probe, walking around your home or office looking for sources of electrical discharge, pulse, or spark interference affecting radio and TV reception. A 3-position filter selects best reception as you listen through the earphone, while an RCA phono jack permits connection to your tape recorder.

WR-3E handheld VLF receiver

You can't hear all of these sounds on your shortwave receiver or scanner, but the very low frequency (VLF) spectrum comes alive with special listening tools like the new WR-3E handheld receiver. Now you can monitor approaching electrical storms, nearby electrical appliances, motors, power lines, and other emitting devices in the 100-8,000 Hz range! Order now and receive a free 90-minute demonstration tape and a listening guide at no extra cost!

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DOWNLINK

By Larry Van Horn
Managing Editor
steditor@grove.net

Letters to the Editor

Setting the Record Straight

To set the record straight (Nov/Dec 1997 *ST* cover story) red sprites and blue jets are two different animals. There are a number of animals in the zoo and we have seen only a few. We have elves and starters also. There have been no observations made, as far as I know, in the ultra violet. So we still have a lot to learn about these phenomena.

The red sprite appears above a thunderstorm and the blue jet actually moves out from the top of the storm at about 100 km per second. Sprites do not shoot upwards. I first saw the sprites and jets from space in 1989 using the shuttle low light level TV cameras; however, they were not in color and did not create too much interest until Sentnan got them in color. (Otha H."Skeet" Vaughan, Jr., NASA)

Reader Vaughan is absolutely correct. Now that we have more space in ST, thanks to our monthly format, it is my intention to publish a proposed article by Otha on these phenomena in a future issue—Larry.

The Death of C-band

The article entitled *The Death of C Band* by Steve Handler of the *Satellite Times* staff has just arrived in my mailbox and is the most insightful article I have seen on the subject. It gives solid reasons why C-band is dying.

As you know "The General" has just downsized. I am sure that the people in charge of this project had more definitive data than Handler's trip through rural Wisconsin and Minnesota to make their conclusions; however, they should be the same. Handler concludes that old C-band customers will opt for small dishes that are easy to operate as they need to replace their systems.

Handler says that C Band systems are too hard to operate and that DSS offers lots of programing without the hassles of moving the dish, etc. Handler does make a false assumption that a 4DTV system will cost $2K and that putting that money in the bank and buying a DSS for $200 would result in $100 interest being drawn which would offset higher programming costs. The 4DTV upgrade is about $800 to $1K if you have to add Ku-band. Otherwise his thinking holds true.

I do not think that 4DTV users should have bad feelings about downsizing at The General. This action will keep the company healthy. One can also speculate that, with the downsizing process in operation during the last few months, major projects such as 4DTV software upgrade may have slowed due to the process. Now everybody doing 4DTV work can move the project forward instead of wondering if they will be a part of the project tomorrow.

Will 4DTV revive C-band? I say a cautious "maybe". Dealers will have to work hard. 4DTV software will have to get better. The General has a top notch team–they can do the job. I hope that five years from now that we will see Handler's article quoting Mark Twain, the news of my demise was premature ... However, denial is the first stage of dealing with death. (Jerry Fisher, **satman@top.net**)

Likes ST

I just want you to know I really appreciate your *Satellite Times* magazine. Reading just one issue convinced me to subscribe, and each issue confirms my initial assessment of your publication's coverage, breadth and technical depth. (MELISS25 via email)

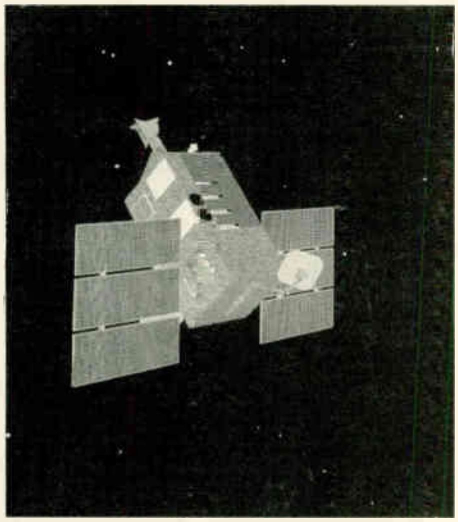
And Finally ...

... from our spacey friend John Dilbeck and the internet .. The Top 10 Signs the New Mir Computer is Running Windows 95, composed by Mike Popovic **carpediem@locnet.com**.

#10 The computer keeps asking you to "Insert Setup Disk #3 to continue."
#9 There is no space left on the hard drive to store mission data.
#8 The computer refuses to interact with the Mir's "Mr. Java" coffee maker.
#7 Millions of dollars are traced to phone calls to a Redmond, Washington, 900 number.
#6 Mir astronauts are caught stealing RAM from other satellites' computers to keep their system running.
#5 The space shuttle can no longer dock with Mir since "the proper driver cannot be found."
#4 The system locks up whenever the astronauts try to run life support, the solar panels and thrusters at the same time.
#3 The astronauts spend three days looking for cyrillic version of the CTRL-ALT-DEL keys.
#2 Alien ships secretly observing Mir flee in terror.
And the number one sign the new Mir computer is running Windows 95 ...
#1 You start receiving welcome e-mail from the Borg ST

Satellite Monitor

By Wayne Mishler, KG5BI



NASA's Rossi X-ray Timing Explorer (RXTE) spacecraft.

Black Hole Distorts Space and Time

Astronomers using NASA's Rossi X-ray Timing Explorer (RXTE) spacecraft report that they have observed a black hole that is literally dragging space and time around itself as it rotates. This bizarre effect, called "frame dragging," is the first evidence to support a prediction made in 1918 using Einstein's theory of relativity.

The phenomenon is distorting the orbit of hot, X-ray emitting gas near the black hole, causing the X-rays to peak at periods that match the frame-dragging predictions of general relativity.

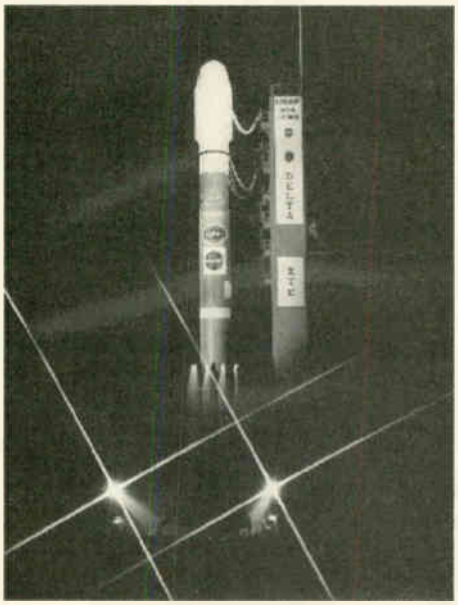
The research team, led by Dr. Wei Cui of the Massachusetts Institute of Technology, announced its results in a press conference during the American Astronomical Society's High Energy Astrophysics Division (HEAD) meeting in Estes Park, Colorado.

"If our interpretation is correct, it could demonstrate the presence of frame dragging near spinning black holes," said Cui. "This observation is unique because Einstein's theory has never been tested in this way before."

The intense gravitational pull of black holes shrouds the center in darkness. Its presence can only be inferred from its effects on nearby matter. Many of the known or suspected black holes are orbiting a close "companion" star. The black hole's gravity pulls matter from the companion star, which forms a disk around the black hole as it is drawn inward by the black hole's gravity, much like soap suds swirling around a bathtub drain. Gas in this disk gets compressed and heated and emits radiation of various kinds, especially X-rays.

The research team used these X-ray emissions to determine if frame dragging was present. The team found that the X-ray emissions were varying in intensity. By analyzing this variation, they found a pattern, or repetition, that was best explained by a perturbation in the matter's orbit. This perturbation, called a precession, occurs when the orbit itself shifts around the black hole. This is evidence for frame dragging because as the matter orbits the black hole, the space-time that is being dragged around the black hole drags the matter along with it. This shifts the matter's orbit with each revolution.

Einstein's Theory of General Relativity has been highly successful at explaining how matter and light behaves in strong gravitational fields, and has been successfully tested using a wide variety of astrophysical observations.



Delta rocket launches the (RXTE) spacecraft.

The frame-dragging effect was first predicted using general relativity by Austrian physicists Joseph Lense and Hans Thirring in 1918. Known as the Lense-Thirring effect, it has not been definitively observed thus far, so scientists will scrutinize the new reports very carefully.

The possible detection of frame dragging around another type of very dense, quickly spinning object, called a neutron star, was accomplished very recently by Italian astronomers, whose work led Dr. Cui's team to seek the effect near black holes. Their observations also were made using the RXTE, which is available for use by astronomers throughout the world.

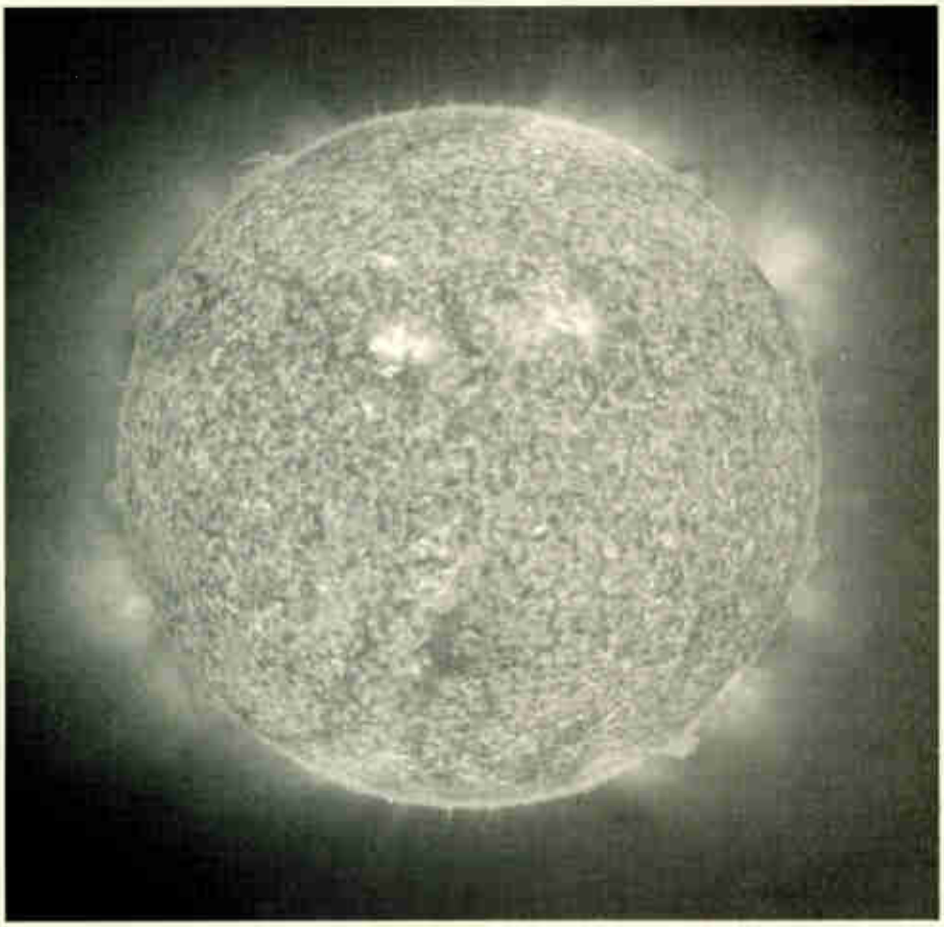
Solar Mystery Nears Solution

A likely solution to one of the major mysteries of the Sun has emerged from recent observations with the European Space Agency/NASA Solar and Heliospheric Observatory (SOHO) mission.

The new findings seem to account for a substantial part of the energy causing the very high temperature of the corona, the outermost layer of the Sun's atmosphere which becomes visible to the naked eye only during a total solar eclipse. Since the corona's temperature was first measured 55 years ago, scientists have lacked a satisfactory explanation for why that temperature is over one million degrees while the visible surface of the Sun is only about 6,000 degrees Celsius.

According to the laws of physics, thermal energy cannot flow from the cooler surface to the much hotter corona, so the energy transfer has to be in the form of waves or magnetic energy, but no measurement to date had found adequate energy to account for the corona's high temperature.

"We now have direct evidence for the upward transfer of magnetic energy from the Sun's surface toward the corona above. There is more than enough energy coming up from the loops of the 'magnetic carpet' to heat the corona to its known temperature," said Dr. Alan Title of the Stanford-Lockheed Institute for Space Research, Lockheed Martin Advanced



Technology Center, Palo Alto, California, who led the research. "Each one of these loops carries as much energy as a large hydroelectric plant, such as the Hoover dam, generates in about a million years."

Energy flows from the loops when they interact, producing electric and magnetic "short circuits." Strong electric currents in these short circuits are what heats the corona to a temperature of several million degrees.

The observations with SOHO's Michelson Doppler Imager (MDI) provided long-duration, highly detailed, and well calibrated time-lapse movies of the magnetic fields on the visible surface or "photosphere" of the Sun. These revealed the rapidly changing properties of what Title calls "the Sun's Magnetic Carpet," a sprinkling of tens-of-thousands of magnetic concentrations. These concentrations have both north and south magnetic poles, which are the "foot points" of magnetic loops extending into the solar corona.

Like field biologists who study the populations and life cycles of animal herds, the SOHO researchers analyzed the appearance and disappearance of large numbers of the small magnetic concentrations on the solar surface. "We find that after a typical small magnetic loop emerges, it fragments and drifts around and then disappears in only 40 hours," Title said. "It's very hard to understand how such a short-lived effect could be driven by the magnetic dynamo layer that is over 150,000 km beneath the surface of the Sun. This may be evidence that unknown processes are at work in or near the solar surface that continuously form these loops all over the Sun."

Magnetosphere Movies May Debut on TV

Early next century, watching the "weather" in Earth's magnetosphere could be as commonplace as watching satellite imagery of cloud fronts drifting across Earth's landscape on the evening news.

Los Alamos National Laboratory scientists are leading a national team in developing a pair of unique instruments that will provide three-dimensional imagery of changing conditions in the magnetosphere.

Scientists have discovered that various solar eruptions and space disturbances can inject particles and energy to the magnetosphere, creating conditions for storms that can knock out satellites and electrical power grids on the ground.

The US$18 million "TWINS" imagers funded by NASA will ride on two separate satellites to create stereoscopic, three-dimensional movies of the churning activity in Earth magnetosphere.

"We believe the images obtained by TWINS will revolutionize the study of the magnetosphere," said Dave McComas, principal investigator for TWINS. "Scientists have an immense amount of data from the magnetosphere, but it's all tied to specific locations; you have to do statistical analyses to build up an average picture of the magnetosphere.

"This will be the first time we'll be able to get a stereoscopic view of the overall magnetospheric behavior. Once we get that global view we expect to determine unambiguously the connections and causal relationships between activity in different regions," McComas said.

TWINS stands for Two Wide-Angle Imaging Neutral-atom Spectrometers. These instruments are scheduled for launch aboard two U.S. government satellites sometime between 2002 and 2004.

Using neutral atoms to image the magnetosphere was an idea first realized by researchers at Johns Hopkins University's Applied Physics Laboratory in the late 1980s.

A major advance came with the 1996 launch of NASA's Polar satellite. A Los

Alamos instrument, originally designed in the '80s and built during the early '90s, rides on Polar and provides the first true images of the magnetosphere.

Number of Lightning Strikes Misreported

Just three months after its launch, Los Alamos National Laboratory's FORTE satellite is detecting many thousands more radio bursts from lightning strikes and other phenomena than previously reported.

FORTE, which stands for Fast On-orbit Recording of Transient Events, is a lightweight satellite designed to test technology to monitor compliance with arms control treaties. Its instruments detect, record and analyze bursts of radio energy and light arising from near Earth's surface, and gather data on the physics of lightning and the ionosphere.

In 1993, an experiment on board Los Alamos' ALEXIS satellite detected radio impulses a hundred times stronger and a thousand times shorter than radio emissions generated by lightning. They called trans-ionospheric pulse pairs (TIPPS), and are believed to come from an altitude of three to 10 miles above thunderstorms.

"Where [that experiment] detected about 1,000 TIPPs over the past four years, FORTE can detect 1,000 a day, including those buried in radio noise," Franz said.

FORTE is revolutionary because it integrates a wide-field optical imager that can locate lighting flashes and a sensitive radio frequency sensor system on the same platform.

The optical imagers allow researchers on the ground to pinpoint a lightning flash within six miles, roughly the size of single thunderstorm cell.

"We've already seen the trail of lightning locations as FORTE tracks a thunderstorm over just a few minutes of satellite motion," Franz said. This precision and the integrated way that FORTE looks at both natural and man-made radiofrequency and optical signals may help researchers determine whether TIPPs are associated with a corresponding optical pulse, Franz said.

Los Alamos scientists are using another major FORTE instrument, an event classifier, to distinguish the inherent structures of radio frequency signals in the 30-300 megahertz range, which includes commercial television, FM radio, aircraft navigation and communication bands. Weeding these out from lightning and signals from rogue nuclear weapons tests is a key to future nonproliferation satellites.

FORTE receives radio frequency signals via a novel, 35-foot-long antenna that has two arrays set at right angles to each other. The antenna, which was coiled up like a Slinky toy in a foot-high canister aboard the satellite, was unfurled last month.

Data from FORTE eventually will aid scientists studying global climate effects, where the lightning flash rate within a thunderstorm can be related to the precipitation rate. The associated radio frequency emission data can help explain the atmospheric breakdown mechanisms that lead to lightning discharges.

The improved detection technology on FORTE is the first step toward an autonomous radio frequency detection system that performs reliably in the electromagnetically noisy environment of near-Earth space. Known as the V-sensor, for Verification, the sensor is to be placed aboard a future mission of the Global Positioning System, or GPS.

FORTE is the second satellite built by Los Alamos. The first one, ALEXIS, was launched in 1993 and is still in operation, despite its one-year projected lifetime.

European Space Market Booming–Literally

Arianespace has announced that it is ordering 20 more launch vehicles from the European space industry to compete in the booming satellite launch market.

The order is worth 12 billion francs (about US$2 billion) and will enable Arianespace to fulfill launch demand during the first two years of the next century, says a company spokesperson.

To date, European space suppliers have booked orders for 160 Arianespace launch vehicles, including an Ariane 5 order. The company plans to offer 12 to 14 launches per year. Most will carry payloads of two satellites. Arianespace's orders now stand at 42 satellites to be launched. The bottom line of those orders is about 20 billion francs (US$3 billion).

The overall number of geostationary commercial satellites is expected to increase by 50 percent by the end of this century.

The message from Arianespace these days is that satellite operators from around the world can count on flexible, available launch solutions from Ariane 4 and 5 to get their satellites safely into orbit.

New Partnership Extends PCS Communications to North America and Africa

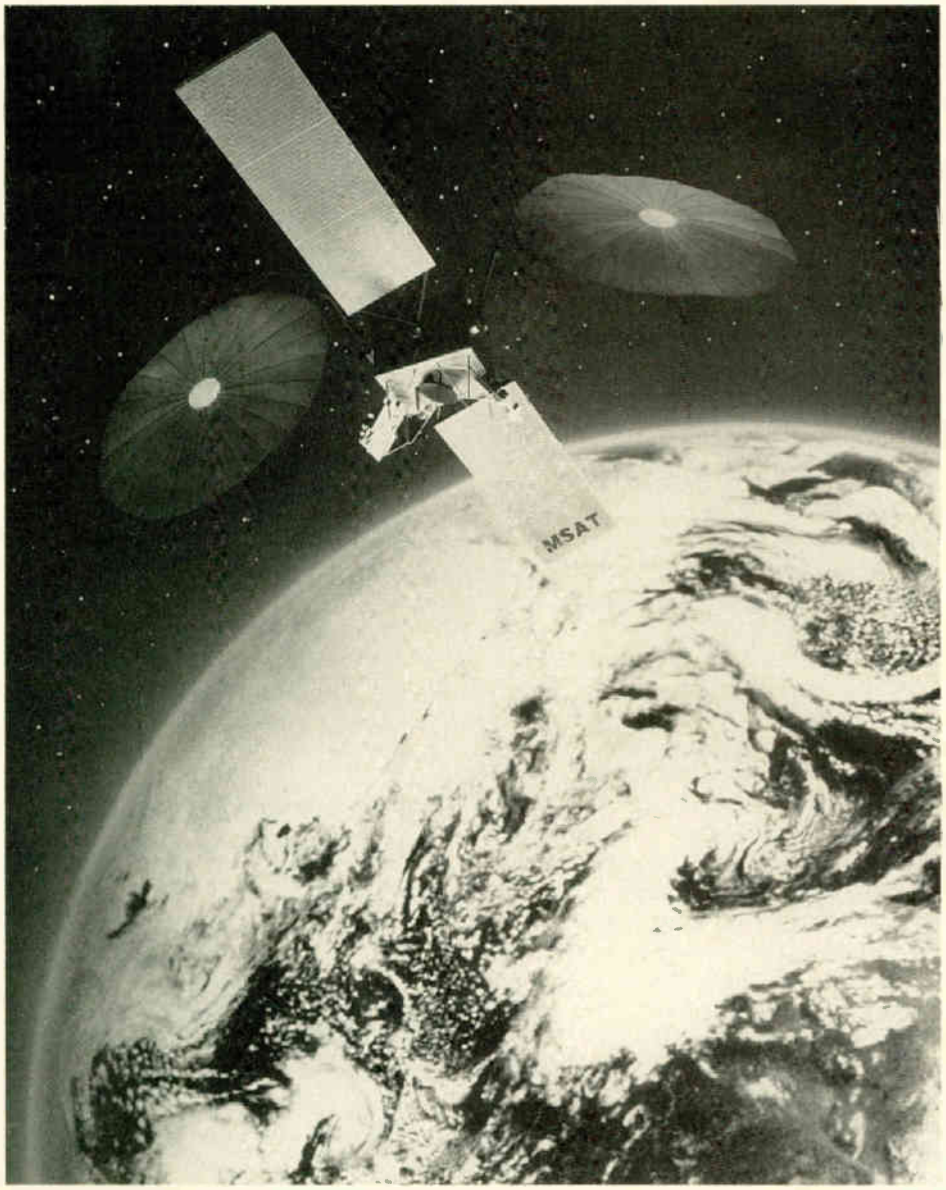
In a joint venture announced in December, the American Mobile Satellite Corporation and TMI Communications are moving their MSAT-2 satellite to provide mobile telecommunications service in southern Africa. A twin satellite, MSAT-1, will be positioned to provide similar services in North America.

American Mobile Satellite will buy half interest in MSAT-1 from TMI, and share the cost of operating it. They are to lease MSAT-2 to African Continental Telecommunications Limited (ACTEL) for service in Africa.

Services will include telephone communications, digital broadcast dispatch, data transfer, mobile messaging, and position reporting.

"MSAT mobile satellite technology is well suited to the needs of maritime, government, transportation, utility, and oil and gas industries," says Gary Parsons,

SATELLITE MONITOR



president and CEO of American Mobile Satellite.

The two companies have worked together in the past to develop MSAT mobile satellite technology, and to place twin MSAT satellites in service over Canada and the United States.

MSAT technology uses geostationary earth-orbit satellites with "spot beam" capability to cover target areas with services such as wide area dispatch for business customers.

And finally...

How small can you make a satellite?

About half an ounce is the startling answer from a team of Los Alamos National Laboratory researchers who are designing cheap microsatellites with control systems based on the simplest "twitches" of animal neurons.

These insect-like space vehicles could open up important new space missions, said Kurt Moore and co-authors Janette Frigo and Mark Tilden in a paper presented to the American Geophysical Union. Their missions could include measuring solar wind or capturing precise images of Earth's features.

Satellites often fail because space radiation wipes out delicate on-board microprocessors. "We're working on satellites that have no microprocessors or fixed algorithmic behaviors," Moore said.

"Our satellites are survivors–designed from the bottom up and domesticated by their sensors and control payloads into performing high-reliability tasks."

These robust microsatellites represent a trend in space exploration toward clusters of small, cheap satellites that can achieve results even when some in the clusters fail, Moore said.

The control systems are based on simple "nervous nets," an instinct-like neural net in which a single electronic neuron is sufficient to produce a control pulse, or twitch, in a robotic creature lacking an advanced processor or computer commands.

A robotics engineer found that with just two neurons he could create a walking, insect-like robot with remarkable survival skills.

"We've never really been able to do real-time monitoring of the position of the magnetopause as the solar wind pushes it around," Moore explained. "With hundreds of these microsatellites, we should be able to do that."

Another experiment might place on each microsatellite a single imager sufficient to gather just one high-resolution piece of an image. By collecting all the pieces, researchers on the ground could obtain highly accurate pictures of Earth features.

"These microsatellites can go where expensive, big satellites can't go and they can perform a class of business and science missions that no other platform can do," Moore said.

"Nobody knows how little you can go. That's what we aim to find out." ST

Sources: American Mobile Satellite, Arianespace, European Space Agency, Los Alamos National Laboratory

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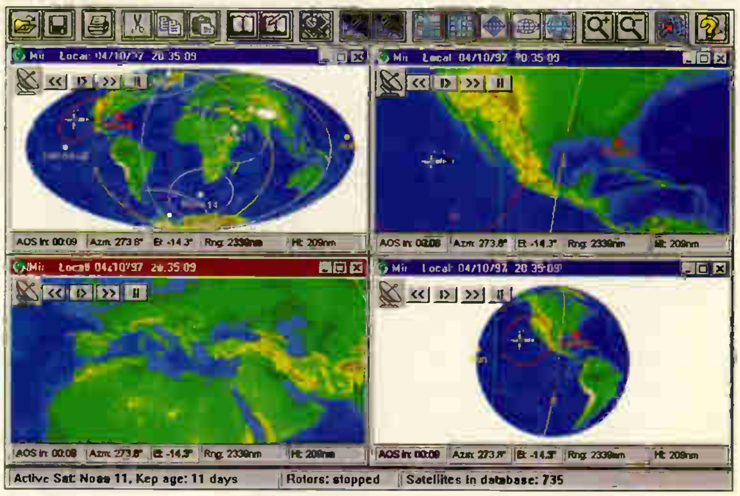

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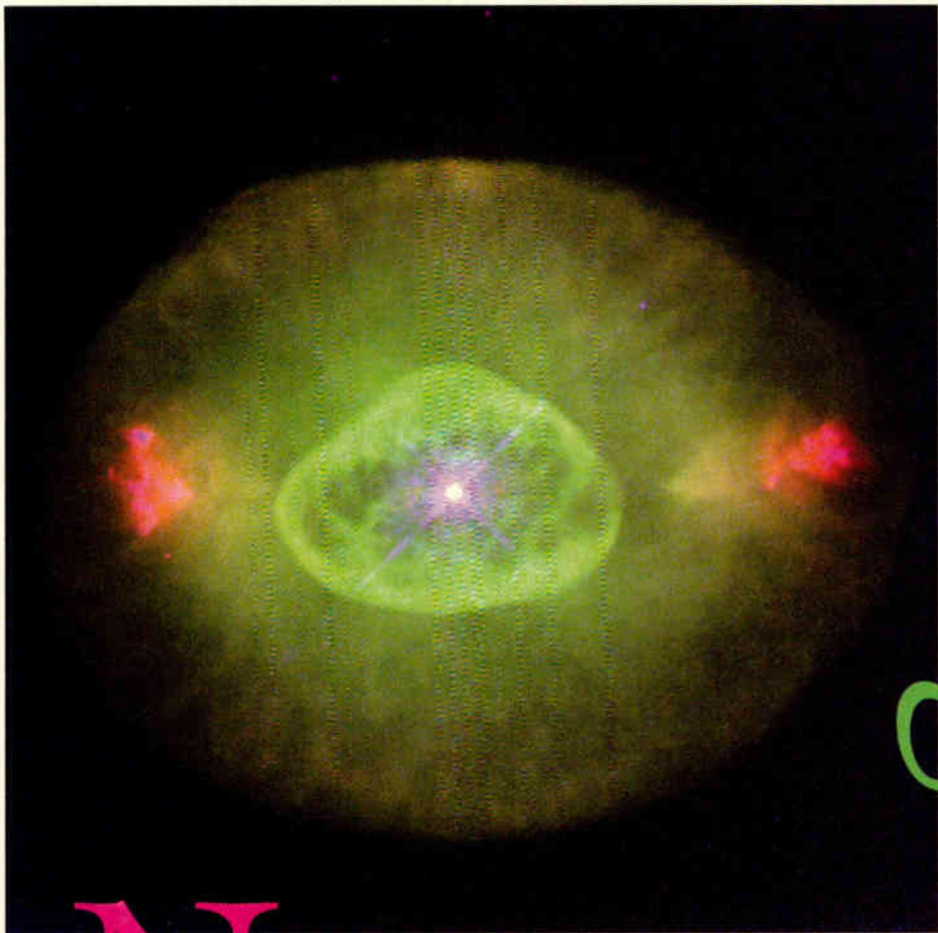
Life on the Edge

Story by Satellite Times staff and the Space Telescope Institute
Photos courtesy of NASA



Now is a good time to buy real estate on Titan, the largest of Saturn's moons. Land there is dirt cheap. But just wait five billion years when the sun begins its wild ride into retirement.

As the sun swells and becomes a red giant, life on Earth might get a little uncomfortable: The average temperature on our planet could catapult to a sizzling several thousand degrees Fahrenheit. Then it is time to reach for sunscreen with an SPF of 2,000, or pack up your belongings and take the next space shuttle to a place with a more hospitable climate.

That could be Titan, a moon larger than the planet Mercury and about half the size of Earth. Titan is one of the safest bets to colonize because it is far enough from the sun's death rattles, and it has an atmosphere to trap heat.

For those who find searing heat appealing, stick around. Earth will be the place for you. The weather will be fairly predictable. No snowstorms or ice storms. Just extremely hot and dry.

The only question is, how large will the sun get once it consumes its thermonuclear fuel, hydrogen, and begins expanding? Will the sun swell so much that it engulfs Earth? Or will Earth just barely escape the sun's grasp, only to be scorched by the dying star's prodigious increase in energy output as it fights off death?

The Glorious End of Stellar Life

The end of a sun-like star's life was once thought to be simple: the star gracefully casting off a shell of glowing gas and then settling into a long retirement as a burned-out white dwarf.

Now, a dazzling collection of Hubble telescope images reveals surprisingly intricate glowing patterns spun into space by aging stars: pinwheels, lawn sprinkler style jets, elegant goblet shapes, and even some that look like a rocket engine's exhaust.

"These eerie fireworks offer a preview of the final stage of our own Sun's life," says Bruce Balick of the University of Washington in Seattle. More than simply a stellar "light-show," these outbursts provide a way for heavier elements–predominantly carbon–cooked in the star's core, to be ejected into interstellar space as raw material for successive generations of stars, planets and, potentially, life.

Garden-variety stars like our Sun live undistinguished lives in their galactic neighborhoods, churning out heat and light for billions of years. When these stars reach retirement age, however, they become unique and colorful works of art.

As ordinary, sun-like stars begin their 30,000-year journey into their twilight years, they swell and glow, shrugging off their gaseous layers until only their small, hot cores remain. The ejected gaseous layers are called planetary nebulae, so named in the 18th century because, through small telescopes, these gas clouds had round shapes similar to distant planets such as Uranus or Neptune.

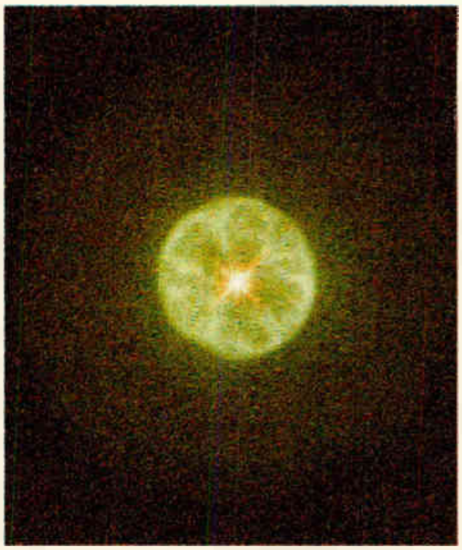
The gaseous debris glows like a fluorescent design, producing objects with striking shapes and names like *The Cat's Eye* and *The Hourglass.* Astronomers have recorded more than 1,000 of them in our galaxy.

The astronomers say the incandescent sculptures are forcing a rethinking of stellar evolution. In particular, the patterns may be woven by an aging star's interaction with unseen companions: planets, brown dwarfs, or smaller stars.

Dying Stars Create New Life

Gas released by these dying stars helps create new life. This gas contains new chemical elements, including carbon, which eventually are incorporated into stars and planets. Scientists believe that the carbon found on Earth came, in part, from planetary nebulae billions of years ago. The rest came from supernova explosions.

Supernova explosions may be more powerful, but the light show from the death of ordinary stars is a more captivating. As bright as one billion suns, supernovae explosions signal the demise of massive stars (roughly eight solar-masses



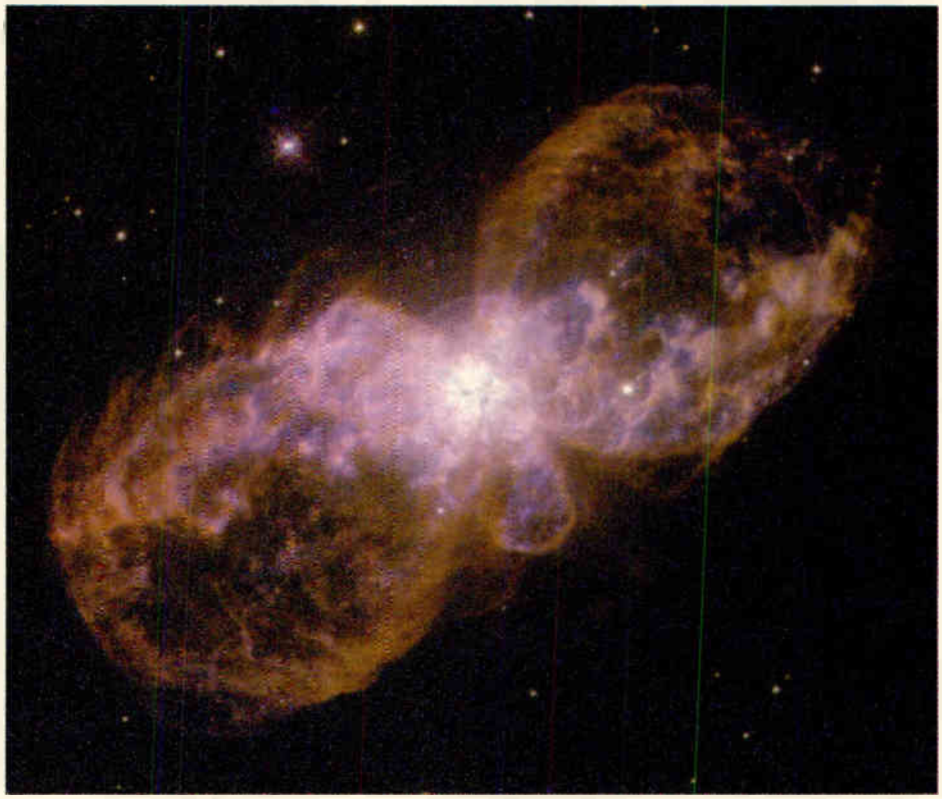
or more). These powerful blasts occur, though, only once every 30 years in galaxies like ours. The demise of an ordinary star, on the other hand, occurs every year. By understanding how these garden-variety stars live and die, scientists are developing a clearer picture of our Sun's fate. The Sun will enter its twilight years in another five billion years.

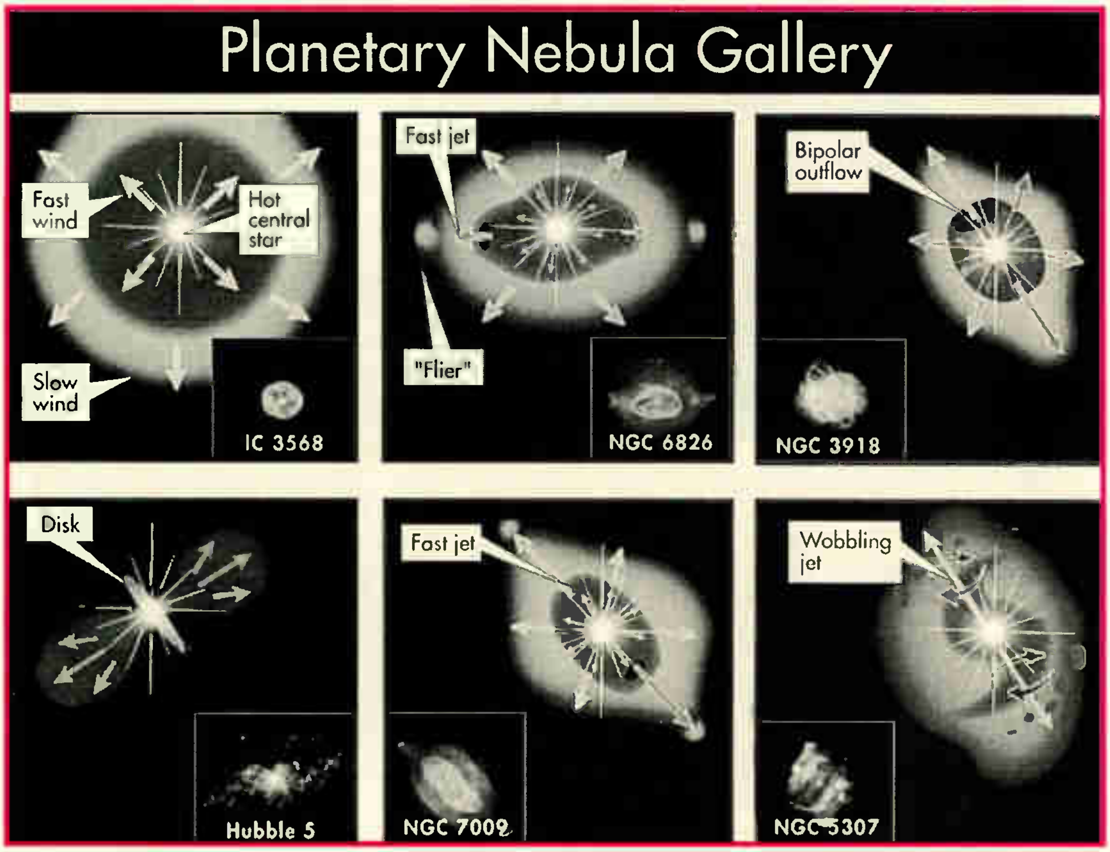
Sun-like stars, like humans, are born, live their lives, and die. A sun-like star's life lasts about 10 billion years. Most of that time is spent in adulthood or the "main sequence" phase, living a blissful life in a suburban galaxy neighborhood. A star's peaceful appearance, however, belies what is happening inside its core where its energy-producing "engine" resides. A highly powerful, self-regulated, 30-million-degree Fahrenheit engine powers the sun. The engine is constantly busy converting hydrogen to helium (called nuclear fusion), which produces the energy necessary to sustain life. The Sun's engine produces the heat that makes the Earth habitable. Energy generated by the core also keeps gravity at bay.

Stars Wage Battles Against Gravity

All stars wage a continuous battle against gravity, specifically, the crushing weight of their outer layers. During most of a star's lifetime, pressure and gravity hold an uneasy truce. It is analogous to two people arm wrestling to a draw. The weight of the outer stellar layers pushes against a star's inner layers. At the same time, heat generated in a star's high-metabolism core–by the conversion of hydrogen to helium–produces pressure. This pressure exerts an outward force, like the pressure of gas in a hot air balloon, and combats the inward force of gravity.

As a star ages, it begins to exhaust its supply of hydrogen. When the hydrogen runs out, there is not enough gas pressure inside a star to fight off gravity. A star, then, must make adjustments to keep on





running. This signals the beginning of a star's twilight years.

As humans reach their golden years, they retire, take trips, relax. But a sun-like star's senior years are full of drama. It is as if it has ditched its peaceful lifestyle for one last adventure. Once the hydrogen runs out and gravity begins to claim its victory, the core begins to contract and become denser and hotter. At this point the star has completed 90 to 95 percent of its lifetime. Then the metamorphosis begins with the red giant stage (in which a star swells, to 200 times its normal diameter) and ends with a slowly fading white dwarf (a hot, Earth-sized fossil). One handful of a white dwarf weighs as much as a 747 airplane. A sun-like star spends a fraction of the intervening years (about 10,000) stripping off its outer layers until it uncovers the white dwarf within.

In desperation, the star buys some time for itself by firing up its thermonuclear furnace to convert the remains of hydrogen fusion (helium) into carbon. This process is not particularly productive, buying only about a few hundred million years of life.

Meanwhile, the prolific waste heat from the core is being absorbed in the star's outer layers, causing them to become 3,000 times more luminous, then to expand and, ironically, to cool. A red giant star is formed. This phase lasts about 1 billion years.

Once the helium is exhausted, the core again becomes inactive. The red giant is dying, but the inactive carbon core is still very hot. Surrounding the core are two shells rich in unprocessed hydrogen and helium.

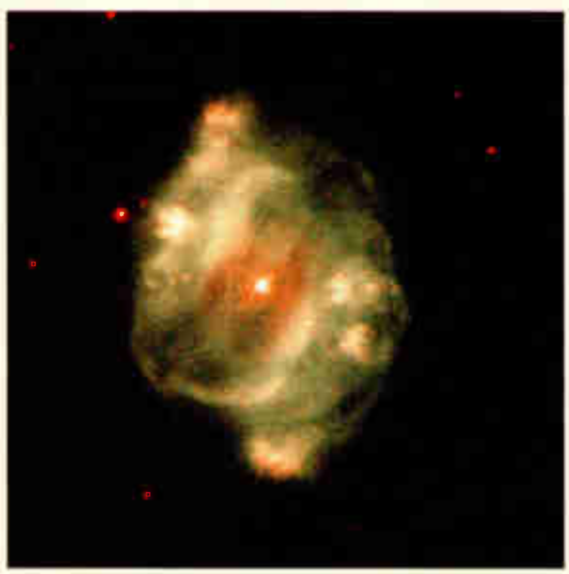
The star's surface pulsates and shudders with seismic energy from the activity of the shells beneath it. With each pulse, which lasts about a year, the surface layers expand and cool. Each time this happens some of the stellar exterior is flung into space and is carried away in a "slow wind," traveling at 10 miles per second. This process continues for a few thousand years until only about two-thirds of the star's mass remains: its carbon-oxygen core.

In a few thousand years, as these last outer layers are stripped off, much hotter inner layers of the star become exposed. Soon only the bare carbon-oxygen core is left. The core's temperature is rising rapidly. Over about 20,000 years, the core's surface temperature leaps to approximately 250,000 degrees Fahrenheit, compared with about 11,000 degrees Fahrenheit for the surface of a sun-like, main-sequence star. The dense carbon-oxygen star is not much larger than Earth.

Ultraviolet light from this intensely hot surface heads into the star's former outer layers, which are still moving outward in space at 10 miles per second. This light is so energetic that it causes the gas to fluoresce–like a fluorescent light bulb–forming the bright planetary nebulae surrounding dying stars.

A new wind, which carries very little mass but lots of energy, is blown outward at 1,000 miles per second (3.6 million mph). The low-density wind races outward and snowplows into the older gas. This so-called "fast wind" helps to sculpt planetary nebulae, creating some strikingly remarkable shapes.

The star's radiation begins to heat the planetary nebula, causing different gases to glow. At first, the nebula appears red because hydrogen gas has been heated. As the exposed stellar surface



becomes hotter, the colors shift to green (oxygen) and blue (helium). From far away, the former layers of the star appear as a glowing planetary nebula, about 1,000 times the size of our solar system. The fluorescent light of planetary nebulae lasts for only about 10,000 years.

Eventually, the core stops ejecting gas into space. The gas expelled earlier ultimately swirls away and merges into the interstellar medium, much as smoke from a train dissipates in our atmosphere. The gas carries traces of newly minted carbon and nitrogen from the atmosphere of the dying star. This material wanders through space until it is drawn into a newly forming star.

Hubble Overhauls Old Ideas

"The first time we looked at the Hubble's breathtaking pictures, we knew that our older and simpler ideas of how these objects are formed had to be overhauled," says Howard Bond of the Space Telescope Science Institute (STScI), Baltimore, Maryland. "The basic question is: how do these nebulae shape themselves?"

"Hubble's colorful views are a feast for the eyes," says Mario Livio, also of the STScI. "Their beauty is matched only by the mystery."

Surprising new details revealed by the Hubble pictures include:

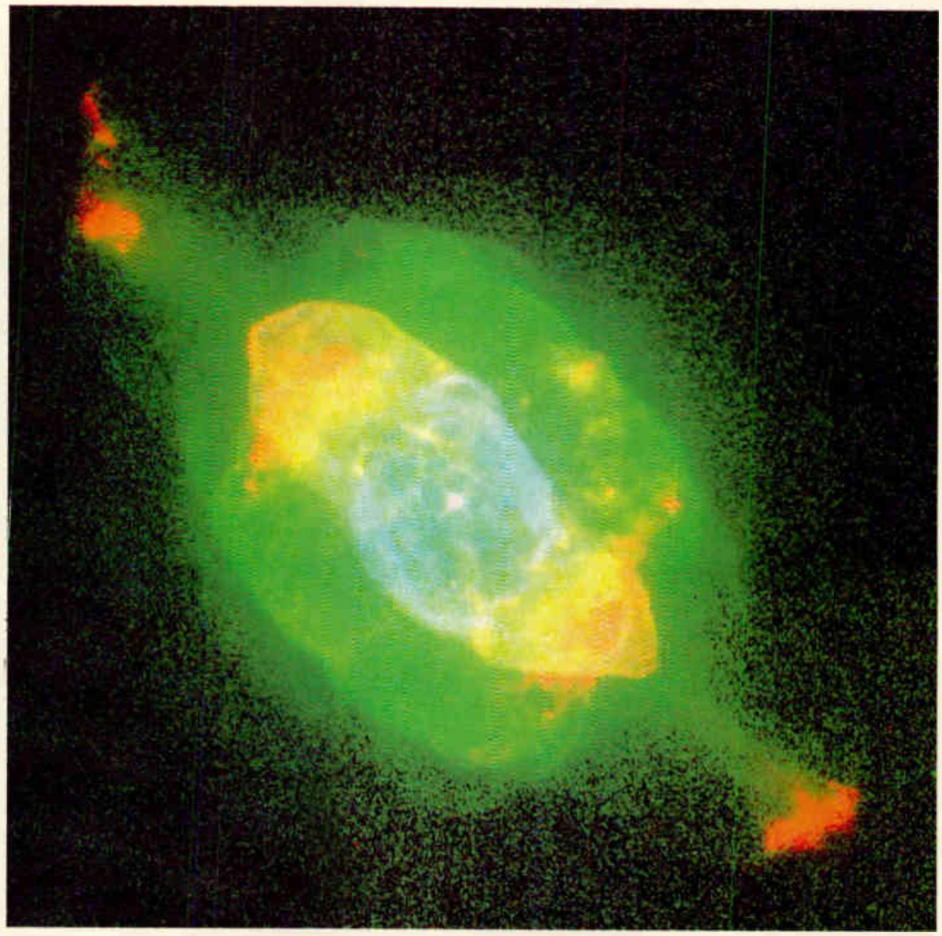
- Unexplained disks and "donuts" of dust girdling a star, which pinch outflowing gas. These may be linked to the presence of invisible companions.

- Remarkably sharp, inner bubbles of glowing gas–like a balloon inside a balloon–blown out by the violently outflowing gasses called a "fast wind" (1,000 miles/sec) ejected during the final stages of a star's death.

- Strange, glowing "red blobs" placed along the edge of some nebulae may be chunks of older gas caught in the stellar gale of hot flowing material from the dying star.

- Jets of high-speed particles which shoot out in opposite directions from a star, and plow through surrounding gas, like a garden hose stream hitting a sand pile.

- Pinwheel patterns formed by symmetrical ejection of material so that intricate structures are mirrored on the opposite side of a star.



"We're still reveling in the quality of the data and the wealth of new details. In the longer term we're going to have to confront these strikingly symmetric structures with some fundamentally revised ideas about the final stages of a star's life," says Balick. "The lovely patterns of gas argue that some highly ordered and powerful process orchestrates the ways stars lose their mass, completely unlike an explosion."

A long-standing puzzle is how these nebulae acquire their complex shapes and symmetries. The red giant stars which preceded their formation should have ejected simple, spherical shells of gas. "Hubble's ability to see very fine structural details–usually blurred beyond recognition in ground-based images–enables us to look for clues to this puzzle," says Balick.

More Observations with Hubble Planned

Several teams of astronomers will be observing planetary nebulae using new infrared instruments installed on the Hubble telescope in February 1997. This way, astronomers can glimpse the ejection of material at a very early stage long before the expelled nebula starts to become visible optically. Given Hubble's high resolution, astronomers also hope to revisit the same nebula in a few years to actually see how the shell has further expanded into space. Their observations will be compared to predictions and either refine or dismiss current ideas on the mass ejection mechanisms of dying stars.

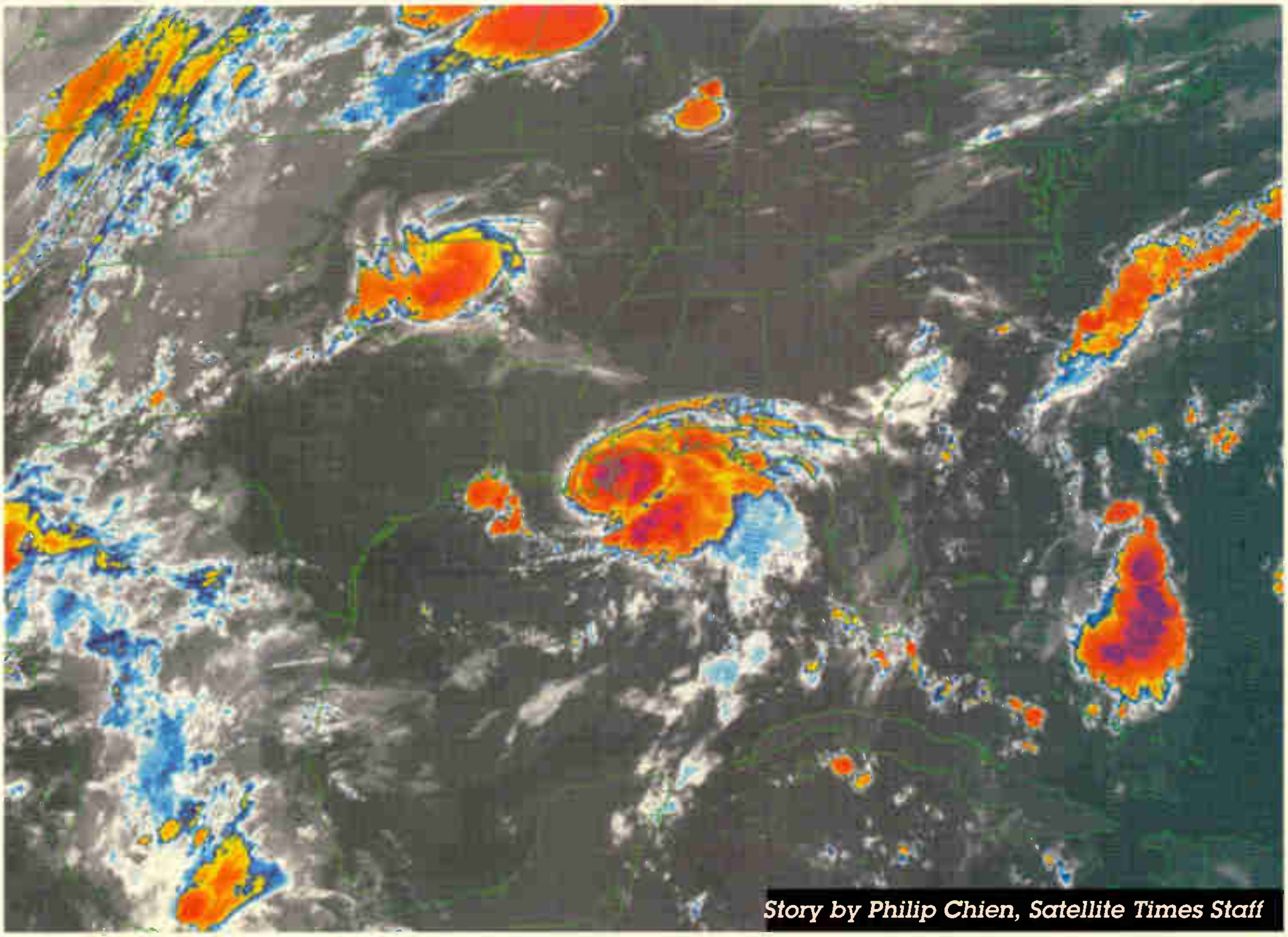
Won't Happen During a Human's Lifetime

If a few opportunistic people decide to videotape our own sun's cataclysmic event, they will be very disappointed. The sun's death will not be recorded during a human's lifetime. Its journey into retirement will take more than a billion years.

But these nebulae observed by Hubble gives us a preview of our own Sun's fate. Some five billion years from now, after the Sun has become a red giant and burned the Earth to a cinder, it will eject its own beautiful nebula and then just fade away.

ST

Story by the Satellite Times staff and the Space Telescope Science Institute.



CHEAP Weather Satellite Reception

The NOAA-12 polar orbiting, weather satellite passes over your northwest horizon while you're still asleep. Your computer is programmed to track this pass and at the correct time, turn on your personal home weather satellite intercept station.

A directional antenna on the roof rotates to follow NOAA-12 as it passes overhead.

While your receiver decodes the downlink signal, which sounds like a fax machine or computer modem, a tape recorder automatically turns on and records the satellite audio from your receiver.

Audio is also fed into a decoder box connected to your computer and a picture of what the satellite camera sees is saved to your computer's hard drive.

Finally, NOAA-12 sets below the southeast horizon while your receiver, tape recorder and computer automatically shut off to await another scheduled weather satellite pass. A couple of hours later, while having breakfast, you look at the satellite images which were saved on your computer. You are looking at an automatic picture transmission or APT image as commonly received by weather satellite enthusiasts worldwide.

The APT standard was developed based on existing facsimile standards. APT was developed to make the signal as simple as possible to receive and decode, and to permit low cost stations at local meteorological offices.

The first APT equipped satellite was TIROS-VIII, launched in December 1963. Within a couple of years of its launch, avid satellite experimenters received APT images with their own homebrew receivers built out of surplus military equipment. In the early days, receiving setups featured oscilloscopes, chart recorders, modified fax machines and other esoteric devices.

A typical setup consisted of an analog receiver which would drive an oscilloscope and generate blips of light. Since the format wasn't real-time you had to take a long exposure photograph of the scope's screen and develop the film before you could see whether or not you had successfully captured an image.

Polar orbiting APT satellites use VHF frequencies just above the civilian aircraft band. APT signals are transmitted at 120 lines per minute or half a second per line. An inexpensive VHF radio can monitor the NOAA satellites on 137.500 or 137.620 MHz; the Russian Meteor satellites on 137.300, 137.400 and 137.850 MHz; and the Chinese Feng Yun satellites on 137.795 MHz. The geosynchronous United States GOES satellites use the S-band around 1691 MHz.

Improvements in semiconductors and low noise amplifiers have made VHF radios extremely inexpensive. The power in today's home computers also makes it easy to decode weather satellite signals. If you have a PC with a VGA monitor and a VHF scanner you already have the hardware you need to receive and decode weather satellite images.

A weather satellite receiving station typically consists of four components: the antenna, a VHF radio, a demodulator (to decode audio signal into pictures) and a display unit. Optional components include a preamplifier to boost weak signals and a motorized antenna to track the satellite as it moves across the sky.

WEFAX image from GOES 9. This is a full disk image from our newest GOES satellite. (Photo courtesy of Chuck Vaughn, AA6G)

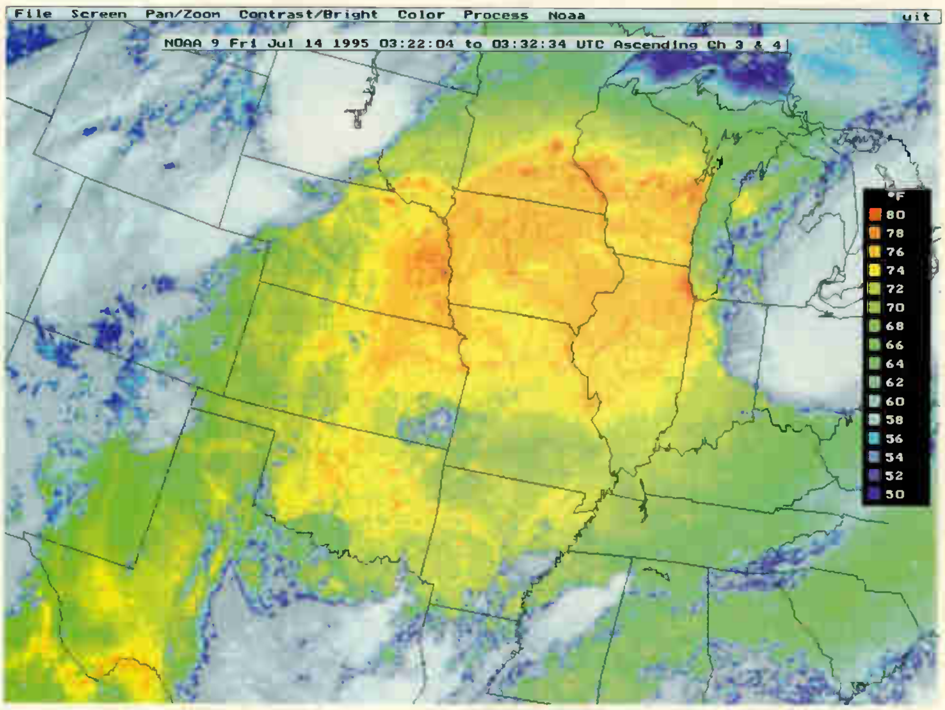
Most of the software and hardware available to decode weather satellite signals are designed to work with PC compatibles, but there is some software available for the Macintosh and other platforms.

Antennas for Weather Satellite Reception

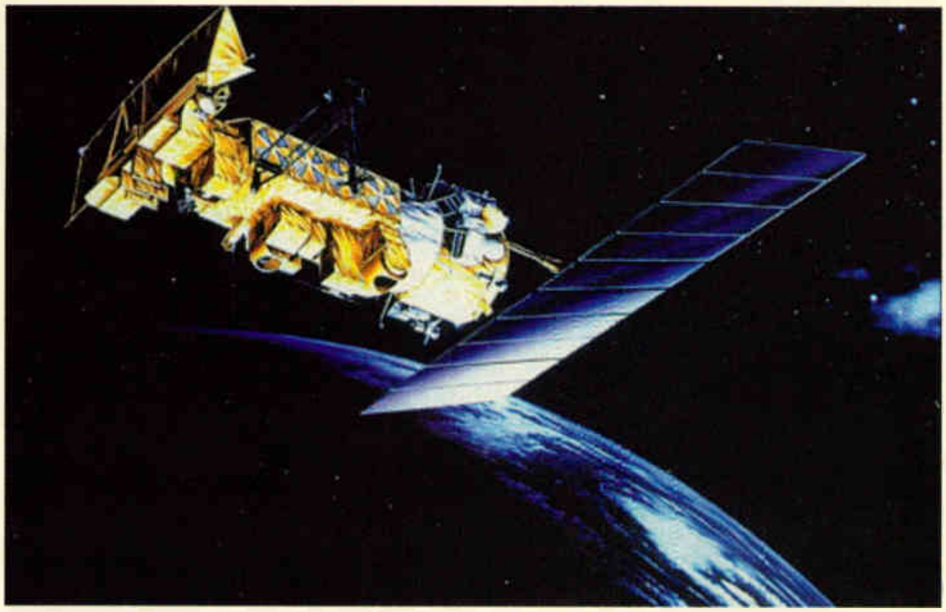
For various technical reasons most low and medium altitude satellite downlinks use circular polarized antennas. This "evens out" transmission levels caused by polarization shifts in the Earth's atmosphere. Weather satellites are no exception; U.S. NOAA spacecraft use right hand circular antennas and some of the Russian satellites use left hand polarization. If you use a linear polarized antenna, such as a simple dipole, the signal will fade in and out. A right hand circular is the most desirable choice.

Fairly simple omnidirectional antennas can be used with reasonable results. This is because the VHF transmitter is very powerful, permitting lower gain antenna. Start your experimentation with simple ground plane antennas, but remember that a higher gain antenna will give you better signal-to-noise in your images.

A very popular weather satellite receiving antenna is the turnstile. It is basically



Previous page: GOES 8 infrared image of Hurricane Danny in the Gulf of Mexico taken July 18, 1997. Above: The killer 1995 heatwave in the U.S. midwest is shown in this false color nighttime IR image taken by NOAA 9 on July 14 at about 9:30 p.m. local time. Temperatures as high as 80ºF are widespread across Illinois, Iowa and Wisconsin. (Photo courtesy of Chuck Vaughn, AA6G).



NOAA polar orbiting satellite in orbit.

two crisscrossed two-element Yagi antennas wired together to create a circular polarized pattern. Turnstile antennas can be purchased for about $50 to $100, or you can build one out of $20 worth of PVC and TV antenna wire. You can obtain a reprint of Ray Smith's portable turnstile article that appear in the July/August 1995 issue of *Satellite Times*, page 18, by contacting Grove Enterprises.

Another highly recommmended *Satellite Times* antenna article reprint you should have is Clem Small's *Antenna Primer for Satellite Reception* that appeared in the premier issue of *Satellite Times* (September/October 1994, page 80).

Other popular choices include eggbeaters and quadrifilars. The highest quality signal is obtained from a highly directional antenna like a multi-element Yagi with a motorized controller which will track the satellite as it goes across the sky. This is normally very expensive, but will give the best results of any of the previously discussed methods.

Remember that the antenna doesn't have to be perfect–you're only receiving–and it's much easier to receive than to transmit. If you already have 2-meter amateur radio antennas tuned to 145 MHz then you are in pretty good shape to monitor weather satellite signals around 137 MHz.

Equipment

An optional piece of equipment is a preamplifier. If your antenna isn't quite perfect or if your receiver isn't that sensitive, a preamp can make the difference between a barely discernible image and a high quality photo which rivals what you see on the evening news or in newspapers. A 137 MHz preamp should cost no more than US$70 assembled or US$35 for a kit. You can put the preamp in a waterproof weather-tight case at the antenna, or indoors by your radio. If you choose the latter you must use a good quality, low loss coax cable from the antenna to the preamp. If you mount the preamp at the antenna then your coax doesn't have to be as good.

The VHF receiver is one of the most important parts of your system, and the most difficult component to obtain. Most inexpensive (under US$100) VHF scanners and many extended range 2-meter amateur radios will receive the 137 MHz band. However, most of these VHF radios are designed with 15 kHz wide bandwidth. The APT signal standard uses a 40 kHz wide signal. An unmodified VHF radio will "chop out" portions of the signal you're trying to receive.

The obvious solution is to modify the radio for a wider bandwidth. Most VHF radios have a 10.7 MHz first intermediate frequency (IF) and a second IF at 455 kHz. If you replace these filters with 40 kHz wide filters you'll receive great APT pictures.

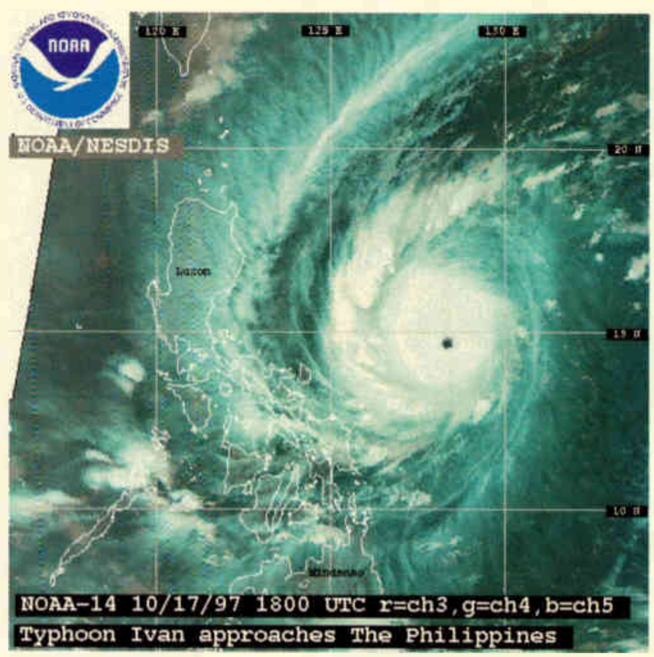
The big problem is finding wide filters. Many APT enthusiasts have reported good success by replacing 455 kHz filters in some scanners with a 0.01 mF capacitor. Check table two for some excellent Internet websites for radio modifications.

It cannot be overstressed that the bandwidth is critical. You can easily hear the distinctive clicks and carrier of the APT downlink on most radios, but you will end up with an unusable image unless you increase the radio's bandwidth. Several users have reported surprisingly good images with an unmodified Radio Shack Pro-43.

There are commercial radios specifically designed for weather satellite reception. They've been designed specifically for the weather satellite frequencies and bandwidth. Typically they're crystal controlled radios which can scan between the various weather satellite frequencies; you will need to purchase a different crystal for each frequency. The receiver is one place where a commercial radio designed specifically for APT reception makes sense.

The Weather Satellite Image Decoder

Commercial decoder units for weather satellite reception run about $200 to $500. These units are basically analog to digital converters which take the incoming audio signals and convert them into ones and zeros for your computer. Some units attach to your computer's parallel or serial port; others are cards which plug in to



Colorized Typhon Ivan approaching Phillipines, shot from NOAA-14.

your computer's bus.

A $30 computer sound card will also do a good job of decoding weather satellite signals with the appropriate software. Ad Lib's Soundblaster is the defacto audio standard for PC compatible computers, and there are a wide variety of other sound cards available from different manufacturers. You don't need anything fancy, just a plain, ordinary sound card with a microphone input.

I have not seen any commercial software for Soundblaster weather satellite reception. However, there are several shareware choices. FTV is an excellent DOS program written by Brian E. Cauchi, 9H1JS, and WXSAT is a Windows program from Christian Bock. The only Macintosh software available is the RadFAX 0.9 by Juri Munkki, but it's a generic FAX reception software and doesn't automatically configure itself for weather satellite reception.

There are a variety of inexpensive satellite tracking programs which will predict when the polar satellites are visible from your location. Some tracking programs can operate actuators which move to follow the satellite as it goes across your local horizon. Regrettably there isn't any combined satellite tracking/sound card fax reception program yet.

The careful reader will note that there's nothing terribly complicated in this setup.

In fact you can set up a completely portable APT station for use on camping trips or other situations where you're traveling to remote locations: Many laptop computers include audio input ports, a VHF scanner is a reasonably portable piece of equipment, and a turnstile antenna can easily break down into components which would fit in a small carrying bag (especially if you build our *ST* version mentioned earlier in this article).

Polar weather satellites are in relatively low altitude orbits. The relatively close distance reduces the size of your antenna, but the satellites can only be viewed for a short period of time, a maximum of 15 minutes per pass. Geostationary weather satellites can be continuously viewed, but a higher gain antenna, which is less portable antenna, is required. Meteorologists consider the polar satellites more suitable for long term predictions and GOES satellites more suitable for day-to-day forecasts. They're complementary and both are important tools for weather forecasters.

Getting GOES is a Bit Harder

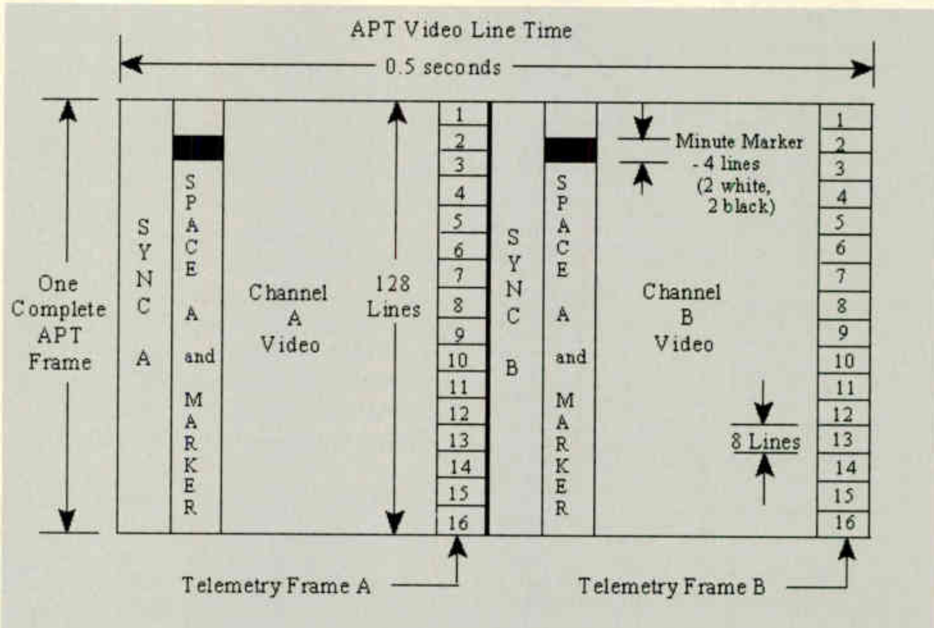
Receiving GOES WEFAX images is more difficult than the NOAA APT images for two reasons: the signal's coming from a much further distance and it's at a higher frequency.

The geostationary weather satellite downlink equivalent of APT is WEFAX. It was designed so existing APT users could easily upgrade to WEFAX reception. WEFAX is transmitted at 240 lines per minute, twice the APT rate. And while APT is primarily used for real-time transmissions of the satellite's signal, WEFAX is used for many purposes, such as retransmitting non-weather satellite images (e.g. radar information or weather charts). NOAA publishes a regular schedule of transmissions via the various WEFAX communications transponders. These schedules are run in *Satellite Times* magazine from time to time.

The most popular GOES antenna is a parabolic dish. An old junk C-band TVRO satellite dish is usually the least expensive solution–often available for the asking. Dishes as small as 2-3 feet have also been used successfully. It's also possible to piggyback a GOES receiver on an existing in-use C-band system. Just add a GOES feedhorn next to your C-band feedhorn.

The GOES feedhorn is small enough so it won't hurt your C-Band signal strength, and even though it's off axis it will still collect enough signal for good image recption. Program the two GOES satellites as additional positions on your satellite receiver. GOES-East is located at 75ºE near Galaxy 6 and GOES-West is located at 135ºW which is the same location as Satcom C4.

The definitive home-brew GOES feedhorn is an empty two pound coffee can. A hole is drilled into the can, then a small brass tube is soldered to an N connector and mounted on the can. The *Weather Satellite Handbook* (sold by Grove)



WEDGE #1 1	WEDGE #2 2	WEDGE #3 3	WEDGE #4 4	WEDGE #5 5	WEDGE #6 6	WEDGE #7 7	WEDGE #8 8
Zero Modulation Reference 9	Thermistor Temp. #1 10	Thermistor Temp. #2 11	Thermistor Temp. #3 12	Thermistor Temp. #4 13	Patch Temp. 14	Back Scan 15	Channel I.D. Wedge 16

Notes:
1) Each telemetry frames consists of 16 points
2) Telemetry frame rate is 1 frame per 84 seconds
3) Each telemetry point is repeated on 8 successive APT video lines

APT picture transmission format

includes the formulas for calculating where to drill the hole and how long to cut the tube. In most setups a weatherproof preamp-downverter unit is used to amplify the incoming signal and convert it from 1691 MHz to 137 MHz. Commercial GOES downverters are available for about $300. At the lower frequency inexpensive coax cable can be used to transmit the signal from the antenna to your receiving setup. It should be noted that the 137 MHz used by these downconverters was specifically chosen for compatibility with existing APT setups. From there the hardware and software are identical to a polar orbiting APT reception station.

If you choose to use a radio which can already receive 1691 MHz you will need an extremely low loss coax from your dish to your radio. Cheap coax such as RG-58, which is somewhat forgiving at 137 MHz, will absorb much of the WEFAX signal at 1691 MHz. Don't scrimp on coax at higher frequencies. Get the best you can afford.

Getting More Advanced

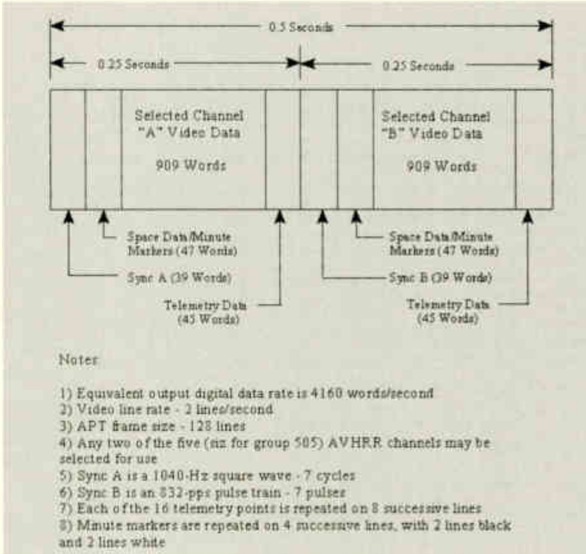
The APT/WEFAX downlinks are a small subset of the actual data generated by the polar orbiting and geostationary satellites. APT has a ground resolution of four kilometers and only has one or two channels generated by the satellite's advanced very high resolution radiometer (AVHRR) instrument. The AVHRR has a resolution of one kilometer and generates images in several visible and infrared frequencies. The different channels can be combined to create false-color images. Table one lists the frequencies for the AVHRR channels.

Some amateurs have developed the sophisticated tracking hardware to collect the high resolution picture transmission (HRPT) signals from the polar orbiting NOAA spacecraft. These setups require high bandwidth S-band dishes which can track the satellites as they orbit across the sky.

Besides the imaging instruments the

TABLE 1: AVHRR Frequencies

Channel 1:	0.58 - 0.68 microns / Visible
Channel 2:	0.725 - 1.10
Channel 3:	3.55 - 3.93
Channel 4:	10.3 - 11.3 microns / Longwave Infrared
Channel 5:	11.5 - 12.5



APT video line format

NOAA weather satellites also feature atmospheric sounders, instruments which measure the ozone layer, and instruments which measure "space weather." These instruments measure the particles and fields created by the Sun's interaction with the Earth's magnetic fields. In addition the satellites also have receivers which are used to collect data from small weather instruments in the field and animal tracking devices.

Operational Birds

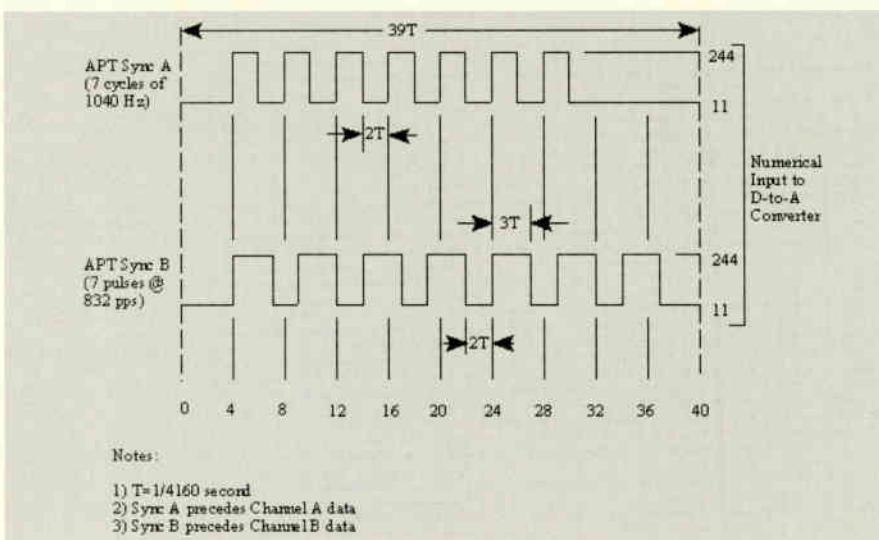
The current U.S. polar orbiting weather constellation consists of NOAA-12 (morning passes) and NOAA-14 (afternoon passes). This next spacecraft to be launched in this series is NOAA-K which is tentatively scheduled for launch in May. It will be named NOAA-15 after it reaches orbit and it will become the morning satellite to replace the aging NOAA-12.

The Global Atmospheric Research Program (GARP) is an international project to provide continuous meteorological coverage of the entire Earth. The United States, European Space Agency, Russia and Japan have agreed to launch their own geostationary weather satellites and share the data for scientific purposes as well as weather forecasting.

Eumetsat operates Meteosat at 0º; the Russian Geostationary Operational Meteorological Satellite (GOMS) is located at 77º East; and the Japanese GMS satellite is at 140º East. Russia was the last GARP partner to put up a geostationary satellite. GOMS was launched in October 1994 and it completed the five satellite constellation.

Until the Russian GOMS was in place some data was given to GARP by India's INSAT payloads. However, India was very specific that the data could only be used for scientific purposes and could not be used to provide day-to-day weather forecasts, especially to rival neighbor Pakistan.

The Department of Defense and NOAA are now in the process of merging the DoD Defense Meteorological Satellite Program (DMSP) and NOAA polar programs into one for budgetary reasons. They've always had overlapping capabilities and it's felt that a combined system will be able to serve all of the users at a much lower cost to the taxpayer. In addition Europe is joining the low altitude weather satellite club with its METOP-1 satellite scheduled for launch in 2002. ST



APT synchronization details

EMWIN

Emergency Managers Weather Information Network

As an integral part of its mission, the National Weather Service (NWS) provides the emergency management community with access to basic NWS warnings, watches, forecasts and other products at no cost.

EMWIN, the Emergency Managers Weather Information Network, is now evolving into a fully operational and supported NWS service in partnership with the Federal Emergency Management Agency (FEMA) and other public and private organizations.

EMWIN makes available a live datastream of basic weather data, and provides access to stored sets of basic unenhanced data, using a variety of techniques and technologies. Each method has advantages and disadvantages over the others; hence this multilayered approach to enable multiple methods of availability.

EMWIN's present methods in use or under development for disseminating the basic datastream include:

- Radio–formerly called the Wireless Weather Information Network (WWIN) technical information

- Internet–the Interactive Weather Information Network (IWIN) technical information online Graphics version at **http://iwin.nws.noaa.gov/iwin/graphicsversion/main.html** (for Netscape viewers, etc., that support tables and in-line graphics) and online text-only version at **http://iwin.nws.noaa.gov/iwin/textversion/main.html** (for slow links or non-enhanced viewers).

- Satellite–currently on GOES 8, GOES 9 and Galaxy 4

The EMWIN broadcasts on GOES 8 and GOES 9 satellites are courtesy of NESDIS (NOAA's National Environmental Satellite, Data and Information Service). GOES 8 is at 75 degrees West, elevation 45 degrees (from the latitude of Washington, D.C.). GOES 9 is at 135 degrees West.

The initial test for interference with WEFAX was done in March 1996, and an extended test of EMWIN reception was done in April/May 1996. The GOES broadcasts will continue on a permanent basis. Higher speed broadcasts are being tested.

The NWS GOES downlink frequency used for the 1200 baud EMWIN datastream is 1690.6 MHz, 400 kHz lower than the standard WEFAX 1691.0 MHz signal. The signal is 5 dB weaker than the GOES WEFAX downlink, but can be received with various sized dishes or even a single-array yagi system. The signal is passed through a downconverter, received as if a radio signal at 137.1 MHz, for example, and then demodulated to 1200 baud. The hardware cost is now not much more than the cost of VHF radio reception.

The EMWIN data is also currently uplinked to the Galaxy 4 satellite by Spacecom Systems of Tulsa, Oklahoma, as a public service. Galaxy 4 is at 99 degrees W: Ku-band, Transponder 4, FM-FM, DFSK, .5425 MHz subcarrier.

Satellite Times will have more on EMWIN in a future issue. In the meantime if you have questions or comments send e-mail to **Kenneth.Bashford@noaa.gov.** Snail mail requests should be sent to: Kenneth Bashford, NWS EMWIN Project Coordinator, National Weather Service, W/OSO13, 1325 East-West Highway, SSMC2, #16358, Silver Spring, Maryland 20910. You will also find extensive information on the worldwide web at: **http://www.nws.noaa.gov/oso/oso1/oso12/document/emwin.htm** ST

UNDER CONSTRUCTION:

The KD2BD 9600 Baud Modem

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

The KD2BD 9600 baud modem is a low-cost, high-performance 9600 bit per second FSK (Frequency Shift Keying) modem designed to interface between a standard packet radio terminal node controller (TNC) and an FM voice transmitter and receiver. The modem uses commonly available components, allows full-duplex access to the 9600 baud digital communication satellites,

and is suitable not only for digital satellite communications, but for terrestrial packet radio communications as well.

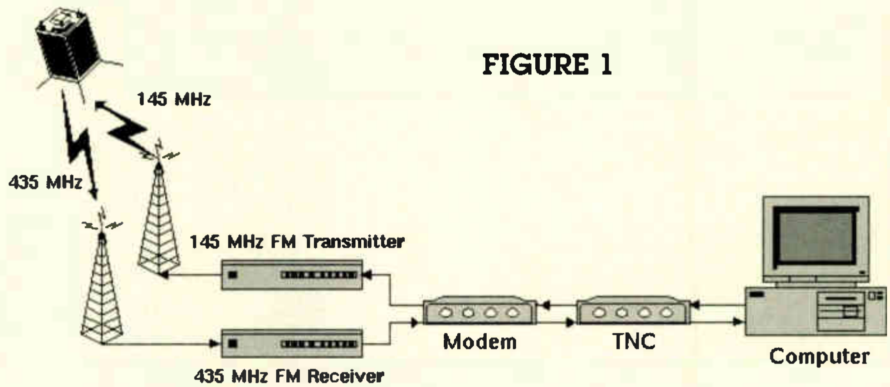
The KD2BD 9600 Baud Modem went from conception to reality in just seven days. It uses some of the time-proven signal processing techniques used in the 1200 Baud KD2BD Pacsat Modem developed several years ago, and should be of interest to amateurs wishing to add 9600 baud digital communication capabilities to their satellite or terrestrial packet radio stations.

Design Goals

The KD2BD 9600 baud Pacsat modem was designed with several important design goals in mind. First, it was designed to use commonly available components and not rely on special EPROMS for transmit waveform synthesis or bit clock detection to allow easy, inexpensive, and uncomplicated duplication.

Secondly, since it has been shown that even randomized 9600 baud baseband data contains a DC component that is ignored in other 9600 baud modem designs, DC coupling is used throughout the modulator and demodulator sections of the KD2BD 9600 baud modem for optimum performance. And lastly, the design is essentially uncomplicated, allowing an understanding and appreciation of its operation by both veteran OSCAR users and beginners alike.

FIGURE 1



Block diagram of a typical Pacsat groundstation. Digital uplinks are carried out on the 2-meter VHF band, while downlink transmissions are received on the 70-cm UHF band, producing a full-duplex virtual connection with the satellite.

9600 Baud Communications

Before getting into the details of this particular modem design, it is helpful to look back to the beginning of amateur packet radio communications to have an understanding of the events and logic that led to the protocol standards used today in 9600 baud digital communications.

When AX.25 protocol amateur packet radio communications first began in the early 1980s, early experimenters used Bell-202 type audio frequency shift keying (AFSK) telephone modems to pass packet binary data over the air using voice-grade VHF narrowband FM transceivers. Bell-202 modems were selected not for technical or performance reasons, but because of their wide availability at the time on the surplus market. A data rate of 1200 bits per second was used, which was four times faster than what telephone modems were capable of at the time, and was many times faster than the fastest amateur radio radioteletype (RTTY) communications.

Although Bell-202 modems were originally designed for 300 bit per second data communications over telephone lines, they were found to function satisfactorily for half-duplex radio work at four times their design speed.

When terminal node controllers made their appearance on the commercial market, they included internal Bell-202 AFSK modems for communications at 1200 bit per second as standard equipment. This was done for compatibility with the early standards set by the packet experimenters, and because the Bell-202 AFSK modem protocol was proven to work satisfactorily for packet communications. Unfortunately, the trend caught on, and while the transmission rate of telephone modems soared from 300 bits per second to 56 kilobits per second, packet radio communications stagnated at just 1200 bits per second, causing many hams to turn away from wireless digital communications in favor of landline-based (Internet) communications.

While some vendors offered packet radio TNCs with 2400 bit per second capabilities, few people purchased them for fear of being incompatible with the rest of the packet community. Before 9600 bps digital satellites came into play, the only people who got involved with higher data rates were those enterprising individuals who developed high speed packet radio "backbone" networks on UHF frequencies. Unfortunately, few end users got the chance to experience high-speed packet radio communications first hand, and directly witness the significant improvement that could be made over a "standard" TNC with an internal Bell-202 modem.

The Bell-202 AFSK modem standard that is still widely used for the majority of 1200 bit per second VHF-FM packet radio communications uses audio tones of 1200 Hz and 2200 Hz to represent the binary '1's and '0's of packet radio's HDLC baseband serial data. The use of an audio frequency shift keying protocol allows binary data to pass over an AC-coupled voice grade communications link. The method works, but it's not without its problems. It occupies a lot of bandwidth–so much so that it is possible to pass data at 9600 bits per second in slightly less bandwidth if a different modem and RF Frequency Shift Keying (FSK) modulation are used.

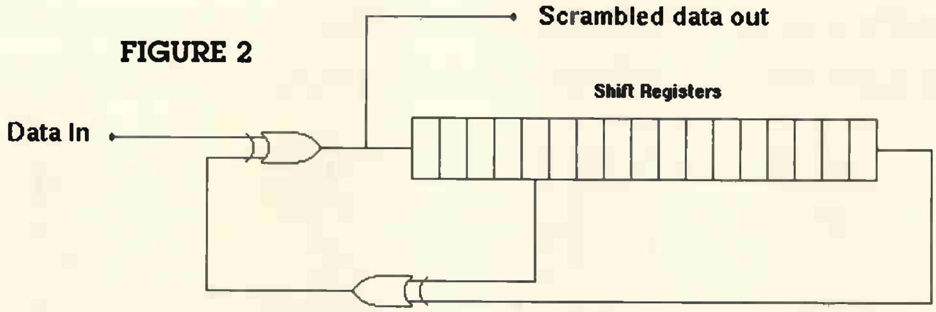
At 9600 bits per second, it is not possible to convert the '1's and '0's of a serial binary data stream into audio tones for application to an FM voice transmitter and remain within legal RF bandwidth limitations. The use of AFSK at 9600 bits per second would also exceed the bandwidth limitations of voice-grade communications equipment. Instead, 9600 bit per second baseband data is used to directly frequency modulate the RF carrier of the transmitter.

Early Experiments

When early high-speed packet radio communications experiments were conducted on VHF frequencies over a decade ago, Steve Goode, K9NG, found that directly modulating an FM transmitter with transmit data generated by a packet radio terminal node controller was not a very effective way of transmitting high-speed data.

To begin with, the square waveshape of the TTL-level data generated by the TNC is rich in harmonics and would occupy a very wide bandwidth if used to directly modulate an RF carrier. Steve found that passing the transmit data stream through a multi-section low-pass filter was an effective way of reducing the bandwidth of the transmitted signal to the minimum required for effective communications. The smaller bandwidth also reduces the chances of causing interference to adjacent channel users, and allows the signal to pass through the IF filters of standard narrowband FM voice receivers without excessive phase distortion.

FIGURE 2



Block diagram illustrating the scrambler circuitry used in 9600 baud amateur communications. This particular design is based on the use of shift registers and exclusive-OR gates.

Steve also realized that the unsymmetrical waveshape of AX.25 baseband data carried a significant DC component that needed to pass without distortion through the RF communications link between transmitter and receiver.

In theory, this is not difficult. In reality, however, the frequency stability of commonly available narrowband VHF-FM communications equipment was found to be rarely high enough to pass a DC-referenced digital signal without significant bias distortion. Something needed to be done to reduce the DC component level of the signal in such a way that would not increase its bandwidth.

Steve tackled this problem by passing all transmitted data through a scrambling or randomization circuit prior to transmission and unscrambling received data to restore the signal back to normal. The scrambler randomized the data transmitted data pattern, thereby minimizing the chances of transmitting long runs of '1's or '0's or repetitious patterns containing significant low frequency energy.

Randomizing techniques are typically identified by the scrambling polynomial they synthesize. Steve's circuit was based on a 17-bit maximal length linear feedback shift register (LFSR). A total of eight different maximal length randomizing techniques can be employed using a single tap 17-bit shift register.

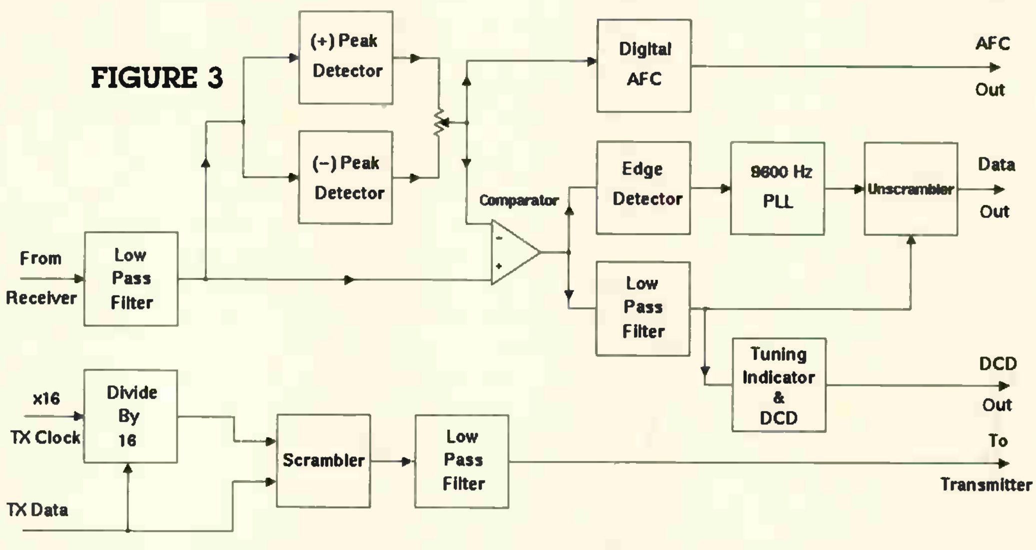
The technique Steve chose has become the standard for 9600 bit per second digital communications, and is authorized by the Federal Communications Commission for amateur use. The technique produces a pseudo-random data sequence of bits that repeats after 131,071 clock pulses, or every 13.65 seconds at 9600 bits per second. A maximum of 17 ones or 16 zeros can occur in a row with this method of scrambling.

Figure 2 illustrates the design of the type of data randomizer used in amateur communications.

Circuit Overview

Figure 3 shows a block diagram of the KD2BD 9600 baud Pacsat modem. The modem consists of a data modulator and

FIGURE 3



Block diagram of the KD2BD 9600 baud modem. Both receive and transmit sections function independently of one another allowing full-duplex communications with Pacsat satellites.

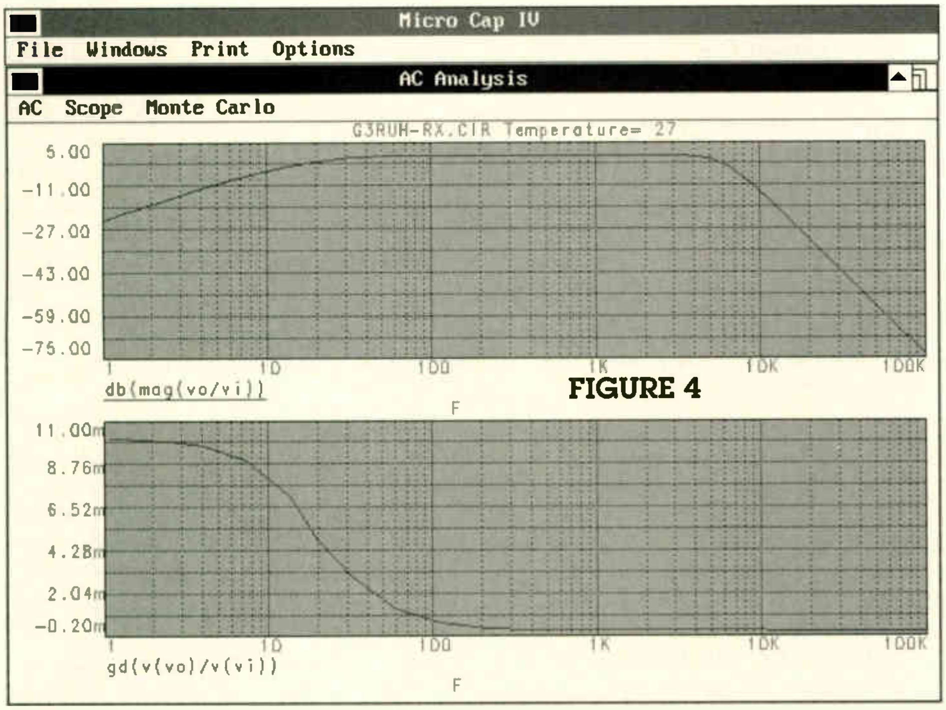


FIGURE 4

Simulated performance of the receive filter used in the G3RUH 9600 Baud Modem. In this figure, voltage gain and group delay characteristics are both plotted as a function of frequency. This filter exhibits uneven frequency response and excessive group delay distortion below 400 Hz.

demodulator that act independently of one another. This mutual exclusion allows the modem to be used for full-duplex satellite communications as well as half-duplex (simplex) terrestrial communications.

The modulator portion of the modem is very simple. It takes transmit data (TXD) and clock signals (TXCLK) from the host TNC, applies them to a 17-bit linear feedback shift register scrambler, and filters the resultant through a 6th order low-pass filter. This technique produces an exceptionally clean raised cosine waveshape that is suitable for direct connection to the modulator of an FM voice transmitter.

The demodulator portion of the modem is a bit more complicated. The demodulator connects to the detector of a narrowband FM voice receiver, and gently filters the received signal through a second low-pass filter. The purpose of the filter is remove any residual 455 kHz IF (Intermediate Frequency) noise that may be present on the demodulated signal. The filtered signal is then fed to a pair of precision peak voltage detectors that are used to measure the maximum positive and negative voltage excursions of the input waveform. The average of the peak excursions represents the voltage midpoint of the received waveshape regardless of any DC offset present on the received signal, and is used as a reference in a data slicer and a digital automatic frequency control (AFC) circuit. The data slicer is used to convert the received signal to a square waveshape for later processing in digital logic circuits. The digital AFC is used to slowly tune the receiver lower in frequency in compensation for Doppler shift when receiving signals from satellites in low earth orbit.

The processed signal is then diverted into two different directions. The first direction takes it through a bit clock regenerator, and the second takes it through an unscrambler and then out to the host TNC for packet disassembly.

Bit clock regeneration is performed in a very uncomplicated manner. The filtered and processed received signal is applied to an edge detector designed around an exclusive-OR (XOR) gate and an RC delay network. The edge detector produces a short output pulse each time the waveform of the received signal passes through its voltage midpoint. The waveform produced by the edge detector is known as a protoclock, and is in phase with the clock of the received signal. Unfortunately, the waveform produced is non continuous, so it is processed through a phase locked loop (PLL) circuit. The phase locked loop operates at the bit rate of the incoming signal (9600 Hz), and rapidly locks its oscillator to the average phase of the protoclock, thereby generating a continuous, noise-free clock suitable for further processing of the received signal.

The received signal is also passed through a fifth-order low-pass filter. The filter serves two purposes. First, it attenuates any remaining noise present on the received signal, and secondly, it delays the incoming signal long enough so that the center of each received bit is concurrent with the rising edge of the regenerated clock waveform. This delay is necessary because the unscrambler is triggered on the rising edge of the regenerated clock signal rather than the center of each clock pulse. The filtered signal is then applied along with the regenerated clock to the unscrambler, the output of which is converted to TTL levels and made available to the host TNC for final processing.

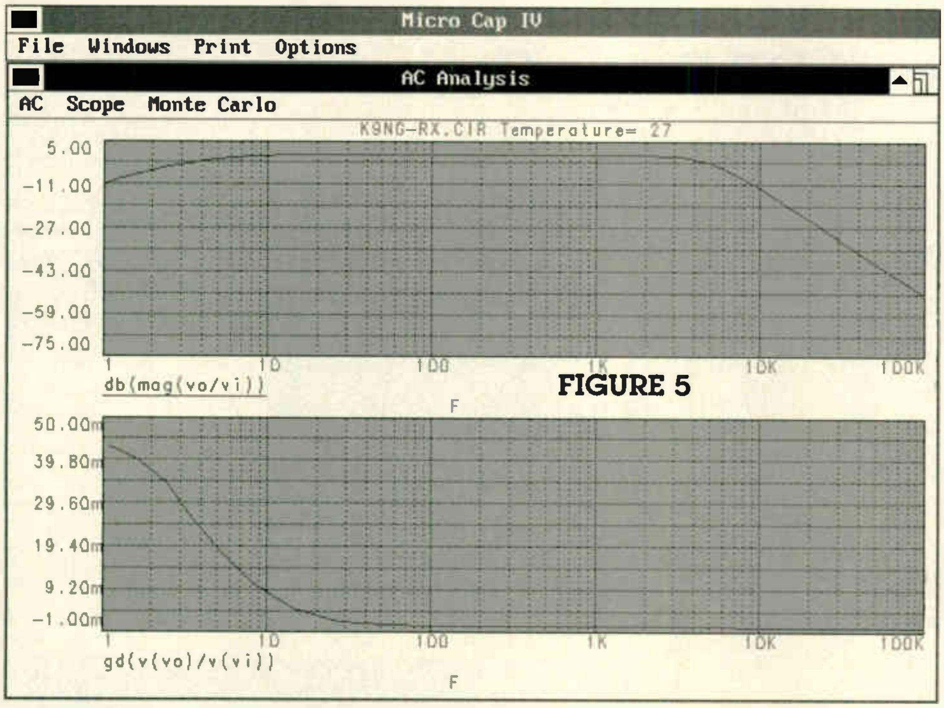
Filter Design

The low-pass filters used to remove noise from the received signal and properly shape the waveform of the transmitted signal play a critical role in the overall performance of the KD2BD 9600 Baud Modem. Considerable time and effort was spent in testing and optimizing these filters to adequately process the received and transmitted waveforms without introducing undesirable products, such as phase distortion. The filters need to have a flat frequency response up to their cutoff frequency, and must also exhibit a flat group delay characteristic.

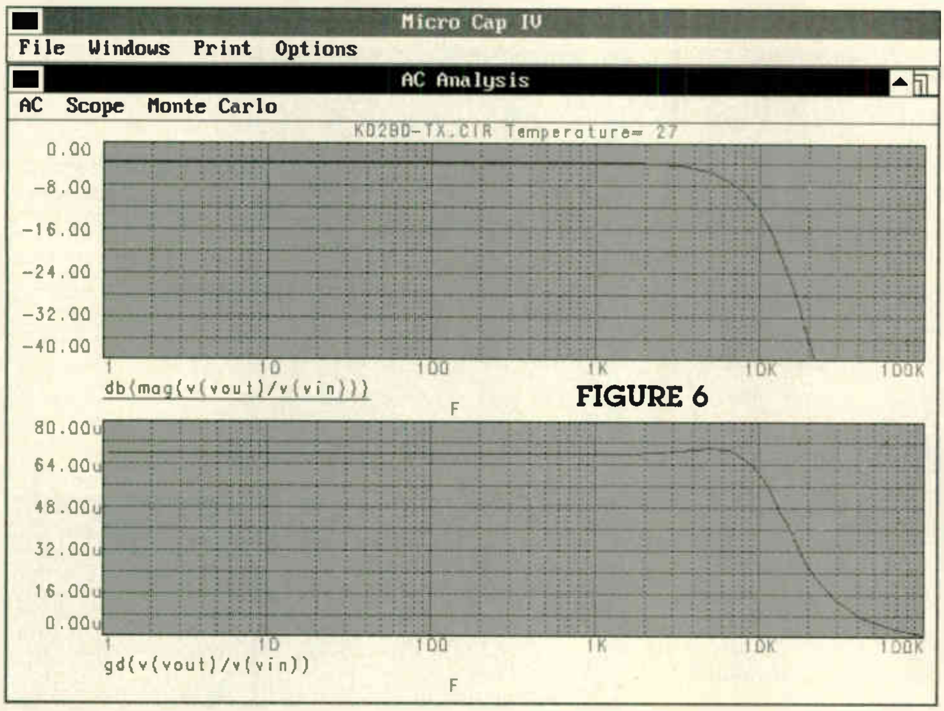
Uneven frequency response causes an unfair bias either toward or away certain bit pattern sequences, while uneven group delay causes the filtered waveform to undergo uneven propagation time depending on the frequency of the signal being passed through the filter. In terms of data communications, uneven group delay produces phases jitter which causes bit zero crossing point instability, making receiver bit clock detection and extraction difficult and less reliable.

Figure 4 shows the frequency response and group delay characteristics of the receive filter used in the G3RUH 9600 Baud Modem (Issue 3) as simulated using MicroCAP IV circuit analysis software. Notice the uneven low frequency response and the excessive group delay distortion below 400 Hz. While the purpose of the receive filter is to gently remove IF noise from the received signal, the analysis suggests that the G3RUH receive filter may actually do more harm than good to the incoming signal. On the transmit side, the

G3RUH Modem uses a Transversal or Finite Impulse Response (FIR) filter to tailor the transmit waveshape to compensate for distortions present in the IF filters typically used in commonly available FM receivers.



Simulated performance of the receive filter used in the K9NG/TAPR 9600 baud modem. In this figure, voltage gain and group delay characteristics are both plotted as a function of frequency. While better than the G3RUH filter, the K9NG/TAPR filter simulation shows low frequency roll-off and group delay distortion.



Simulated performance of the transmit waveform shaping filter used in the KD2BD 9600 Baud Modem. This graph plots voltage gain and group delay as a function of frequency. Notice that both plots show exceptionally flat response across the entire frequency range of operation, providing superb modulator performance.

Figure 5 shows the simulated frequency response and group delay characteristics of the receive filters used in the TAPR/K9NG 9600 Baud Modem designed in August 1985. The TAPR/K9NG filters offer a much flatter frequency response, but the receive filter is still a bit narrow, and suffers from some low frequency roll-off and group delay distortion.

Figure 6 shows the simulated frequency response and group delay characteristics of the transmit filters used in the KD2BD 9600 Baud Modem. The extremely flat frequency response and constant group delay characteristics of these filters produce an exceptionally clean raised-cosine transmit waveform and introduce virtually no distortion to the received signal. These filters were actually designed by empirically selecting component values that produced the cleanest waveform patterns as viewed on an oscilloscope. It was only after the filters were designed and the modem constructed that the computer simulations were run, effectively confirming their performance and characteristics.

To Be Continued

In the second part of this article, circuit details of the KD2BD 9600 Baud Modem will be discussed, schematics will be provided, and interface issues will be tackled. In the meantime, additional information regarding the digital modulation formats used for amateur satellite communications can be found in the *Amateur Satellites* column of the January/February 1997 issue of *Satellite Times* magazine. ST

By Lawrence Harris
lawrenceh@ndirect.co.uk

Meteor APT Edge Codes

As *Satellite Times*' newest columnist, I welcome the move by Grove Enterprises to take *ST* monthly. I have found that when writing about events taking place in the weather satellite world, such as the ever-changing seasonal effects (perhaps seen for the first time by new readers), and with the changing face of the technology, there is usually a wide choice of topics that can be covered on a monthly basis.

In this month's column we will discuss the edge code that appears on Meteor APT pictures, the fire-fighters of Australia, and pictures from Fengyun-2B–the Chinese weather satellite.

If you have an internet connection and want to contact me, note my new email address: **lawrenceh@peverell.demon.co.uk.** My web pages are moving to URL: **http://www.peverell.demon.co.uk**. I welcome any correspondence and can handle images attached to e-mails. In fact, three such images from Australia are included in the column this month.

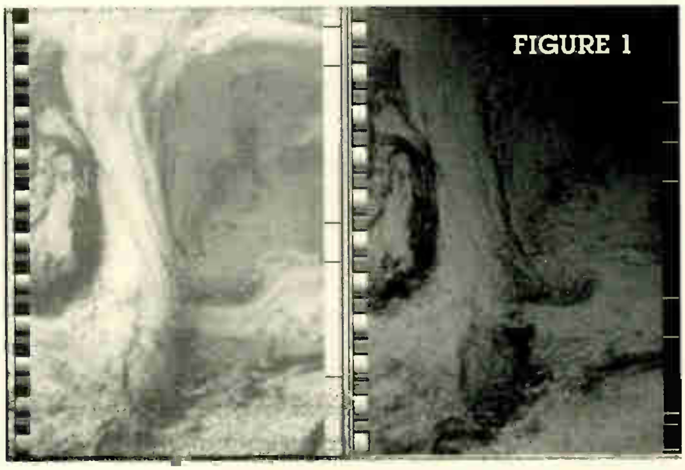


Fig. 1: 14 December 16 at 1439UTC from Plymouth, UK

Fig. 2: Meteor 3-5 on December 8 at 1554UTC

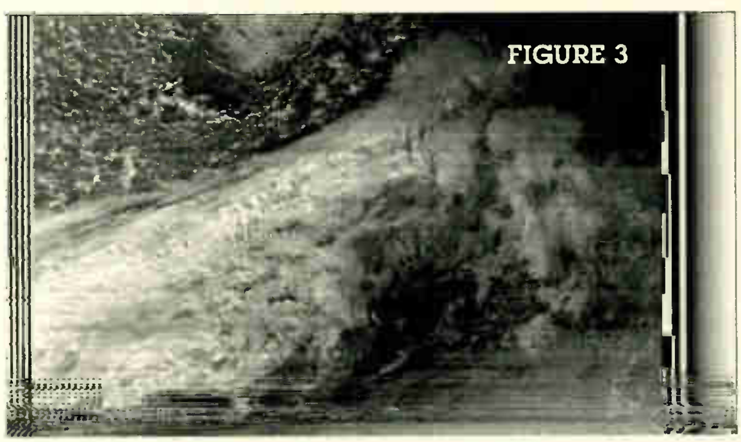


Fig. 3: Meteor 3-5 on December 11 at 1501UTC

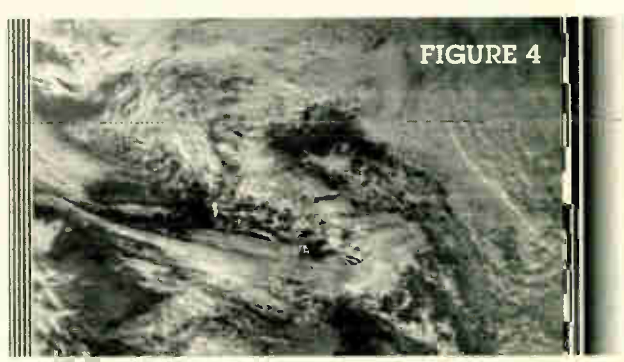


Fig. 4: Meteor 3-5 on December 15 at 1348UTC

NOAA and Meteor Solstice Views

At the time of the December solstice, the sun reaches its most southerly point, giving minimal illumination to the northern hemisphere during the hours of daylight. The orbital planes of the NOAA weather satellites maintain a (nominally) fixed angle to the sun–they are sun-synchronous.

The effect of this is that they always pass over any particular location (for example Plymouth, UK, where I live), at about the same time each day. Figure 1 shows the APT image from NOAA-14 passing over Britain just a few days before the solstice–and therefore experiencing the darkest (visible-light) images of the year. For this image I used my backup crossed-dipole antenna, which is mounted on a low-level clothes line (with permission from my wife).

My main antenna is roof-mounted at the high level of a three-floor house. Our weather comes straight off the Atlantic and the effect of salt water on the cable and

At the time of the December solstice, the sun reaches its most southerly point, giving minimal illumination to the northern hemisphere during the hours of daylight. The orbital planes of the NOAA weather satellites maintain a (nominally) fixed angle to the sun–they are sun-synchronous.

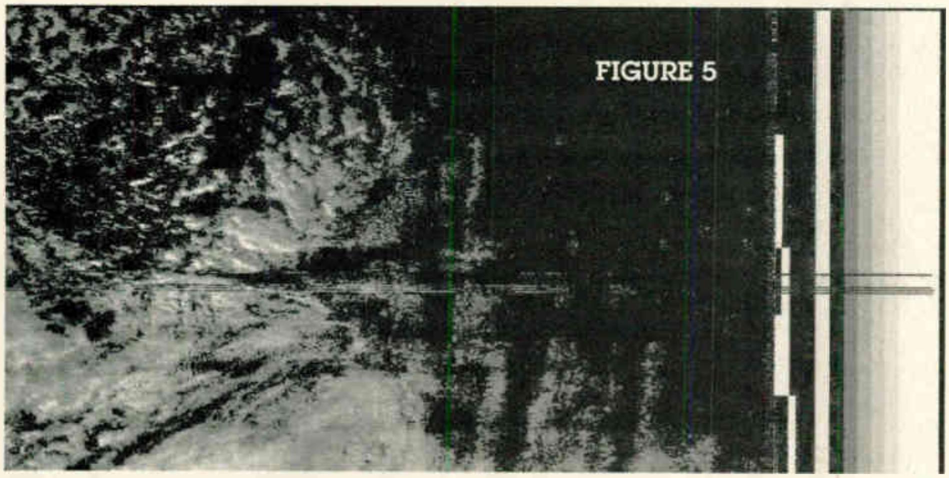


Fig 5: close-up of Meteor edge code (from fig 2 left)

connectors is considerable–despite their high level of protection. The signal from this antenna has degraded considerably during the last year and I haven't arranged for it to be swapped with the other antenna. Being at a low height, the second antenna can only monitor satellites which are well above the horizon. Consequently figure 1 does not show the switch-over of the visible-light channel to infra-red, which occurs before the satellite has set below the northern horizon.

With both NOAA-12 and 14 providing routinely high quality APT images, I have found it particularly interesting to watch the emergence of Meteor 3-5 into daytime sunshine in the northern hemisphere. The orbital planes of the Meteors slowly rotate around the earth such that the solar illumination varies each time they pass. This is illustrated by figures 2, 3 and 4, transmitted by Meteor 3-5 while passing northwards over the UK and experiencing differing levels of solar illumination.

In figure 2, Meteor 3-5 rises above the United Kingdom horizon (hence the initial noise level), and quickly shows extensive darkness (the upper right area) as the satellite approaches the polar region late in the UK afternoon at an angle to the terminator. Figure 3 demonstrates that just three days later, the satellite's orbit has drifted forward and is passing the UK a little earlier in the day, and therefore approaching the terminator less obliquely. By December 15 the orbit now reaches the dark polar regions more directly, as seen in figure 4.

Meteor Edge Code

Many years ago the content of Meteor weather satellite APT was carefully studied by members of the Kettering group. Kettering is a town in the UK, where Sir Geoffrey Perry, a member of the staff of a local school, was taking a close interest in the transmissions from a number of Soviet satellites, including the Meteors. He established the significance of what came to be known as the Meteor "edge code"–the sequence of black-and-white bars shown in figure 5.

There are six bars and each can be considered to represent binary "1" when black and "0" when white. Just before the satellite enters darkness, the aperture is wide open as indicated by the binary number 111111. Within a few seconds of this indication the transmission from the satellite ceases.

At the other extreme of illumination over bright desert sands, the aperture may be reduced to the minimum level, indicated by a solid white bar (all six bars set to zero). The effect of reducing sunlight on the landscape below the weather satellite can be observed prior to the cessation of APT as a sequential change (increment) in the binary numbers. In figure 5, the sequence ends as follows:

111111 (followed by transmission cut-off)
011111
101111
001111
110111
and earlier numbers (not shown).

These numbers correlate with the im-

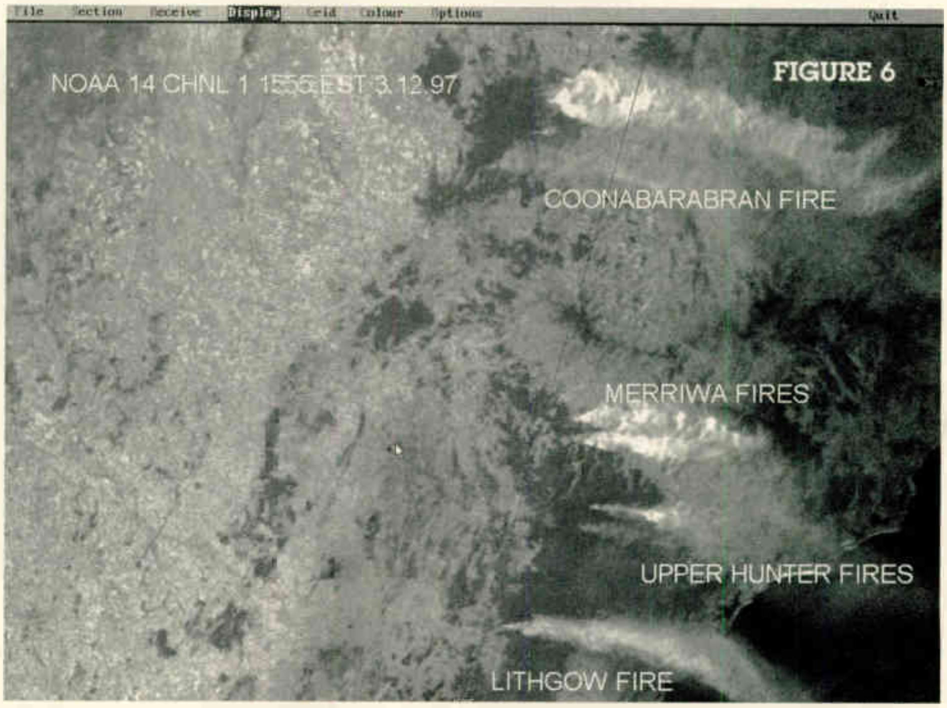


Fig. 6: NOAA-14 channel 1 image from December 3 from Arthur Andrews.

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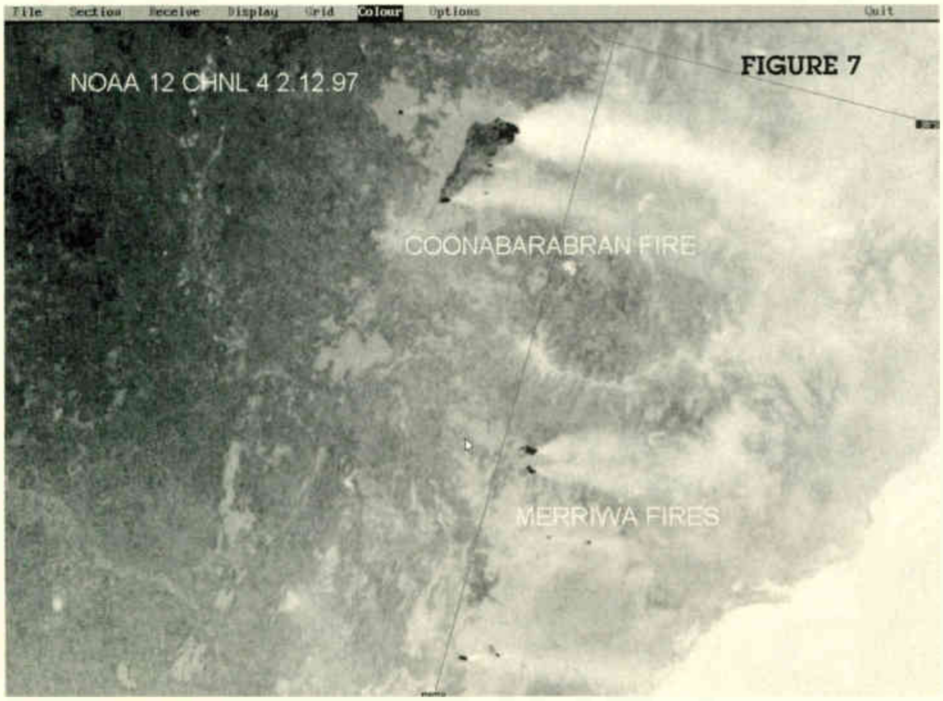


Fig 7: NOAA 14 channel 4 image from December 2 from Arthur Andrews

age edge code, as read from the bottom upwards towards transmission cut-off.

Further details of this and other original work done by members of the Kettering group have been published in earlier editions of the UK's Remote Imaging Group's quarterly magazine (and other publications).

The group went on to make investigations of other aspects of the Soviet satellite program –but that is perhaps for a future column!

Australian fire-fighters use NOAA images

Satellite imagery has never been more important than for those whose lives or property may depend on timely information. The recent Australian bush fires were vast and their progress was monitored by those Australians with access to imaging equipment.

One of those who took a keen interest was Arthur Andrews, who has a high resolution picture telemetry (HRPT) system built by Timestep (a UK company which is represented in America by Spectrum International).

The pictures in figures 6 and 7 show the effect of a change of frequency band. Figure 6 is a channel 1 image. NOAA-14's channel 1 sensor includes that portion of the spectrum between 0.58 to 0.68 microns (micro-meters)–the visible-light portion. Figure 7 is a channel 4 image of the Coonabarabran and Merriwa fires. The channel 4 sensor covers 10.50 to 11.50 microns–thermal infrared.

Arthur writes that using either channel 3 or 4, fires can be spotted which are sometimes not apparent in the visible light spectrum. The full extent of the Coonabarabran fire can be seen with infrared and the area accurately measured. Note that a small fire, top left of the Coona fire, is burning in an isolated area and cannot be seen in visible light. Latitude, longitude, bearing and distance of the fires can be calculated using the Timestep NRPT software.

The white mouse arrow (near lower center left) indicates the position of Arthur's farm. Due to the extremely hot weather, (over 40ºC for five days running,) Arthur's low-noise amplifier became unstable just when it was needed for fire watching, so he contacted Timestep and received a new one which arrived within a few days. Meanwhile, the continuation of the three-year drought means that the possibility of extreme fire danger will extend through March.

FENGYUN-2B operations

The first Chinese geostationary weather satellite–Fengyun-2B–was launched on June

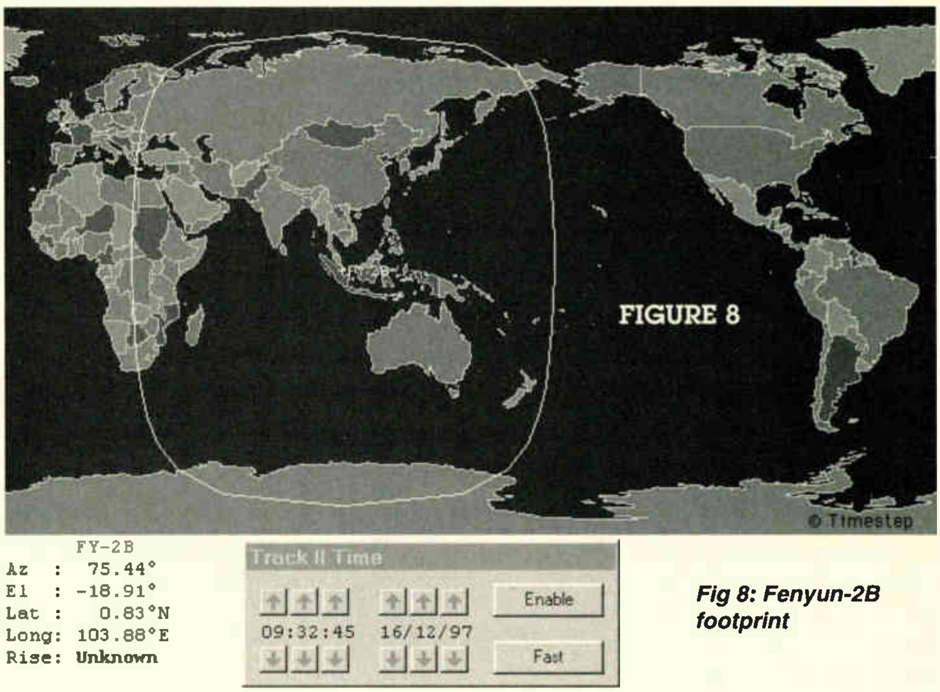


Fig 8: Fenyun-2B footprint

NOAA weather satellites transmit different types of data on 137.50, 137.62, 1698.0 and 1707.0 MHz, and they also transmit beacon telemetry on 136.77 MHz (NOAA-12) and 137.77 MHz (NOAA-14). NOAA-11 is currently not transmitting APT data, but it does periodically use its beacon (137.77 MHz) under command.

10, 1997, and is located at longitude 105ºEast. Figure 8 shows the satellite transmission footprint and, as can be seen, transmissions cannot be received from the United States or Britain.

To find out how commissioning has been progressing I have been monitoring the following web pages:

http://www.cma.gov.cn/
http://www.cma.gov.cn/fy2/fy2.htm
http://edcwww.cr.usgs.gov/china/china.htm

It appears that none of these pages has been updated with FY-2B information since the first official image was displayed some months ago. Fortunately, using the Internet, I was able to contact two people who live in Australia, both of whom have been monitoring many of FY-2B's transmissions. Arthur Andrews mentioned previously and Mike Kenny, who works in Satellite Engineering Division at the Bureau of Meteorology in Melbourne.

Mike has sent an image transmitted by FY-2B. It is a low-resolution, infrared WEFAX polar stereographic projection of China taken on December 3, 1997, at 1502 UTC and transmitted at 1532 UTC. It shows the sector E format.

Low resolution WEFAX (LR-FAX) is transmitted from FY-2B on 1691.0 MHz (the standard frequency for geostationary WEFAX transmissions). Mike reports that LR-FAX transmissions occur every half-hour, except during ranging (geostationary distance monitoring and adjustment) and some other operations. Mike mentioned that the dots in the whites are an artifact of the GIF encoding process at his end, and he reports that sector E formats are transmitted nearly every hour.

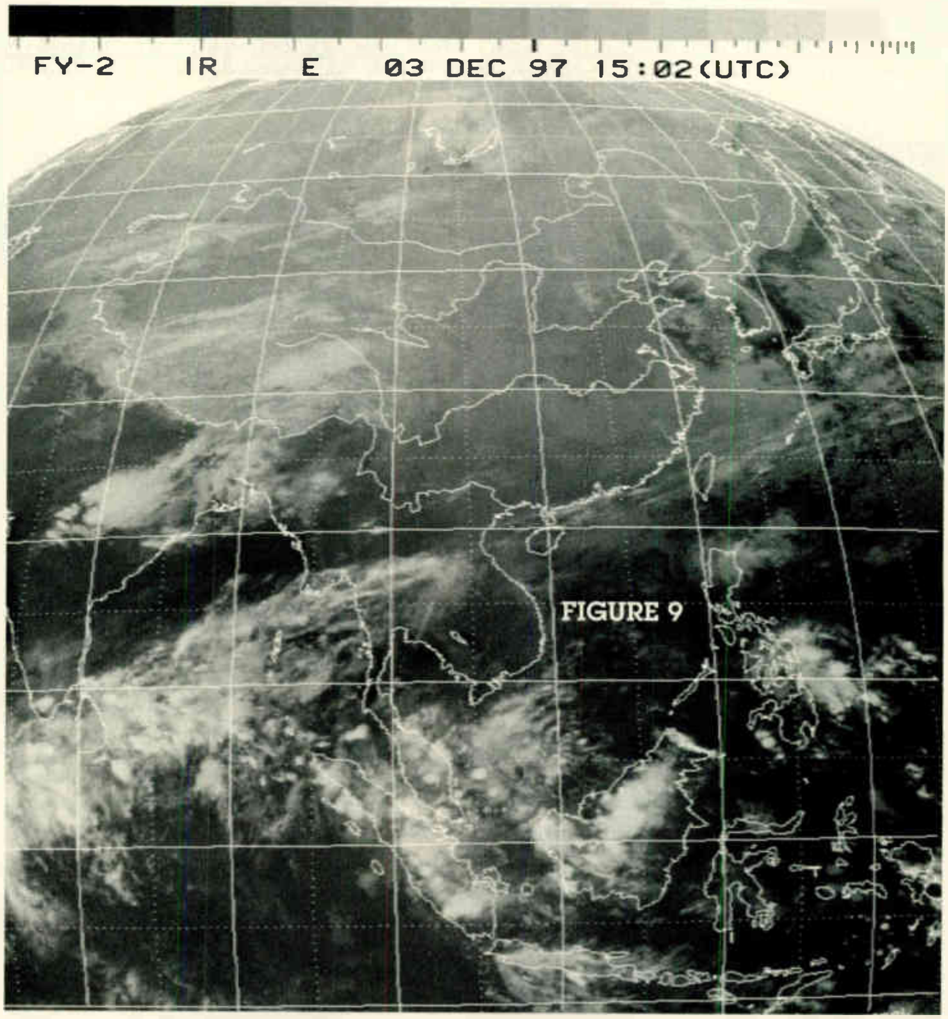


Fig. 9: Fengyun-2B infra-red image of December 3, 1997, from Mike Kenny

NOAA Beacons

NOAA weather satellites transmit different types of data on 137.50, 137.62, 1698.0 and 1707.0 MHz, and they also transmit beacon telemetry on 136.77 MHz (NOAA-12) and 137.77 MHz (NOAA-14). NOAA-11 is currently not transmitting APT data, but it does periodically use its beacon (137.77 MHz) under command. I noticed that because the beacon stops my general purpose scanner from scanning. But the NOAA-14 beacons do not give me similiar results.

I originally speculated whether the beacons had different power output levels, so I enquired about this observation on the Internet weather satellite forum. Wayne Winston (NOAA/NESDIS meteorologist) responded to my query, saying that all satellites in the series use the same one watt transmitter and antenna configuration. The beacon antenna is linearly polarized (compared with the right-hand circular polarization used for APT). If you have also experienced this effect, I would like to hear from you.

Frequencies

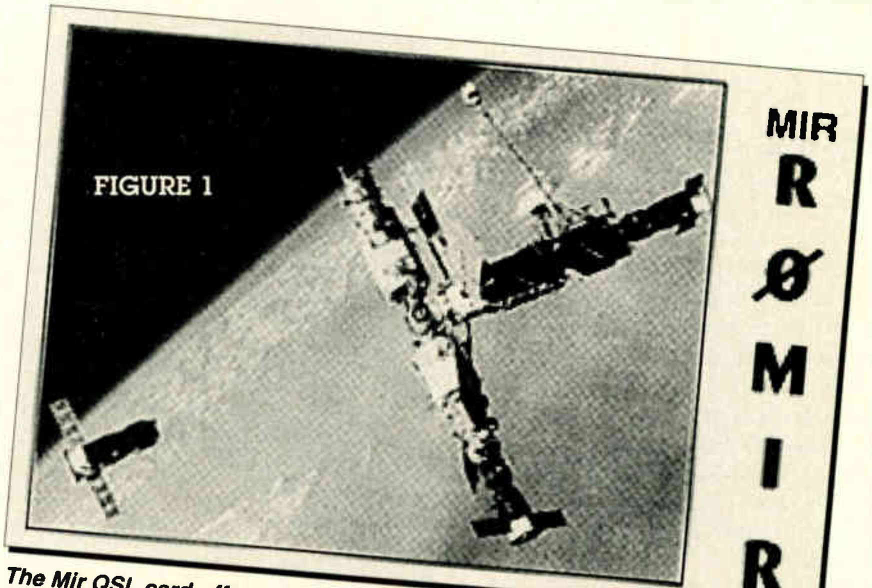
NOAA-12 transmits APT on 137.500 MHz
NOAA-14 transmits APT on 137.620 MHz
NOAA satellites transmit beacon data on 136.770 or 137.770 MHz
Meteor 3-5 transmits APT in sunlight only on 137.850 MHz
OKEAN-4 and SICH-1 (rarely operating) use 137.400 MHz
GOES-8 and GOES-9 use 1691.0 MHz for WEFAX transmissions
Mir voice communications are commonly heard on 143.625 MHz ST

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

A *Mir* Achievement

Establishing amateur radio contact with the Russian space station *Mir* is a popular activity with newcomers to the world of amateur satellites. Amateur radio communications equipment has been onboard *Mir*, starting in November 1988 with the third crew to inhabit the space station, and most crews since then have made good use of the equipment for recreational purposes.

A favorite activity among amateur radio operators is to confirm successful radio contacts, especially unusual or rare contacts, with a QSL or verification card. At the present time, two different types of contact verifications are available to those successful in making two-way radio contact with *Mir*.



The Mir QSL card offers verification of successful two-way radio communications with the amateur radio station on-board the Russian space station Mir.

Figure 1 shows the current *Mir* QSL card that is available to amateurs who have successfully made two-way radio contact with *Mir*, either by FM voice or by packet radio. The QSL is available to stations in North America through Dr. David Larsen, N6CO/K6MIR, or through Sergej Samburov, RV3DR, for stations in the remaining parts of the world.

The Russian address for obtaining a Sputnik-40 QSL card has changed slightly from those previously published. The new address is as follows: Sergej Samburov, PO Box 73, Korolev-10 City, Moscow Area, 141070, Russia.

Include a self-addressed envelope and one or two International Reply Coupons with your Sputnik-40 reception report. Do not include any amateur radio callsigns on the outside of the sending or return envelope.

Callsigns should not be displayed anywhere on the envelopes sent to Sergej. U.S. stations requesting QSLs through Dr. Dave Larsen should include a self-addressed stamped envelope (SASE) in lieu of IRCs.

Proper contact verification requires that stations wishing to receive a QSL card provide information such as their name and callsign, the callsign of the station contacted on *Mir*, the mode of communications used, the number of the message left on the *Mir* packet BBS system (if a confirmation of a packet radio contact is desired), and the date, frequency and time upon which the contact took place.

Table 1 lists the addresses of the *Mir* QSL managers who are able to accept QSL requests and issue them to qualifying ground stations. A QSL card is also available to those wishing verification of their reception of amateur radio transmissions from *Mir*.

TABLE 1: *MIR* QSL MANAGERS

Dr. David Larsen, N6CO/K6MIR, P.O. Box 1501, Pine Grove, California 95665 USA
Dave offers confirmation for stations located in the USA, Canada, Australia, New Zealand and South America. Please include a business-sized SASE or IRCs with your QSL or reception report.

Sergej Samburov, RV3DR, P.O. Box 73, Kaliningrad-10 City, Moscow Area, 141070, Russia
Sergej offers confirmation for stations located in Russia only. Please include a self-addressed stamped envelope with your QSL or reception report.

Last year, a *Mir* Achievement Award program was started to offer yet another incentive for contacting *Mir* and to help raise funds for the MIREX program. MIREX is a team of dedicated amateur radio operators who work together along with officials within the Russian space program to purchase and deliver amateur radio communications equipment to the *Mir* space station. The MIREX volunteers also conduct extensive testing of the amateur radio equipment used on *Mir* and try to resolve electromagnetic compatibility (EMC) problems associated with each component of the amateur radio station and those of the commercial VHF two-way radio communications equipment carried on *Mir*.

The *Mir* Achievement Award is available to amateurs who have successfully made both voice and packet radio contact with crew members living on the *Mir* space station. Figure 2 shows a *Mir* Achievement Award received by your *Satellite Times* Amateur Satellites columnist after making a VHF packet radio contact with *Mir* on August 26, 1997, and a live two-way UHF voice

A favorite activity among amateur radio operators is to confirm successful radio contacts, especially unusual or rare contacts, with a QSL or verification card. At the present time, two different types of contact verifications are available to those successful in making two-way radio contact with Mir.

contact with Astronaut Mike Foale, KB5UAC, on September 12, 1997.

The award is 8.5 by 11 inches in size, and displays a full color image of *Mir* in full sunlight above an earth shrouded with scattered clouds. A ten dollar donation sent to MIREX President Dr. Dave Larsen at the address listed in Table 1 along with the specifics of each contact are all that are needed to qualify for a *Mir* Achievement Award certificate.

New TNC on Mir

A new KAM dual mode packet radio terminal node controller (TNC) that was recently sent to *Mir* from the MIREX team was tested on-board *Mir* during mid-December 1997. The new TNC supports both 1200 as well as 9600 baud connections, and has a message buffer size of 100 kilobytes–substantially larger than that of the PacComm TNC previously in use. The 9600 baud communications capability aboard *Mir* will be delayed until a suitable cable wired and installed.

DOVE-OSCAR-17 QSL Card Available

Ground stations who successfully receive downlink transmissions from the DOVE-OSCAR-17 satellite on 145.825 MHz FM are eligible for a DOVE QSL card. To receive a DOVE QSL, receiving stations need to send a request indicating the date, time and frequency the satellite was received. It is not necessary to send a breakdown of the satellite telemetry or a printout of received data. Include a self-addressed stamped envelope (SASE) or an addressed envelope with an International Reply Coupon (IRC) with your request. Reception reports should be sent to: Dianne White, N0IZO, 45777 Rampart Road, Parker, Colorado 80138-4316 USA

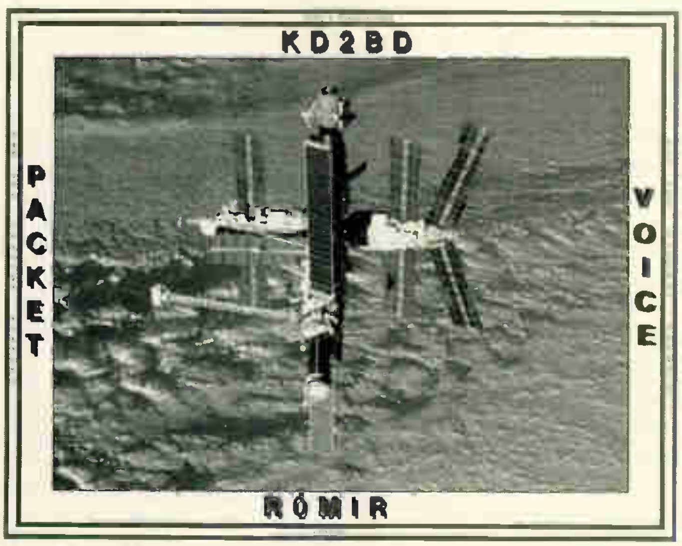
A new DOVE-OSCAR-17 QSL card is available to groundstations who have successfully copied downlink transmissions from the DOVE-OSCAR-17 microsatellite. DOVE has an FM downlink on 145.825 MHz.

Amateur Radio to Fly on International Space Station

NASA recently named the first team members to live and work aboard the International Space Station (ISS), and four crew members are licensed amateur radio operators. Several of the crew members who do not currently hold amateur radio operator licenses are presently studying for their licenses in preparation for their activities on ISS.

The first International Space Station crew will consist of American astronaut William M. Shepherd as the expedition commander. Shepherd is currently studying for his license. He will be accompanied by Russian cosmonauts Yuri Gidzenko and Sergei Krikalev, U5MIR. The first crew is training for an early 1999 launch and a planned five month mission on the International Space Station.

The second crew, which will be headed by Russian cosmonaut Yuri Usachev,



The Mir Achievement Award is available to amateurs who have successfully made two-way radio contact with Mir using both voice and packet radio communications.

Original DOVE-OSCAR-17 QSL card issued by Junior De Castro, PY2BJO of Sao Paulo, Brazil, who sponsored construction of the satellite. The reverse side of the card provides technical information about DOVE-OSCAR-17.

The first International Space Station crew will consist of American astronaut William M. Shepherd as the expedition commander. He will be accompanied by Russian cosmonauts Yuri Gidzenko and Sergei Krikalev, U5MIR. The first crew is training for an early 1999 launch.

Yaesu's new FT-847 transceiver offers state-of-the-art satellite communication capabilities in addition to full coverage of the 6-meter and HF bands in a 10.2-inch wide by 3.4-inch high by 10.6-inch deep package. The new rig is expected to be available by the middle of this month.

R3MIR, will include US astronauts Susan Helms, KC7NHZ, and James S. Voss, who has also indicated an interest in getting his ham license.

No licensed hams are among the third crew, which will be headed by astronaut Kenneth Bowersox and will include Russian crewmates Vladimir Dezhurov and Mikahil Turin. Bowersox also has indicated that he would like to earn an amateur radio operator's license.

The fourth crew will be headed by Russian cosmonaut Yuri Onufrienko. Yuri will be accompanied by American astronauts Carl Walz, KC5TIE, and Daniel Bursch.

Frank Bauer, KA3HDO, AMSAT-NA's Vice President for Manned Space Operations, reports that the international team developing an amateur radio station for the International Space Station is working hard to put together a transportable system in time to be delivered to the Johnson Space Center in Houston, Texas, for flight certification in June.

Initially, International Space Station crews will inhabit the service module, which will include an amateur radio radio antenna. Amateur radio transceivers are expected to be delivered to ISS via Space Shuttle mission STS-96. Communications capabilities are expected to be expanded with the arrival of digital "Microsat-style" store-and-forward transponder and voice repeater payloads to the International Space Station in early 2002.

Yaesu Announces New FT-847 Satellite Rig

Yaesu Communications has announced the introduction of the Yaesu FT-847 transceiver as a successor to their popular FT-736R and earlier FT-726R multi-mode communication transceivers. The FT-847 is due out later this month, and offers coverage of all the amateur high frequency bands as well as the 6-meter band with 100 watts of output power. The rig also covers the 2-meter VHF and 70-cm UHF bands with 50 watts of transmitter power, and offers cross-band full duplex operation as well as normal and reverse tracking for satellite communications, CTCSS and Digital Coded Squelch (CS) encode/decode, high resolution 0.1 Hz tuning steps, DSP filters (notch, NR, BPF), shuttle jog tuning dial for fine or rapid tuning, direct frequency keypad entry, as well as 1200/9600 bps packet radio capabilities.

AMSAT-UK Colloquium Call For Papers

The thirteenth AMSAT-UK Colloquium will be held at Surrey University, Guildford, Surrey, U.K., from Friday July 31, 1998, to Sunday August 2, 1998. This year's event will include technical and operational matters as well as an IARU forum.

AMSAT-UK invites authors to submit papers about amateur radio space and associated activities for this event, and for the *Proceedings* document which will be published at the same time. Colloquium organizers normally prefer authors to present the papers themselves rather than having someone else read them in the authors' absence, but also welcome "unpresented" papers for the document.

Offers of Papers should be submitted as soon as possible; the final date for full documents is mid-June 1998 in order that the *Proceedings* document be available to participants. A second and final call for papers will issue about March 1998, probably at the same time as Colloquium booking information becomes available.

Submissions should be sent to Richard W. L. Limebear, G3RWL via the following routes:

Internet e-mail:
Packet Radio: **G3RWL@GB7HSN.#32.GBR.EU**
Satellite: **AO16/19/22/23/25**
Terrestrial mail: Richard W. L. Limebear, G3RWL, 60 Willow Road, Enfield EN1 3NQ United Kingdom

AMSAT-UK also invites anyone with requests for program topics to submit them as soon as possible to G3RWL.

See you on the birds! ST

Satellite Listening Post

By Keith Stein
kstein@erols.com

INMARSAT and INTELSAT Satellites

On June 3, 1997, INMARSAT 3F4 roared off into orbit on an Ariane 44L rocket from French Guiana. Thanks to this Arianespace launch INMARSAT now has a full constellation second generation and third generation of satellites active in geostationary orbit and thus all services worldwide are fully operational.

Second Gen Satellites

The second generation satellites were designed for a 10-year life. The communications payload on these birds have two transponders providing downlink (C-band to L-band) and uplink (L-band to C-band) with mobile terminals in the 6.4/1.5 and 1.6/3.6 GHz bands. Each satellite's global beam covers roughly one-third of the Earth's surface. INMARSAT can handle communications for maritime, aeronautical and land mobile applications.

The satellite uses L-band for communications with ships and C-band for communications with shore stations. The L-band transmit antenna is a hexagonal array of 61 elements (see chart below).

Cat. #	Intl. Desig.	Sat. Name	Position
20918	1990-093A	INMARSAT 2 F1	178.9° East
21149	1991-018A	INMARSAT 2 F2	55.2° West
21814	1991-084B	INMARSAT 2 F3	64.9° East
21940	1992-021B	INMARSAT 2 F4	17.2° West

The third generation INMARSAT spacecraft use the latest satellite spotbeam technology for worldwide voice and data communication services to increasingly smaller mobile terminals on ships. aircraft and vehicles. These satellites are 20 times more powerful than INMARSAT's first generation models.

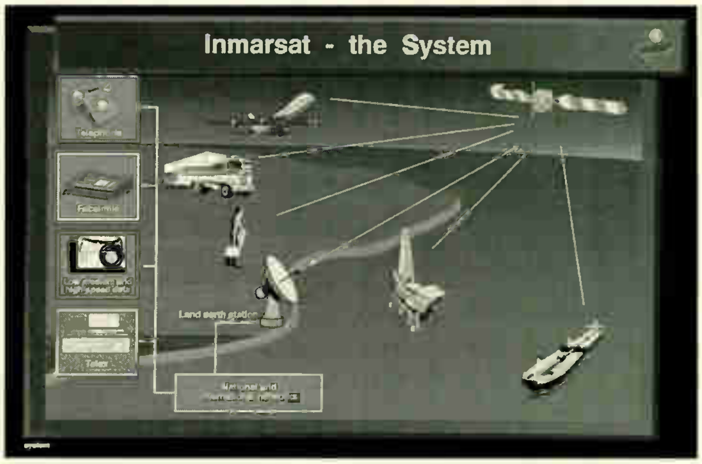
Each satellite has one global beam and five spotbeams. Like the second generation spacecraft, these satellites can support communications for maritime, aeronautical and land mobile applications. The INMARSAT-3s comprise the first commercial satellite system to carry navigation payloads and mobile-to-mobile links.

Inmarsat's Satellite Control Center is located in London and works through ground stations in Pennant Point (Canada), Lake Cowichan (Canada), Fucino (Italy) and Beijing (China).

Cat. #	Intl. Desig.	Sat. Name	Position
23839	1996-020A	INMARSAT 3 F1	63.9°East
24307	1996-053A	INMARSAT 3 F2	15.5°West
24674	1996-070A	INMARSAT 3 F3	178.3°East
24819	1997-027A	INMARSAT 3 F4	54.0°West

If all goes well, by the time you receive this issue of the *Satellite Listening Post* the final INMARSAT 3 series satellite (F5) should be in orbit. Soon after this launch, INMARSAT intends to redeploy several INMARSAT 2 series spacecraft as part of a plan to re-use its L-band mobile satellite frequencies and offer new services.

All INMARSAT 2 series spacecraft will be offset by 40 degrees from their current positions, which will allow double usage of the same spectrum. These satellites will primarily be used for long-term global beam leases. The INMARSAT satellites over the eastern and western Atlantic will be moved to 110°East and 98°West respectively.



INMARSAT	Downlink Frequency Assignments
L-band	1530-1546 MHz
C-band	3600-3621 MHz

International Telecommunications Satellite Organization (INTELSAT)

INTELSAT has more operational satellites in geostationary orbit than any other organization, with many more scheduled to be launched.

Coordination/control of INTELSAT services is performed by their Satellite Control Center (SCC) and Intelsat Operations Center (IOC) at INTELSAT Headquarters in Washington, DC. Tracking, telemetry and control stations are located in Fucino (Italy), Paumalu (Hawaii), Perth (Australia), Raisting (Germany), Beijing (China) and Clarksburg (Maryland, United States).

Columbia Communications Corporation will cease operation of the TDRS-4 spacecraft (Tracking and Data Relay Satellite-4) at 41 degrees West longitude on May 15, 1998. In its place, Columbia will take title to the INTELSAT 515 spacecraft (to be renamed Columbia 515) and begin operating that satellite by April 1, 1998 at 37.5 degrees West longitude. Columbia will lease back to INTELSAT, at no charge, a number of transponders on the Columbia 515 satellite.

The INTELSAT 806 spacecraft will be launched in March 1998 and located at 40.5°East longitude for on orbit operations.

INTELSAT V/VA	Downlink Frequency Assignments
Prime contractor: Ford Aerospace	
L-band	1535-1542.5 MHz (L-band transponder only on Intelsat 505 and 506)
C-band	3.7-4.2 GHz and 4.1925-4.200 GHz Intelsat V: 21 transponders; Intelsat VA: 26 transponders
Ku-band	10.9-11.7 GHz, 11.7-11.95 and 12.5-12.75 GHz (International Business Service on Intelsat 513 and 1515 only) Intelsat V: 4 transponders; Intelsat VA: 6 transponders

If all goes well, by the time you receive this issue of the Satellite Listening Post the final INMARSAT 3 series satellite (F5) should be in orbit. Soon after this launch, INMARSAT intends to redeploy several INMARSAT 2 series spacecraft as part of a plan to re-use its L-band mobile satellite frequencies and offer new services.

TABLE 1: Current INTELSAT Constellation

Catalog No.	Intl Desig	Satellite	Orbital Position (degrees)
12089	1980-098A	INTELSAT 502	40.5ºW (Ku-band only)
13595	1982-097A	INTELSAT 505	73.5ºE (L-band leased to INMARSAT)
14077	1983-047A	INTELSAT 506	31.4ºW (L-band leased to INMARSAT)
15629	1985-025A	INTELSAT 510	33.0ºE
15873	1985-055A	INTELSAT 511	157ºE
16101	1985-087A	INTELSAT 512	55.5ºW
19121	1988-040A	INTELSAT 513	177.0ºW
19772	1989-006A	INTELSAT 515	21.3ºW
21765	1991-075A	INTELSAT 601	35.5ºW
20315	1989-087A	INTELSAT 602	62.0ºE
20523	1990-021A	INTELSAT 603	24.5ºW
20667	1990-056A	INTELSAT 604	60.0ºE
21653	1991-055A	INTELSAT 605	29.5ºW (Attitude control failure, replaced by 803)
21989	1992-032A	INTELSAT K	21.6ºW
22871	1993-066A	INTELSAT 701	180.0ºE
23124	1994-034A	INTELSAT 702	177.0ºE
23305	1994-064A	INTELSAT 703	57.0ºE
23461	1995-001A	INTELSAT 704	66.0ºE
23528	1995-013A	INTELSAT 705	18.0ºW
23571	1995-023A	INTELSAT 706	53.0ºW
23816	1996-015A	INTELSAT 707	1.0ºW
23915	1996-035A	INTELSAT 709	50.0ºW
24742	1997-009A	INTELSAT 801	61.9ºE
24846	1997-031A	INTELSAT 802	173.9ºE
24957	1997-053A	INTELSAT 803	27.5ºW
25110	1997-083A	INTELSAT 804	64ºE
Intelsat VIIIA		INTELSAT 806	March 1998
Intelsat VIIIA		INTELSAT 805	May-June 1998
		INTELSAT K-TV	Jan-Mar 1999
Intelsat IX		INTELSAT 901	3rd Quarter 2000
Intelsat IX		INTELSAT 902	4th Quarter 2000
Intelsat IXA		INTELSAT 903	1st Half 2001
Intelsat IXA		INTELSAT 904	2nd Half 2001

INTELSAT VI **Downlink Frequency Assignments**
Prime Contractor: Hughes Aircraft Company

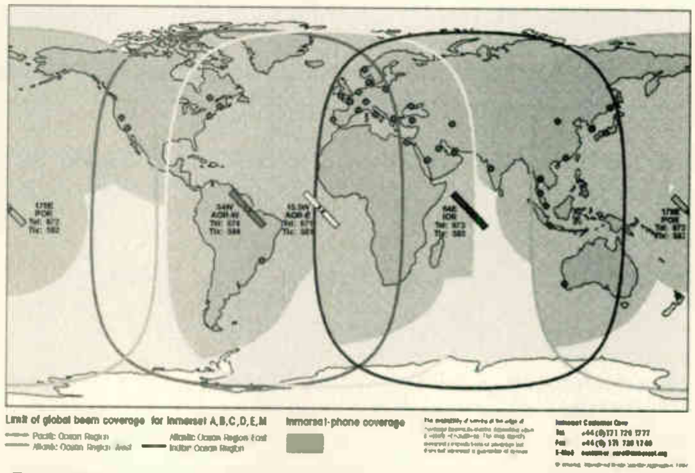
C-band	3.62-4.20 GHz (38 transponders)
Ku-band	10.95-11.2 and 11.45-11.70 GHz (10 transponders)

INTELSAT K **Downlink Frequency Assignments**
Prime Contractor: GE Astro Space (started out life as Satcom K4)
This satellite does not have any C-band downlink service. It is strictly a Ku-band only satellite dedicated to providing service to Europe and the Americas with sixteen 54 MHz transponders.
Ku-band10.954-11.198, 11.7-11.95, 11.454-11.698, and 12.5-12.75 GHz

INTELSAT VII/VIIA **Downlink Frequency Assignments**
Prime Contractor: Space Systems/Loral

C-band	3.6-4.2 GHz (26 transponders, both versions)
Ku-band	11.0-11.2 GHz and 11.5-11.7 GHz Intelsat VII: 10 transponders; Intelsat VIIA 14 transponders

Note: One of the important new features that was introduced with the Intelsat VII/VII-A satellites is the real-time ability to reconfigure the satellite's coverage capabilities in-orbit in response to changing traffic patterns and service requirements.



• Three independently steerable, high powered, Ku-band spot beams offering a total of ten transponders that can be individually assigned on an as-needed basis.

• An independently steerable C-band spot beam capable of switching up to six global transponders to dual polarized, independently steerable C-band spot coverage.

• Switchable C-band zone coverage permitting assignment of capacity for coverage of Northwest or Southeast areas and Northeast or Southwest areas.

INTELSAT VIII/VIIIA **Downlink Frequency Assignments**
Prime Contractor: Space Systems/Loral

C-band	3.625-4.200 GHz (38 transponders)
Ku-band	10.95-12.75 GHz (6 transponders)

INTELSAT K-TV
Prime Contractor: Matra Marconi Space
Satellite will be placed into geostationary orbit at 95ºEast in the first quarter of 1999.

INTELSAT IX
Prime Contractor: Space Systems/Loral
Satellite will carry 44 C-band and 10 Ku-band transponders

Intelsat C-band satellite beacons 3947.5, 3948, 3952 and 3952.5 MHz
Intelsat Ku-band satellite beacons on 11198 and 11452 MHz

ORBCOMM Satellite Status Report

Orbcomm launched eight new satellites on December 23, 1997, at 1911 UTC. The launch used the Orbital Sciences L-1011 aircraft and the Pegasus XL/H rocket. These satellites were launched into orbit from the L-1011 about 100 miles off the coast of Virginia (Wallops Island). Here is a complete list of the Orbcomm satellites that made it into orbit.

Intl Desig	Catalog Number	Satellite Nomenclature
1997-84A	25112	Orbcomm FM 5
1997-84B	25113	Orbcomm FM 6
1997-84C	25114	Orbcomm FM 7
1997-84D	25115	Orbcomm FM 8
1997-84E	25116	Orbcomm FM 9
1997-84F	25117	Orbcomm FM 10
1997-84G	25118	Orbcomm FM 11
1997-84H	25119	Orbcomm FM 12

Each Orbcomm satellite also has a 400.1 MHz doppler beacon and all of the satellite downlinks are transmitting at five watts. The communications downlink signal comprises what sounds like wideband noise with a beat of approximately 1 second cadence.

Object 1997-84K (25121) is the hydrazine (HAPS) fourth stage of the Pegasus XL/H rocket.

Several monitors reported signals from beacons on each of these satellites using a frequency of 137.560 MHz.

Active payload information from the Hearsat-L internet newsgroup sponsored by Grove Enterprises, *Satellite Times*, and by John Corby in Caledon, Canada (Hearsat-L moderator)

Satellite	Catalog No.	Frequency	Status
Orbcomm FM1	23545	137.710 MHz FM	On
Orbcomm FM2	23546	137.680 MHz FM	On

Each Orbcomm satellite also has a 400.1 MHz doppler beacon and all of the satellite downlinks are transmitting at five watts. The communications downlink signal comprises what sounds like wideband noise with a beat of approximately 1 second cadence. Each Orbcomm satellite transmits a very powerful VHF signal. Often the signal is so strong that it cannot be squelched on a scanner–even with the squelch control turned all the way up.

Another interesting phenomenon sometimes occurs in which the squelch circuits becomes confused and lock out the signal. When this happens all you hear is silence. Signal lockout can be overcome by inserting some attenuation in the RF feed to the receiver.

Listening Post Tip of the Month

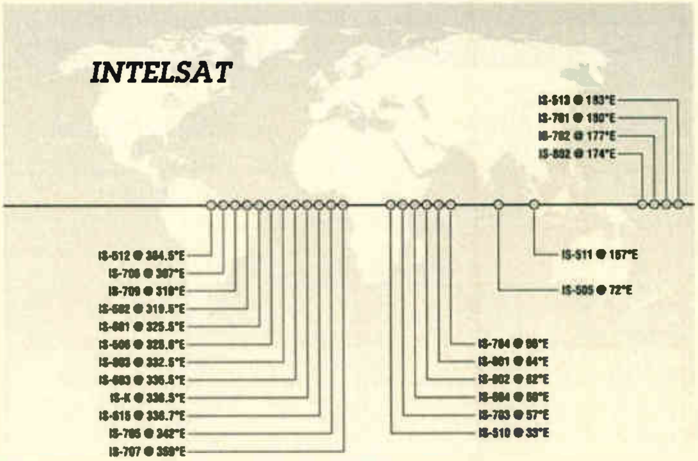
How many people went up on their roof after Christmas to check and make sure their antennas were still there after eight tiny reindeer and Santa made their stop (or maybe due to winter's high winds)?

Have you gone up to the roof to install your first antenna to join the satellite monitoring hobby? Have you gotten that new satellite dish on your roof or C-band antenna in the yard installed yet? Now is the time to do it before thunderstorm season starts up.

Satellite Listening Post Intercepts

All times in UTC

AMSAT	Radio Amateur Satellite Corporation
ER-2	Earth Resources-2
ILS	Instrument Landing System
K	Kilohertz
LSB	Lower Sideband
M	Megahertz
NASA	National Aeronautics and Space Administration
NFM	Narrow FM
NOAA	National Oceanic and Atmospheric Administration



K3839.3	AMSAT North America East Coast Net heard at 0255 in LSB mode (Keith Stein-Woodbridge, VA)
K3842.2	AMSAT North America East Coast Net heard at 0208 in LSB mode. W3STW, Al was net control (Stein-VA)
M123.700	NOAA 61 (aircraft) heard performing ILS calibration checks, 1615, AM mode (JTWard-FL)
M137.560	Unid Orbcomm satellite noted here right after launch on December 23 at 2210 UTC. (Larry Van Horn-Brasstown, NC)
M137.620	Monitored several of the Orbcomm satellites shortly after launch at various times. (Bob Grove-Brasstown, NC)
M138.900	NASA 706 (ER-2 aircraft) calling NASA Ops, then X-Ray Control, reporting to be west of Edwards Complex and wanting to know of any conflicting traffic at Hotel + 2 (James De Witt)
M143.625	Heard *Mir* with both Russian and English voice at 1852, NFM mode (David Priestley-England)
M145.820	Monitored several passes of the Russian RS-17/Sputnik 40 satellite using USB. (Van Horn-NC)
M149.940	Russian military navigation satellite Cosmos 2279 was heard transmitting again at 0123, NFM mode (John Corby, Caledon, Toronto, Canada)
M149.990	Heard a satellite signal between 2300-2304 (Antonio Vilela-Lisbon, Portugal) *Good chance it was one of the old U.S. Transit navigation satellites, also known as OSCAR NAV ##; nice catch-Keith*
M150.000	Heard Russian navigation satellite Cosmos 2315 at 0006, NFM mode (Vilela-Portugal)

INTRODUCTION

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

How to Use the Satellite Service Guide

The various sections of the SSG include:

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

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

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

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

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

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

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

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

Satellite Radio Guide

By Robert Smathers and Larry Van Horn

AUDIO SUBCARRIERS

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

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

Classical Music

SuperAudio—Classical Collections	G5, 21	6.30/6.48 (DS)
WFMT-FM (98.7) Chicago, IL—Fine Arts	G5, 7	6.30/6.48 (DS)
WQXR-FM (96.3) New York, NY	S4, 14	6.20/6.80 (DS)

Satellite Computer Services

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

Contemporary Music

DWRR-FM (101.9) from the Philippines	G4,24 (Ku)	6.80
SuperAudio—*Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
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

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 listen.	G3R, 9	6.80
	G5,2	6.80
United Video—easy listening music	C4, 8	5.895 (N)

Foreign Language Programming

Antenna Radio (Greek)	S4, 14	7.80
Apna Sangeet Radio India	GE1, 16	7.38
Arab Network of America radio network	GE2, 22	5.80
CBC Radio Canada-East (French)	E2, 1	5.38/5.58 (DS)
	E2, 1	7.36
DZMM-AM (630), from the Philippines	G4, 24 (Ku)	6.20
La Cadena CNN Radio Noticias (CNN Radio News in Sp.)	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, 8	7.38
XEW-AM (900) Mexico City, DF Mexico (Spanish), ID-*La Voz de la America Latina*—contemporary music	M2, 14	7.38

Jazz Music

KLON-FM (88.1) Long Beach, CA., ID-*Jazz-88*	G5, 2	5.58/5.76 (DS)
Superaudio—*New Age of Jazz*	G5, 21	7.38/7.56 (DS)
WLVE-FM (93.9) Miami Beach, FL., ID-*Smooth-Jazz-Love-94* (Present as audio for Hero Teleport slate)	S4, 12	6.20/6.80

News and Information Programming

Business Radio Network	C4, 10	8.06 (N)
Cable Radio Network	G5, 2	7.24 (N)
	C1, 21	7.30
CNN Headline News	G5, 22	7.58
CNN Radio News	GE3, 9	5.62
	G5, 5	7.58
	G5, 22	6.30
USA Radio Network—news, talk and information	GE3, 13	5.01 (ch 1), 5.20 (ch 2)
Virginia News Service/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
Inspirational Music (unidentified)	G4, 6	7.96
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

Shortwave Broadcasters via C-band Downlinks

C-SPAN Audio 1: Various shortwave broadcasters	C3, 7	5.20
C-SPAN Audio 2: British Broadcasting Corporation (BBC)	C3, 7	5.41
Deutsche Welle	GE1, 22	7.02, 7.22 , 7.38/7.56, 7.74
WEWN-Worldwide Catholic Radio, Vandiver, Ala.	G1R, 11	5.40 (English), 5.58 (Spanish)
WHRI/KHWR-World Harvest Radio, South Bend, Ind.	G4, 15	7.46/7.55, 7.64
World Radio Network: WRN1 North America	G5, 6	6.80
WRN2 North America	G5, 6	6.20 (Multi-lingual)

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
SuperAudio—Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
Weather Channel—background music	C3, 13	7.78
Wisdom Radio Network	GE1, 12	7.10
Yesterday USA—nostalgia radio	G5, 7	6.80
	G1R, 24	7.38

Talk Programming

American Freedom radio network	GE1, 7	5.80
Amerinet Broadcasting	G1R, 7	5.58
For the People radio network	C1, 6	7.50
Friday Night Live (Friday 9 p.m.ET)	SBS6, 13B (Ku)	6.20
Orbit 7 Radio Network	C1, 14	7.48
Radio America Network	C1, 2	5.58
Republic Radio International	G7, 14	7.70
Talk America Radio Network #1—talk programs	GE3, 9	6.80
Talk America Radio Network #2—talk programs	GE3, 9	5.41
Talk Radio Network—talk programs	C1, 5	5.80
United Broadcasting Network	C1, 2	7.50
WOKIE Network—tech talk	SBS6, 13B (Ku-band)	6.20 (network is active when Megabingo is present)
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)
WWRL-AM (1600) New York, NY-Am. Urban Radio Net.	GE3, 9	6.30/6.48 (DS)

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, 3.750, and 4.830 MHz
Focus on the Family: .510 (ch. 1), .780 (ch. 2) and 1.230 MHz
Information Radio Network: 3.390 MHz
USA Radio Network: .330, 5.010 (ch 1) and 5.200 MHz (ch. 2)

GE-3 Transponder 17 (C-band)

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

Galaxy 4 Transponder 3 (Ku-band)

Blank Audio Carriers: 1.000, 2.060, 3.250, 3.620, 4.340, 4.400 and 4.450 MHz
Data transmissions: 2.950, 3.070 and 3.190 MHz
AP Network News: 3.530 MHz
In-Store audio network ads (various companies): .710, .810, .910, 1.150, 1.260, 3.440, 3.700, 3.800, 3.880 and 3.970 MHz
Muzak Services .150, .270, .390, .510, 1.360, 1.480, 1.600, 1.720, 1.840, 1.960, 2.190, 2.310, 2.440, 2.560, 2.680, 2.800, 3.340, 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, 1.120, 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, 3.475, 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, 2.070 and 2.730 MHz

Anik E1 Transponder 6 (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
1204.45 (55.55)	KJAV-FM (104.9) Alamo, Tex—Spanish language religious programming/ *Nuevo Radio Christiana Network*
1204.25 (55.75)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming
1204.00 (56.0)	SRN (Salem Radio Network) News
1201.50 (58.5)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming
1201.30 (58.7)	Wisconsin Voice of Christian Youth (VCY) America Radio Network—religious programming

GE-3 Transponder 17-Horizontal (C-band)

1109.75 (70.25)	Salem Radio Network
1110.10 (69.90)	Salem Radio Network
1110.40 (69.60)	Salem Radio Network

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/Chicago Blackhawks NHL radio network
1404.80 (55.2)	KOA-AM (850)/KTLK-AM (760) Denver, Colo—news and talk radio/University of Colorado sports
1404.60 (55.4)	WGN-AM (720) Chicago, IL—news and talk radio/Nortwestern University sports
1404.40 (55.6)	Illinois News Network—network news feeds/Chicago Bulls NBA radio network
1404.20 (55.8)	Tribune Radio Networks/Wisconsin Radio Network
1402.70 (57.3)	WLAC-AM (1510) Nashville, TN—news and talk/*Road Gang* trucker program (overnight)/Tennessee sports
1401.80 (58.2)	Michigan News Network—network news feeds/Central Michigan sports
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/Georgia sports/Atlanta Hawks

(Continued on Page 38)

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

(Continued from Page 37)

	NBA radio network
1398.00 (62.0)	Occasional audio
1397.80 (62.2)	Occasional audio/Colorado Avalanche NHL radio network
1397.50 (62.5)	Minnesota Talking Book Radio Network-reading service for the blind
1397.30 (62.7)	Clemson sports
1397.10 (62.9)	WTMJ-AM (620) Milwaukee, WI - talk radio/Wisconsin Radio Network—network news feeds/University of Wisconsin sports
1396.90 (63.1)	Occasional audio
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/Georgia Tech sports
1396.00 (64.0)	WHO-AM (1040) Des Moines, IA—talk radio/Iowa News Network—network news feeds/Iowa sports
1395.80 (64.2)	WTMJ-AM (620) Milwaukee, WI - talk radio/Wisconsin Radio Network—network news feeds/University of Wisconsin sports
1395.60 (64.4)	WGST-AM/FM (640/105.7) Atlanta, GA ID *Planet Radio*—news and talk radio
1395.40 (64.6)	Michigan News Network—network news feeds
1395.00 (65.0)	Occasional audio
1394.70 (65.3)	WJR-AM (760) 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)	Michigan News Network/Michigan State sports
1384.40 (75.6)	KOA-AM (850)/KTLK-AM (760) Denver, CO—news and talk radio/University of Colorado sports
1384.20 (75.8)	WSB-AM (750) Atlanta, GA—news and talk radio/Georgia sports/Atlanta Hawks NBA radio network
1383.70 (76.3)	Motor Racing Network (occasional audio) NASCAR racing
1383.40 (76.6)	United Broadcasting Network—talk radio
1383.10 (76.9)	KIRO-AM (710) Seattle, WA—news and talk radio
1382.90 (77.1)	Michigan News Network—network news feeds/Detroit Pistons NBA radio network
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/Morehead State College sports
1381.80 (78.2)	WHO-AM (1040) Des Moines, IA - news and talk radio/Iowa News Network—network news feeds/Iowa sports
1381.60 (78.4)	KEX-AM (1190) Portland, DR—news and talk radio/Portland Trailblazers NBA radio network
1381.40 (78.6)	Occasional audio
1381.20 (78.8)	KJR-AM (950) Seattle, WA - sports talk radio/Washington State sports
1377.10 (82.9)	In-Touch—reading service for the blind
1376.00 (84.0)	Kansas Audio Reader Network—reading service for the blind
1375.40 (84.6)	USA Radio Network/Agrinet Agriculture news service

Galaxy 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 7-Horizontal (C-band)

1326.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio—Arctic and Labrador 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)

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/Wyoming sports
1400.60 (59.4)	Learfield Communications/Indiana sports
1400.40 (59.6)	Learfield Communications/Missouri Net
1400.20 (59.8)	Occasional audio/Data transmissions
1400.00 (60.0)	Learfield Communications/Purdue sports
1396.60 (63.4)	Kansas Information Network/Kansas Agnet—network news feeds
1396.20 (63.8)	Missouri Network
1396.00 (64.0)	Occasional audio/Red River Farm Network
1395.70 (64.3)	Missouri Net/WIBW-AM (580) Topeka, KS—country music
1386.40 (73.6)	Learfield Communications
1386.20 (73.8)	Radio Iowa/Iowa sports
1386.00 (74.0)	United broadcasting Network—talk radio
1384.60 (75.4)	Capitol Radio Network/North Carolina State sports
1384.00 (76.0)	Occasional audio/ABC Direction Network—network news feeds
1383.80 (76.2)	Occasional audio/Iowa sports
1383.40 (76.6)	Capitol Radio Network
1382.90 (77.1)	Missourinet/Missouri sports
1382.50 (77.5)	Virginia News Network—network news feeds
1382.10 (77.9)	Learfield Communications/Missourinet

RCA C5 Transponder 21-Vertical (C-band)

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

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/Occ video
3	11774-H	MSNBC feeds
4	11798.5-V	Occ video
5	11823-H	Occ video
6	11847.5-V	Unknown user [digital video]
7	11872-H	Occ video
8	11896.5-V	Occ video
9	11921-H	Occ video
10	11945.5-V	Occ video/CONUS Communications (occ)/ 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
15	12142-H	GE Americom K2 ID slate

GE-2 (GE2) 85° West

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

GE-3 (GE3) 87° West

1	11720-H	Data transmissions
2	11740-V	Data Transmissions
5	11800-H	Unknown User [digital video]
10	11900-V	National Technology University (NTU) [Spectrumsaver]
11	11920-H	Data transmissions
13	11960-H	Occ video
17	12040-H	Oregon EdNet
18	12060-V	PBS leased digital services
19	12080-H	PBS leased analog services (occ) / *The Business Channel (occ)*
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] [4DTV]

Telstar 4 (T4) 89°West

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

Galaxy 3R (G3R) 95° West

Ku-band (11.7-12.2 GHz) side of this satellite is used entirely for the Galaxy Latin American direct-to-home system.

Telstar 5 (T5) 97° West

1	11728.5-V	Data transmissions
2	11735.0-H	Data transmissions
3	11789.5-V	Occ video (half transponders common)
4	11796.0-H	Data transmissions
5	11836.0-V	Unknown User [digital video]
8	11873.5-H	Unknown User [digital video]
9	11898.0-V	Occ video
10	11904.5-H	Unknown User [digital video]
11	11929.0-V	Occ video
12	11935.5-H	Occ video
13	11960.0-V	Occ video
14	11966.5-H	Data transmissions
15	11991.0-V	Unknown User [digital video]
17	12022.0-V	Data transmissions
20	12059.5-H	Occ video
21	12084.0-V	Unknown User [digital video]
23	12115.0-V	Unknown User [digital video]
24	12121.5-V	Occ video
26	12152.5-H	T.C.I. [Digicipher]
27	12177.0-V	Asian TV Network/Business TV [MPEG2/DVB]

Galaxy 4 (K4) 99° West

1	11720-H	Data transmissions
2	11750-V	Data transmissions
3	11750-H	FM^2 services/Muzak/Data transmissions
4	11780-H	FM^2/FM^3 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) (occ)
12	11930-H	Occ video
13	11960-H	CCTV-4 (China)
14	11990-V	Data transmissions
15	11990-H	Fordstar [Digicipher 2]
16	12020-H	FM^2 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 (11740-H), 21 (11900-H), and 23 (12060-H) have failed on this satellite.

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

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

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

GE-1 (GE1) 103° West

1	11720-H	Qualcomm data [digital]
2	11740-V	Data transmissions
3	11760-H	NBC Eastern Time Zone programming
4	11780-V	Data transmissions
6	11820-V	Empire Sports [Wegener digital] Kentucky Educational TV (KET) [Digicipher]
7	11840-H	NBC Pacific Time Zone programming
8	11860-V	Qualcomm data [digital]
9	11880-H	NBC Mountain Time Zone programming
10	11900-V	Qualcomm data [digital]
12	11940-V	Microspace Velocity [digital]
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	Vyvx TV Commmercials distribution [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/Unknown user [digital video]
15	12110-V	CNN Newsource (secondary)/ occ video
16	12171-V	Data transmissions

Anik E2 (A1) 107.3° West

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

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

Solidaridad 1 SD1 109.2° West

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

Anik E1 (A2) 111° West

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

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

Solidaridad 2 (SD2) 112.9° West

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

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

This satellite rarely has any Ku-band video transmissions.

7	11900-V	Occ video

Morelos 2 (M2) 116.8° West

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

Anik C1 (C1) 118.6° West

32	12183-H	Occ video

EchoStar 1/2 & Tempo 1 119°West

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

SBS 5 (SBS5) 123° West

1	11725-H	Unknown User [digital video]
2	11780-H	SCPC services/Data transmissions
3	11823-H	Data transmissions
5	11921-H	Data transmissions
6	11970-H	Data transmissions
7	12019-H	Data transmissions
8	12068-H	Data transmissions/Unknown User [digital video]
9	12117-H	Data transmissions/Unknown User [digital video]
10	12166-H	WalMart [V2+]/Occ video
11	11748-V	Data transmissions/U.S.C. TV [digital]
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	Associated Press TV [MPEG/DVB]	o/v	Sega Channel Interactive [digital]	TVN Theatre 1 [V2+]	Telequest DBS [Digicipher]	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+]	Telequest DBS [Digicipher]	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+]	Telequest DBS [Digicipher]	SCPC services	Data Transmissions	PBS Alaska/Caribbean 7-channel [4DTV]	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+]	Telequest DBS [Digicipher]	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+]	Telequest DBS [Digicipher]	4 Media Company feeds	Data Transmissions	Hero Teleport (GEMS/HTV) [4DTV]	CBS feeds
6	NHK (TV Japan) feeds	Kuwait TV	(none)	Infomercials/Hollywood Treasures (shopping)	Game Show Network [V2+]	TVN Theatre 6/TVN Promo [V2+]	Telequest DBS [Digicipher]	Shepherd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	WNBC-NBC New York (PT24E) [V2+]	o/v
7	Video Catalog Channel (VCC)	Data Transmissions	Data Transmissions	Adam and Eve/Spice (adult)/Hot Spice [Digicipher]	The Golf Channel [V2+]	Guthy-Renker TV (infomercials)/TVN Theatre 7 [V2+]	o/v	o/v	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/TVN Theatre 8 [V2+]	ABC NewsOne Channel	Telemundo Telenoticias [PowerVu]	KOMO- ABC Seattle (PT24W) [V2+]	SC Chicago [V2+]	o/v
9	MuchMusic U.S. [V2+]	NASA TV	WPIX-Ind New York [V2+]	Horse Racing [digital video]	CBS Eye on People Network [PowerVu]	TVN Theatre 9-adulTVision (adult) [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	o/v	FOX Feed	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+]	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] ACN	Romance Classics [V2+]	RAI TV Infomericals	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]	CNN feeds	ABC feeds	Independent Film Channel [V2+]	X!/XXXplore 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	SC Alternate/o/v	o/v
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+]	Global TV [PowerVu]
17	o/v	Data Transmissions	FM2 services	FOX feeds	(none)	Cinemax 2 East [V2+]	o/v	CBS feeds [occ VC1]	(none)	SC Alternates (occ)	CBC-D feeds
18	EWTN International Alabama Cable Network [Powervu]	o/v	o/v	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+]	Data Transmissions/Unknown user [digital video]
19	University Network-Dr. Gene Scott (Rel)	Data Transmissions	Fox Sports Detroit [V2+]	Natl Jewish TV/Exotica Promo (adult)	CBS East [occ VC1]	HBO 3 [V2+]	America's Collectibles Network	CBS East [occ VC1]	(none)	National Empowerment TV (Net)	Telesat [PowerVu]
20	o/v	o/v	Gem Shopping Channel	(none)	FOX News Channel	HBO 2 West [V2+]	o/v	CBS East [occ VC1]	(none)	AFRTS [Powervu]	(Inactive)
21	o/v	o/v	Fox Sports World [V2+]	ABC feeds West [LEITCH]	BET on Jazz	Superstar Programming Promo/o/v	ABC West Hot Backup [LEITCH]	CBS feeds/o/v	Data Transmissions	Univision feeds (occ)	Telesat [PowerVu]
22	Horse Racing [digital video]	Arab Network of America (ANA)	(none)	ABC feeds East [LEITCH]	(none)	Horse Racing [digital video]	ABC East Hot Backup [LEITCH]	o/v	Data Transmissions	Deutsche Welle TV	o/v
23	Worship TV/Praise TV (Rel) [MPEG2/DVB]	NHK Secondary Feeds	(none)	FOX feeds/ABC 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] ACN o/v	o/v	CBS Newspath	KPIX-CBS San Francisco (PT24W) [V2+]	WSEE-CBS Erie, PA (PT24E) [V2+]	CTV [PowerVu]

Satellite Transponder Guide

By Robert Smathers

Solidaridad 1 (SD1) 109.2º	Telesat E1 (A2) 111º	Solidaridad 2 (SD2) 112.9º	Morelos 2 (M2) 116.8º	Galaxy 9 (G9) 123º	Galaxy 5 (G5) 125º	Satcom C3 (F3) 131º	Galaxy 1R (G1) 133º	Satcom C4 (F4) 135º	Satcom C1 (F1) 137º	
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+]	Various Fox Sports Nets [V2+]	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	Data Transmissions	Showtime/TMC/SDC (West) [4DTV]	CNN [V2+]	Odyssey (Rel)	Classic Arts Showcase	Product Information Network	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+]	Fox Sports Net [V2+]	Eternal Word TV Network (Rel)	SpeedVision	(none)	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/T.C.M./CNN Spanish [4DTV]	Animal Planet [V2+]	SC Florida [V2+]	15
Data Transmission	(Inactive)	Data Transmissions	XEIMT canal 22	General Communication [digital video]	Cinemax West [V2+]	M2: Music Television	Turner Classic Movies [V2+]	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/SDC (East) [4DTV]	Cinemax East [V2+]	C-SPAN 2 [analog]/CSPAN 3 [digital]	FOXNet [V2+]	19
Data Transmissions	(Inactive)	(none)	Data Transmissions	General Communication [digital video]	BET [V2+]	Jones Computer/GAC/PIN [4DTV]	Home and Garden Network [V2+]	Showtime East 2 [V2+]	Unknown User [digital video]	20
(none)	SCPC services/Data Transmissions	(none)	Mexican Cable [Digicipher]	ESPNews [V2+]	Knowledge TV	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	FOX Sports West 2 [V2+]	21
(none)	(Inactive)	(none)	XHIMT canal 7	o/v	CNN/HN [V2+]	Animal Planet/Discovery Channel Services [Digicipher]	Nostalgia-Good TV Channel [V2+]	FLIX [V2+]	SSN FOX Sports NW [V2+] (occ)	22
(none)	(Inactive)	Data Transmissions	Mexican Cable [Digicipher]	(none)	A&E [V2+]	E! Entertainment TV (East) [V2+]/E! (West) [PowerVu]	HBO/Cinemax [4DTV]	VH-1 [V2+]	KWGN-Ind Denver [V2+]	23
Unknown User [digital video]	(Inactive)	(none)	XHDF canal 13	General Communication [digital video]	Showtime/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)

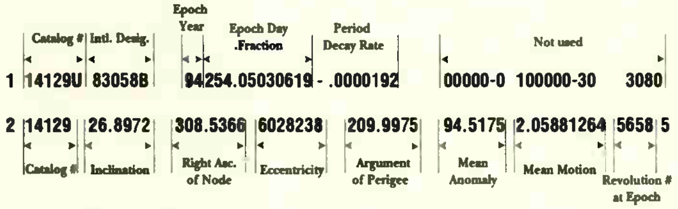
Not available in U.S. (black)

o/v = occasional video

Amateur and Weather Satellite Two-Line Orbital Element Sets

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

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



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

AMATEUR RADIO SATELLITES
OSCAR 10 (AMSAT OSCAR 10, AO-10)
1 14129U 83058B 97364.20594789 -.00000076 00000-0 10000-3 0 5257
2 14129 26.5297 109.5624 6017685 180.3162 178.8336 2.05880558 81423
OSCAR 11 (UoSAT 2, UoSAT 11, UOSAT OSCAR-11, UO-11)
1 14781U 84021B 97362.96718877 .00000224 00000-0 45539-4 0 265
2 14781 97.8568 336.6578 0012812 97.6990 262.5671 14.69641685739860
Russian Mir Space Station
1 16609U 86017A 97365.12810806 .00004867 00000-0 61976-4 0 1305
2 16609 51.6566 175.3858 0008378 144.6662 215.4928 15.61394989677775
OSCAR 16 (PACSAT, AMSAT OSCAR-16, AO-16)
1 20439U 90005D 97364.72629107 -.00000004 00000-0 15108-4 0 1171
2 20439 98.5265 85.3981 0011801 355.8038 4.3039 14.30033946414328
OSCAR 17 (DOVE, DOVE OSCAR-17, DO-17)
1 20440U 90005E 97364.20279986 -.00000002 00000-0 16089-4 0 1157
2 20440 98.5317 85.8896 0012022 355.9387 4.1706 14.30177735414281
OSCAR 18 (WEBERSAT, WEBERSAT OSCAR-18, WO-18)
1 20441U 90005F 97363.22575180 -.00000014 00000-0 11348-4 0 1228
2 20441 98.5295 84.8027 0012580 358.9047 1.2106 14.30143305414140
OSCAR 19 (LUSAT, LUSAT OSCAR-19, LO-19)
1 20442U 90005G 97363.24713263 .00000053 00000-0 37042-4 0 1206
2 20442 98.5329 85.6061 0013011 357.3343 2.7762 14.30261983414178
OSCAR 20 (JAS 1B, FUJI 2, FUJI OSCAR 20, FO-20)
1 20480U 90013C 97362.86807598 .00000038 00000-0 16674-3 0 208
2 20480 99.0718 288.0455 0539962 296.6781 58.0000 12.83242543369673
RS-12/13 (Radio Sputnik 12/13, Cosmos 2123)
1 21089U 91007A 97362.42065399 .00000022 00000-0 73322-5 0 326
2 21089 82.9221 134.6084 0030434 115.0779 245.3541 13.74090021345830
OSCAR 22 (UoSAT-F, UoSAT-5, UOSAT OSCAR 22, UO-22)
1 21575U 91050B 97364.72907596 .00000017 00000-0 19637-4 0 8255
2 21575 98.2755 58.0594 0008380 26.5899 333.5692 14.37105910338711
OSCAR 23 (KITSAT-A, KITSAT-1, KITSAT OSCAR-23, KO-23)
1 22077U 92052B 97365.22944413 -.00000037 00000-0 10000-3 0 7145
2 22077 66.0819 92.6744 0002145 358.1925 1.9085 12.86306394253091
OSCAR 27 (EYESAT-A, EYESAT-1, AMSAT OSCAR-27, AO-27
1 22825U 93061C 97364.22012161 .00000003 00000-0 18621-4 0 6095
2 22825 98.5266 73.8894 0009484 29.6861 330.4854 14.27750470222047
OSCAR 26 (ITAMSAT, ITAMSAT OSCAR-26, IO-26)
1 22826U 93061D 97364.73403671 .00000033 00000-0 30771-4 0 6062
2 22826 98.5270 74.6887 0009847 29.2285 330.9446 14.27861674222134
OSCAR 25 (KITSAT-B, KITSAT-2, KITSAT OSCAR-25, KO-25)
1 22828U 93061F 97365.21132646 .00000016 00000-0 23625-4 0 5856
2 22828 98.5231 75.2496 0010748 12.2275 347.9161 14.28208400190330
OSCAR 28 (POSAT, POSAT OSCAR-28, PO-28)
1 22829U 93061G 97363.27286422 .00000037 00000-0 32130-4 0 6016
2 22829 98.5224 73.4656 0010351 18.6925 341.4653 14.28194700221970
RS-15 (Radio Sputnik 15)
1 23439U 94085A 97364.52963421 -.00000039 00000-0 10000-3 0 2707
2 23439 64.8110 195.3533 0145979 94.1591 267.6025 11.27529320124070
OSCAR 29 (FUJI 3, FUJI OSCAR-29, FO-29)
1 24278U 96046B 97364.52956248 -.00000035 00000-0 -14755-5 0 1313
2 24278 98.5176 18.7637 0352320 37.3661 325.1429 13.52636466 67667
RS-16 (Radio Sputnik 16)
1 24744U 97010A 97362.20419811 .00005174 00000-0 16362-3 0 1283
2 24744 97.2618 263.6275 0008353 106.8027 253.4132 15.33190896 45790

WEATHER/IMAGING SATELLITES
Geostationary Satellites
GOES 7 (Standby Geostationary Spacecraft-USA)
1 17561U 87022A 97364.24916897 -.00000129 00000-0 10000-3 0 4413
2 17561 4.1420 65.7171 0002475 227.8144 156.5366 1.00266506 22930
GOES 8 (Operational East-USA)
1 23051U 94022A 97353.21462878 -.00000252 00000-0 10000-3 0 9717
2 23051 0.3986 91.7581 0005048 175.2274 183.3102 1.00265999 20882
GOES 9 (Operational West-USA)
1 23581U 95025A 97364.28052384 .00000095 00000-0 00000+0 0 7318
2 23581 0.0110 181.9384 0004360 104.8653 137.7230 1.00278676 9556
GOES 10 (Standby Geostationary Spacecraft-USA)
1 24786U 97019A 97364.26257108 -.00000076 00000-0 00000+0 0 1538
2 24786 0.0121 16.6006 0007049 289.9623 140.9976 1.00262390 2529
ELEKTRO (Operational-Russia)
1 23327U 94069A 97359.64828704 -.00000086 00000-0 00000+0 0 4277
2 23327 1.1706 89.3361 0004583 174.3924 139.8632 1.00271533 11572
Feng Yun 2B (Operational-China)
1 24834U 97029A 97359.71490877 -.00000318 00000-0 00000+0 0 1011
2 24834 0.8086 256.0792 0000083 289.8213 270.3601 1.00281659 1989
Meteosat 5 (Operational ESA, aka MOP-2)
1 21140U 91015B 97364.17850694 -.00000070 00000-0 00000+0 0 4052
2 21140 1.6722 78.6404 0008475 145.2923 289.7712 1.00272753 27234
Meteosat 6 (Operational-ESA)
1 22912U 93073B 97364.30119792 .00000004 00000-0 00000+0 0 9396
2 22912 0.3359 308.8820 0001132 257.2911 1.2027 1.00265889 13488
Meteosat 7 (Operational ESA)
1 24932U 97049B 97364.88407714 -.00000076 00000-0 00000+0 0 834
2 24932 1.5773 290.3066 0003794 343.0409 134.0369 1.00273144 1219
GMS 4 (Standby-Japan, aka Himawari 4)
1 20217U 89070A 97364.50601045 -.00000359 00000-0 10000-3 0 6906
2 20217 2.8953 72.2708 0000658 311.0366 18.0392 1.00269441 31044
GMS 5 Operational-Japan, aka Himawari 5)
1 23522U 95011B 97344.27831341 -.00000290 00000-0 10000-3 0 5347
2 23522 0.4111 355.3700 0002478 240.5569 83.0495 1.00260353 9871

Near Polar/Polar Orbiting Imaging Spacecraft
NOAA 12 (Operational morning spacecraft-USA 137.500 MHz)
1 21263U 91032A 97364.92439145 .00000114 00000-0 69526-4 0 6495
2 21263 98.5322 13.1128 0013859 80.9758 279.2990 14.22778747344338
NOAA 14 (Operational afternoon spacecraft-USA 137.620 MHz)
1 23455U 94089A 97364.85194012 .00000128 00000-0 95248-4 0 3096
2 23455 99.0171 316.8289 0010233 95.9428 264.2918 14.11725358154695
Meteor 2-21(Off at last report)
1 22782U 93055A 97362.27359354 .00000048 00000-0 30068-4 0 6134
2 22782 82.5491 264.0397 0021034 209.6257 150.3713 13.83088931218414
Meteor 3-5 (Operational-Russia 137.850 MHz)
1 21655U 91056A 97361.34744703 .00000051 00000-0 10000-3 0 315
2 21655 82.5508 286.2414 0012579 215.0353 144.9941 13.16858149306130
Meteor 3-6 (Off at last report)
1 22969U 94003A 97363.15465410 .00000051 00000-0 10000-3 0 3981
2 22969 82.5631 225.4048 0014436 281.3209 78.6291 13.16753096188745
DMSP B5D2-7 (DoD meteorological polar orbiter: downlink encrypted)
1 23233U 94057A 97364.90774053 .00000162 00000-0 11025-3 0 5001
2 23233 98.7531 59.1789 0013322 28.8086 331.3816 14.12870648172141
DMSP B5D2-8 (DoD meteorological polar orbiter: downlink encrypted)
1 23533U 95015A 97364.91167165 .00000086 00000-0 69895-4 0 2494
2 23533 98.8498 6.5071 0006461 266.0208 94.0229 14.12828094142949
DMSP B5D2-9 (DoD meteorological polar orbiter: downlink encrypted)
1 24753U 97012A 97364.88912229 .00000089 00000-0 71607-4 0 2995
2 24753 98.9101 48.4700 0008236 209.3099 150.7612 14.13025779 38164

EARTH RESOURCES IMAGING SATELLITES
OKEAN 1-7 (Okean 4-Russia 137.400 MHz)
1 23317U 94066A 98001.43983825 .00000323 00000-0 45331-4 0 2947
2 23317 82.5431 260.8058 0027800 50.9166 309.4529 14.74179211173510
SICH-1 (Oceanographic satellite-Russia 137.400 MHz)
1 23657U 95046A 98003.17086907 .00000297 00000-0 41952-4 0 2238
2 23657 82.5336 40.4798 0028482 18.4135 341.8098 14.73634391126036
IRS-1C (Remote Sensing-India)
1 23751U 95072A 98002.65002103 -.00000044 00000-0 00000+0 0 2820
2 23751 98.6898 79.9059 0000899 91.8463 268.2817 14.21641565104637
IRS-P3 (Remote Sensing-India)
1 23827U 96017A 98003.83075780 -.00000044 00000-0 00000+0 0 2499
2 23827 98.6988 84.8991 0001134 99.1602 260.9705 14.21631935 92855
TOMS-EP (Total Ozone Mapping Spectrometer-USA)
1 23940U 96037A 98002.30032217 .00000190 00000-0 66993-4 0 2046
2 23940 98.3847 271.9647 0005846 194.6880 165.4142 14.45007321 83285
IRS-1D
1 24971U 97057A 98002.59950926 .00000049 00000-0 33414-4 0 1157
2 24971 98.6168 80.3593 0063169 92.0251 268.8169 14.32777903 13721

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

AMSAT OSCAR 10 (AO-10)
Uplink 435.030-435.180 MHz (CW/LSB)/Downlink 145.975-145.825 MHz (CW/USB)/Beacon: 145.810 MHz (Steady unmodulated carrier)

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

AMSAT OSCAR 16/PACSAT (AO-16)
Uplinks 145.900, 145.920, 145.940 and 145.960 MHz FM, 1200 bps Manchester FSK/Downlinks 437.0513 and 437.025 (secondary) MHz SSB, 1200 bps RC-BPSK and 1200 baud PSK/Beacon 2401.1428 MHz

DOVE (DO-17)
Downlink 145.825 MHz FM, 1200 baud AFSK/Beacon 2401.220 MHz. DOVE is presently sending 1200 baud AX.25 (standard packet) ASCII telemetry about every minute on two meters. On S-band it transmits PSK flags continuously and also the same data that is sent on 2 meters.

WEBERSAT (WO-18)
Downlink 437.104 MHz SSB, 1200 baud PSK AX.25

LUSAT (LU-19)
Uplink 1200 bps Manchester FSK: 145.840, 145.860, 145.880 and 145.900/Downlinks 437.125 and 437.150 (secondary) MHz SSB, 1200 bps RC-BPSK

Fuji OSCAR 20 (FO-20)
JA mode: Uplink 145.900-146.000 MHz (CW/LSB)/Downlink 435.800-435.900 MHz (CW/USB). FO-20 in mode JA continuously.

OSCAR 22 (UO-22)
Uplink 145.900 or 145.975 MHz FM/Downlink 435.120 MHz FM 9600 baud FSK

KITSAT 23 (KO-23)
Uplink 145.850 and 145.900 MHz FM/Downlink 435.175 MHz FM 9600 baud FSK

KITSAT (KO-25)
Uplink 145.980 MHz FM/Downlink 436.5 MHz FM, 9600 baud FSK

ITAMSAT (IO-26)
Uplink 145.875, 145.900, 145.925 and 145.950 MHz FM/Downlink 435.822 MHz SSB, 1200 baud PSK

OSCAR 27 (AO-27)
Uplink 145.85 MHz FM/Downlink 436.792 MHz FM

Fuji OSCAR 29 (FO-29)
Voice/CW Mode JA: Uplink 145.900-146.000 MHz (CW/LSB)/Downlink 435.800-435.900 MHz (CW/USB). Digital Mode JD: Uplink 145.850, 145.870 and 145.910 MHz FM/Downlink 435.910 MHz FM 9600 baud BPSK

Radio Sputnik 10 (RS-10)
Uplink 145.865-145.905 MHz (CW/SSB)/Downlink 29.360-29.400 MHz (CW/SSB) Not operational at this time.

Radio Sputnik 12 (RS-12)
Uplink 145.910-145.950 MHz (CW/SSB)/Downlink 29.410-29.450 MHz. Operational, now in mode A.

Radio Sputnik 15 (RS-15)
Uplink 145.858-145.898 MHz (CW/SSB)/Downlink 29.354-29.394 MHz (CW/SSB)

Radio Sputnik 16 (RS-16)
Uplink 145.915-145.948 MHz/Downlink 29.415-29.448 MHz, HF Beacons 29.408 and 29.451 MHz, UHF Beacon 1 435.504 MHz, UHF Beacon 2 435.548 MHz

Radio Sputnik 17/Sputnik 40 (RS-17)
Downlink 145.820 MHz

MIR Space Station
Uplink: 437.850 MHz/Downlink: 145.800 MHz
From March 1, 1998 the SAFEX MIR 70-cm repeater will be operational. Uplink 435.750 MHz FM/Downlink 437.950 MHz FM, subaudible tone 141.3 Hz

Geostationary Satellite Locator Guide

By Larry Van Horn

This guide shows the orbital locations of 260 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
22912	1993-073B Meteosat 6 (MOP 3) (ESA)	0.6E#	Met (L)
23730	1995-067A Telecom 2C (France)	2.9E	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)	5.0E#	Reg BSS (Ku)
20193	1989-067A Sirius/Marcopolo 1(BSB R-1)	5.1E	Reg BSS (Ku)
25049	1997-071A Sirius 2 (Sweden)	5.0E	Reg BSS (Ku)
22921	1993-076A USA 98 (NATO 4B)	5.9E/i	Mil-Comm (P/S/X)
22028	1992-041B Eutelsat II F4	6.9E	Reg FSS (Ku)
21056	1991-003B Eutelsat II F2	10.0E	Reg FSS (Ku)
22269	1992-088A Cosmos 2224 (Russia)	11.7E#	Mil-Earl Warning (X)
22557	1993-013A Raduga 29 (Russia)	12.0E/i	Dom FSS/Gov-Mil (X/C)
19596	1988-095A Raduga 22 (Russia)	12.3E/i	Dom FSS/Gov-Mil (X/C)
24208	1996-044A Italsat 2 (Italy)	13.1E#	Dom-Telephone/Mob (L/S/K/Ka)
23537	1995-016B Eutelsat II F6 (Hot Bird 1)	13.1E	Reg BSS (Ku)
21055	1991-003A Italsat 1 (Italy)	13.2E#	Dom-Telephone (S/K/Ka)
20777	1990-079B Eutelsat II F1	13.3E	Reg FSS (Ku)
24665	1996-067A Eutelsat II F7 (Hot Bird 2)	13.3E	Reg BSS (Ku)
24931	1997-049A Hot Bird 3	13.6E	Reg BSS (Ku)
21803	1991-083A Eutelsat II F3	16.0E	Reg FSS (Ku)
23842	1996-021A Astra 1F	19.1E	Reg BSS (Ku)
25071	1997-076A Astra 1G	19.1E	Reg BSS (Ku)
22653	1993-031A Astra 1C	19.3E	Reg BSS (Ku)
23331	1994-070A Astra 1D	19.3E	Reg BSS (Ku)
23686	1995-055A Astra 1E	19.4E	Reg BSS (Ku)
19688	1988-109B Astra 1A	19.4E	Reg BSS (Ku)
21139	1991-015A Astra 1B	19.5E	Reg BSS (Ku)
19331	1988-063B Eutelsat 1 F5 (ECS 5)	21.5E/i	Reg FSS (VHF/Ku)
22175	1992-066A DFS 3 (Germany)	23.5E	Dom BSS (S/Ku/K)
18351	1987-078B Eutelsat 1 F4 (ECS 4)	25.4E/i	Reg FSS (VHF/Ku)
20659	1990-054A Gorizont 20 (Russia)	25.4E/i	Dom/Gov FSS (C/Ku)
23948	1996-040A Arabsat 2A (Arabsat)	26.0E	Reg FSS/BSS (C/Ku)
20706	1990-063B DFS 2/Kopernikus (Germany)	28.5E	Dom BSS (S/Ku/K)
24652	1996-062A Arabsat 2B (Arabsat)	30.6E	Reg FSS/BSS (C/Ku)
23200	1994-049B Turksat 1B (Turkey)	31.3E	Reg FSS (Ku)
15629	1985-025A Intelsat 510	32.8E/i	Int FSS (C/Ku)
20263	1989-081A Gorizont 19 (Russia)	33.5E/i	Dom/Gov FSS (C/Ku)
21821	1991-087A Raduga 28 (Russia)	34.5E/i	Dom FSS/Gov-Mil (X/C)
23717	1995-063A Gals 2 (Russia)	35.9E	Dom BSS (Ku)
22963	1993-002A Gals 1 (Russia)	35.9E	Dom BSS (Ku)
20929	1990-095A USA 65 (DSP F15) (US)	37.4E#	Mil-Early Warning (S/X)
23775	1996-005A Gorizont 31 (Russia)	39.9E#	Dom/Gov FSS (C/Ku)
23949	1996-040B Turksat 1C (Turkey)	42.0E	Reg FSS (Ku)
19874	1989-020A JCSAT 1 (Japan)	45.7E#/d	Dom FSS (Ku)
22981	1994-008A Raduga 1-3 (Russia)	49.0E#	Dom FSS/Gov-Mil (X/C)
23880	1996-034A Gorizont 32 (Russia)	52.7E#	Dom/Gov FSS (C/Ku)
19687	1988-109A Skynet 4B (UK)	52.8E/i	Mil-Comm (P/S/X/Ka)
25045	1997-070A Kupon 1 (CIS)	55.0E	Dom FSS (Ku)
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	56.9E	Int FSS (C/Ku)
20667	1990-056A Intelsat 604	60.1E	Int FSS (C/Ku)
22913	1993-074A USA 97 (DSCS III B10) (US)	60.0E/i	Mil-IOR primary operational (P/S/X)
24742	1997-009A Intelsat 801	61.9E	Int FSS (C/Ku)
20315	1989-087A Intelsat 602	61.9E	Int FSS (C/Ku)
23839	1996-020A Inmarsat 3 F1	63.9E#	Int Mar (L/C)
25110	1997-083A Intelsat 804	64.0E	Int FSS (C/Ku)
21814	1991-084B Inmarsat 2 F3	64.9E#	Int Mar-POR (L/C)
23461	1995-001A Intelsat 704	65.9E	Int FSS (C/Ku)
23636	1995-040A PanAmSat 4 (PAS 4)	68.4E	Int FSS (C/Ku)
23448	1994-087A Raduga 32 (Russia)	70.2E#	Dom FSS/Gov-Mil (X/C)
22787	1993-056A USA 95 (UFO-2) (US)	71.0E/i	Mil-IOR primary (P/S)
10669	1978-016A Ops 6391 (FltSatCom 1) (US)	72.5E/i	Mil-IOR Reserve (P-Alpha/S/X)
23589	1995-027A USA 111 (UFO-5) (US)	72.5E/i	Mil-IOR reserve (P/S/K)
08882	1976-053A Marisat 2 (US)	72.9E/i	Int Mar-IOR (P/L/C)
13595	1982-097A Intelsat 505	73.5E/i	Int FSS/Mar (L/C/Ku)
22027	1992-041A Insat 2A (India)	73.7E	Dom FSS/BSS/Met (S/C)
21894	1992-010B Arabsat 1C (India)	74.0E#	Reg FSS/BSS (S/C)
23327	1994-069A Elektro 1 (Russia)	75.9E#	Met (L)
25010	1997-062A Apstar 2R (China)	76.0E	Dom FSS (C/Ku)
23680	1995-054A Luch 1-1 (Russia)	77.3E#	Tracking & Relay SDRN-2 (Ku)
24768	1997-016A Thaicom 3 (Thailand)	78.3E	Reg FSS (C/Ku)
23314	1994-065B Thaicom 2 (Thailand)	78.4E	Reg FSS (C/Ku)
21759	1991-074A Gorizont 24 (Russia)	79.7E/i	Dom/Gov FSS (C/Ku)
23653	1995-045A Cosmos 2319 (Russia)	79.9E#	Data Relay (C)
24435	1996-058A Express 2 (Russia)	79.9E	Int FSS (C/Ku)
20643	1990-051A Insat 1D (India)	82.6E	Dom FSS/BSS/Met (S/C)
18922	1988-014A Zhongxing 1 (DFH2A-1/PRC-22) (China)	85.0E/i	Dom FSS (C)
22836	1993-062A Raduga 30 (Russia)	85.3E#	Dom FSS/Gov-Mil (X/C)
19548	1988-091B TDRS F3 (US)	84.6E/i	Gov-Tracking & Relay (C/S/Ku)
22880	1993-069A Gorizont 28 (Russia)	89.9E#	Dom/Gov FSS (C/Ku)
23765	1995-003A Measat 1 (Malaysia)	91.2E	Dom FSS/BSS (C/Ku)
23731	1995-067B Insat 2C (India)	93.1E	Dom FSS/BSS/Met (S/C/Ku)
22724	1993-048B Insat 2B (India)	93.2E	Dom FSS/BSS/Met (S/C)
22245	1992-082A Gorizont 27 (Russia)	95.9E/i	Dom/Gov FSS (C/Ku)
20473	1990-011A Zhongxing 3 (DFH2A-3/PRC-26) (China)	98.4E#	Dom FSS (C)
22210	1992-074A Ekran 20 (Russia)	99.3E/i	Dom BSS (P)
23723	1995-064A AsiaSat 2	100.4E	Reg FSS (C/Ku)
21922	1992-017A Gorizont 25 (Russia)	103.1E/i	Dom/Gov FSS (C/Ku)
24834	1997-029A Fengyun 2B (China)	103.6E#	Met (L)
20558	1990-030A Asiasat 1	105.6E	Reg FSS (C/Ku)
25050	1997-071B Indostar 1 (Indonesia)	107.7E	BSS (L/S)
20570	1990-034A Palapa B2R (Indonesia)	108.0E	Reg FSS (C)
23176	1994-040B BS-3N (Japan)	108.8E	Dom BSS (Ku)
24769	1997-016B BSAT-1A (Japan)	109.6E	Dom BSS (Ku)
20771	1990-077A BS-3A (Yuri 3A)(Japan)	109.6E	Dom BSS (Ku)
21668	1991-060A BS-3B (Yuri 3B)(Japan)	110.1E	Dom BSS (Ku)
19710	1988-111A Zhongxing 2 (DFH2A-2/PRC-25) (China)	110.8E/i	Dom FSS (C)
23864	1996-030A Palapa C2 (Indonesia)	112.7E	Reg FSS (C/Ku)
14985	1984-049A Zhongxing 5 (Chinasat 5/Spacenet 1)	115.3E#	Dom FSS (C/Ku)
23639	1995-041A Koreasat 1 (Mugunghwa 1)	115.6E	Dom FSS/BSS (Ku)
23768	1996-003A Koreasat 2 (Mugunghwa 2)	115.6E	Dom FSS/BSS (Ku)
21964	1992-027A Palapa B4 (Indonesia)	117.6E	Reg FSS (C)
20217	1989-070A GMS-4 (Himawari 4) (Japan)	119.7E/i	Met (P/L)
22931	1993-078B Thaicom 1 (Thailand)	119.9E	Reg FSS (C/Ku)
23108	1994-030A Gorizont 30 (Rimsat 2)	122.0E#/d	Reg FSS (C/Ku)
24798	1997-021A Zhongxing 8 (DFH 3-2) (China)	125.0E	Dom (C)
21132	1991-014A Raduga 27 (Russia)	127.4E/i	Dom FSS/Gov-Mil (X/C)
23649	1995-043A JCSAT 3 (Japan)	127.9E	Dom FSS (Ku)
23651	1995-044A N-Star 1 (Japan)	131.9E	Dom/Mob FSS (S/C/Ku/Ka)
23943	1996-039A Apstar 1A (China)	134.0E	Reg FSS (C)
23781	1996-007A N-Star 2 (Japan)	135.9E	Dom/Mob FSS (S/C/Ku/Ka)
23185	1994-043A Apstar I (China)	137.9E	Dom BSS (C)
23522	1995-011B GMS-5 (Himawari 5) (Japan)	140.0E#	Met (P/L)
20953	1990-102A Gorizont 22 (Russia)	140.1E/i	Dom/Gov FSS (C/Ku)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
17706	1987-029A Palapa B2P (Indonesia)	142.4E#	Reg FSS (C)
24880	1997-036A Superbird C (Japan)	143.8E	Dom FSS (Ku/K)
20923	1990-094A Gorizont 21 (Russia)	144.5E/i	Dom/Gov FSS (C/Ku)
20066	1989-046A USA 39 (DSP F14) (US)	145.4E/i	Mil-Early Warning (S/X)
24901	1997-042A Agila 2 (Mabuhay 1) (Philippines)	145.9E	Dom FSS (C/Ku)
24653	1996-063B Measat-2 (Malaysia)	147.9E	Dom FSS/BSS (C/Ku)
24732	1997-007A JCSAT 4 (Japan)	150.0E#	Dom FSS (Ku)
25067	1997-075A JCSAT-5 (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)
20402	1990-001B JCSAT 2 (Japan)	153.9E	Dom FSS (Ku)
23227	1994-055A Optus B3 (Australia)	155.9E	Dom BSS/Mob (L/Ku)
12994	1981-119A Intelsat 503	157.0E/i	Int FSS (C/Ku)
22253	1992-084A Superbird A1 (Japan)	157.9E	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)	160.6E#	Reg 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)	171.3E/i	Mil-POR reserve (P-Bravo/S/X)
24846	1997-031A Intelsat 802	173.9E	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	177.0E	Int FSS (C/Ku)
24674	1996-070A Inmarsat 3 F3	178.3E#	Int Mar (L/C)
20918	1990-093A Inmarsat 2 F1	178.9E#	Int Mar-IOR (L/C)
16117	1985-092C USA 12 (DSCS III B5) (US)	180.0E/i	Mil-WPAC reserve operational (P/S/X)
22871	1993-066A Intelsat 701	179.9W	Int FSS (C/Ku)
19121	1988-040A Intelsat 513	177.1W#	Int FSS (C/Ku)
23467	1995-003A USA 108 (UFO-4) (US)	177.1W/i	Mil-POR (P/S/K)
21639	1991-054B TDRS F5 (US)	174.4W	Int FSS/Gov-Tracking & Relay (C/S/Ku)
23613	1995-035B TDRS F7 (US)	170.9W#	Int FSS/Gov-Tracking & Relay (C/S/Ku)
18631	1987-100A Raduga 21 (Russia)	170.6W/i	Dom FSS/Gov-Mil (X/C)
20499	1990-016A Raduga 25 (Russia)	170.5W/i	Dom FSS/Gov-Mil (X/C)
21392	1991-037A Satcom C5 (Aurora II)(US)	139.0W	Dom FSS (C)
20945	1990-100A Satcom C1 (US)	137.0W	Dom FSS (C)
23581	1995-025A GOES 9 (US)	135.4W	Met (P/L/S)
21873	1992-006A USA 78 (DSCS III B14) (US)	135.0W/i	Mil-EPAC primary operational (P/S/X)
22096	1992-057A Satcom C4 (US)	134.5W	Dom FSS (C)
23016	1994-013A Galaxy 1R (US)	132.9W	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)	119.2W	Dom BSS (Ku)
23754	1995-073A EchoStar 1 (US)	119.0W	Dom BSS (Ku)
24748	1997-011A Tempo 2 (US)	118.8W	Dom BSS (Ku)
16274	1985-109B Morelos 2 (Mexico)	116.8W	Dom FSS (C/Ku)
14133	1983-059B Anik C2 (Canada)	115.0W	Dom (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)	106.4W/i	Mil-Experimental (P/Ka)
15677	1985-035A Gstar 1 (US)	105.0W#	Dom FSS (Ku)
20946	1990-100B Gstar 4 (US)	105.0W	Dom FSS (Ku)
19483	1988-081A Gstar 3 (US)	105.0W/i	Dom FSS/Mob (L/Ku)
24786	1997-019A GOES 10 (USA)	104.7W	Met (P/L/S)
03029	1967-111A ATS 3 (US)	104.5W/i	Experimental (VHF/C)
23696	1995-057A USA 114 (UFO-6) (US)	104.5W/i	Mil-CONUS (P/S/K)
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)	101.2W	Dom FSS (C/Ku)
23553	1995-019A AMSC 1 (US)	100.9W	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)	100.3W	Experimental (C/K/Ka)
17181	1986-096A USA 20 (FltSatCom F7)(US)	99.2W/i	Mil-CONUS (P/S/X/K)
22694	1993-039A Galaxy 4 (US)	99.0W	Dom FSS (C/Ku)
17561	1987-022A GOES 7 (US)	97.9W/i	Met (P/L/S)
24812	1997-026A Telstar 5 (US)	97.0W	Dom FSS (C/Ku)
08746	1976-023A LES 8 (US)	95.7W/i	Mil-Experimental (P/Ka)
23741	1995-069A Galaxy 3R (US)	95.1W	Dom/BSS (C/Ku)
25086	1997-078A Galaxy 8i (US)	95.0W	BSS (Ku)
16650	1986-026B SBTS 2 (Brazil)	92.0W#	Dom FSS (C)
22205	1992-072A Galaxy 7 (US)	91.0W	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)	84.9W	Dom FSS (C/Ku)
18951	1988-018A Spacenet 3R (US)	83.2W	Dom FSS (C/Ku)
16276	1985-109D Satcom K2 (US)	81.0W#	Dom FSS (Ku)
15561	1985-015B SBTS 1 (Brazil)	79.0W/i	Dom FSS (C)
15235	1984-093B SBS 4 (US)	77.0W/i	Dom FSS (Ku)
12309	1981-018A Comstar D4 (US)	75.7W/i	Dom FSS (C)
23051	1994-022A GOES 8 (US)	74.6W#	Met (P/L/S)
20873	1990-091B Galaxy 6 (US)	74.3W	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)	65.4W	Dom FSS (C/X)
25004	1997-059A Echostar III (US)	61.5W/d	Dom BSS (Ku)
24916	1997-046A PanAmSat 5 (PAS 5)	58.4W	Reg BSS ©
16101	1985-087A Intelsat 512	55.5W/i	Int FSS (C/Ku)
21149	1991-018A Inmarsat 2 F2	55.2W/i	Int Mar-AOR-W (L/C)
24819	1997-027A Inmarsat 3 F4	54.0W	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)	47.1W	Int FSS/Gov-Tracking & Relay (C/S/Ku)
19217	1988-051C PanAmSat 1 (PAS 1)	45.1W	Int FSS (C/Ku)
24891	1997-040A PanAmSat 6 (PAS 6)	43.4W	Int FSS (C/Ku)
23764	1996-002A PanAmSat 3R (PAS 3R)	43.1W	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)	41.0W#	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)	37.6W	Int FSS (Ku)
21765	1991-075A Intelsat 601	34.6W	Int FSS (C/Ku)
20401	1990-001A Skynet 4A (UK)	34.2W/i	Mil-comm (P/S/X/Ka)
14077	1983-047A Intelsat 506	31.3/i	Int FSS/Mar (L/C/Ku)
22723	1993-048A Hispasat 1B (Spain)	30.1W	Dom BSS/FSS (Ku)
22116	1992-060A Hispasat 1A (Spain)	30.0W	Dom BSS/FSS (Ku)
24957	1997-053A Intelsat 803	27.7W	Int FSS (C/Ku)
21653	1991-055A Intelsat 605	26.6W/d	Int FSS (C/Ku)
15386	1984-114B Marecs B2	26.2W/i	Int Mar-AOR (L)
20523	1990-021A Intelsat 603	24.5W	Int FSS (C/Ku)
20253	1989-077A USA 46 (FltSatCom 8) (US)	23.7W/i	Mil-AOR (P-Charlie/S/X/K)
23967	1996-042A USA 127 (UFO-7) (US)	22.8W/i	Mil-AOR (P/S/K)
19772	1989-006A Intelsat 515	21.7W	Int FSS (C/Ku)
21989	1992-032A Intelsat K	21.6W	Int FSS (Ku)
15391	1984-115A NATO III D	18.3W/i	Mil-Comm (P/S/X)
23528	1995-013A Intelsat 705	18.0W	Int FSS (C/Ku)
21047	1991-001A NATO IV A	17.9W/i	Mil-Comm (P/S/X)
21940	1992-021B Inmarsat 2 F4	17.2W/i	Int Mar-AOR-W (L/C)
23426	1994-082A Luch 1 (Russia)	16.1W#	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)	14.3W/i	Mil-AOR primary (P/S)
23319	1994-067A Express 1 (Russia)	14.0W	Int FSS (C/Ku)
23267	1994-060A Cosmos 2291 (Russia)	13.4W#	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)	11.5W/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)	9.4E#	Met (L)
21813	1991-084A Telecom 2A (France)	8.0W	Dom FSS/Gov-Mil (X/C/Ku)
21939	1992-021A Telecom 2B (France)	5.1W	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)	4.1W	Dom FSS (C)
23816	1996-015A Intelsat 707	1.1W	Int FSS (C/Ku)
20776	1990-079A Skynet 4C (UK)	1.0W#	Mil-comm (P/S/X/Ka)
24808	1997-025A Thor 2A	0.8W	Reg BSS (Ku)
20168	1989-062A TV Sat 2 (Germany)	0.6W	Dom BSS (Ku)
20762	1990-074A Thor 1/Marcopolo 2 (BSB R-2)	0.6W	Reg BSS (Ku)

Satellite Launch Schedules

By Keith Stein

Japanese Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1998	H-II (5)	Tanegashima	COMETS

COMETS **Downlink Frequency Assignments**
This satellite will carry S-band, Ka-band (27/21 GHz), and millimeter-band transponders located at 121ºEast longitude in geostationary orbit.

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1998	Delta II	VAFB	Iridium 7 (5 payloads)
February 1998	Delta II (251)	CCAS	Globalstar-1 (4 payloads)
February 1998	Atlas II	CCAS	Eutelsat W1
February 1998	MSLS-4	VAFB	JawSat-1
February 1998	Pegasus XL	WFF	Orbcomm-2 (8 payloads)
February 1998	Delta II	CCAS	GPS IIR-5
February 1998	Taurus	VAFB	STEX (DoD)
March 1998	Pegasus XL	VAFB	SWAS
March 1998	Delta II	VAFB	ARGOS, SUNSAT, & ORSTED
March 1998	Atlas IIAS (152)	CCAS	Intelsat 806
March 1998	Atlas II (132)	CCAS	GBS F8
March 1998	Pegasus XL	VAFB	TRACE (SMEX-4)
March 1998	Athena II (3)	CCAS	CRSS-1
March 1998	Atlas	CCAS	Sky-2
March 1998	Titan II	VAFB	NOAA-K

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

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

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

GBS F8 **Downlink Frequency Assignments**
UHF communications transponder (240-270 MHz), S-band telemetry, and EHF milstar type downlinks.

Globalstar	Downlink Frequency Assignments
L-/S-band User links	1610-1626.5 MHz (user-to-satellite) and 2483.5-2500 MHz (satellite-to-user)
C-band Feeder links	5091-5250 MHz (gateway-to-satellite) and 6875-7055 MHz (satellite-to-gateway)

GPS IIR-5	Downlink Frequency Assignments
L-band	1227.6 (L2), 1381.05 (L3) and 1575.42 (L1) MHz
	S-band TRK 2227.5 MHz

Intelsat 806	Downlink Frequency Assignments
C-band	3.625-4.200 GHz (38 transponders)
Ku-band	10.95-12.75 GHz (6 transponders)

Intelsat C-band satellite beacons 3947.5, 3948, 3952 and 3952.5 MHz
Intelsat Ku-band satellite beacons on 11198 and 11452 MHz

Iridium	Downlink Frequency Assignments
L-band	1616-1626.500 MHz
Ka-band	19.4-19.6 GHz (Ka-band to gateway/earth terminals)
Ka-band	23.18-23.38 GHz (Ka-band intersatellite links)

JawSat **Downlink Frequency Assignments**
This satellite will carry VHF, UHF and S-band downlinks

L-1011 Orbital Sciences Launch Aircraft	Downlink Frequency Assignments
L-band	1480.5 and 1727.5 MHz
S-band	2250.5 MHz
C-band	4583.5 and 5765.0 MHz

NOAA-K	Downlink Frequency Assignments
VHF-band	137.350, 137.5, 137.62 and 137.770 MHz
L-band	1544.5, 1698.0, 1702.5 and 1707.0 MHz
S-band	2247.5 MHz

Orbcomm	Downlink Frequency Assignments
VHF-band	137.560, 137.680 and 137.710 MHz
UHF-band	400.100 MHz

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

SWAS	Downlink Frequency Assignments
S-band	2215.0 MHz

Taurus Launch Vehicle	Downlink Frequency Assignments
S-band TLM	2269.500 and 2288.500 MHz
C-band TRK	5765.000 MHz

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

TRACE	Downlink Frequency Assignments
S-band	2275.3 MHz

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1998	Start 1	Svobodnyy	Odin
February 1998	Soyuz-U	Baikonur	Progress M-38

Satellite Launch Schedules

By Keith Stein

Odin	**Downlink Frequency Assignments**

This satellite will carry a S-band downlink for telemetry and telecommand communications.

Progress M-38	**Downlink Frequency Assignments**
VHF	166.000 MHz
UHF	922.750 and 926.050 MHz

Start 1	**Downlink Frequency Assignments**
VHF-band	75.670 MHz
UHF-band	203.270 and 219.700 MHz

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
February 1998	Ariane 44L (106)	Guiana	Hot Bird-4
March 1998	Ariane 40L (107)	Guiana	SPOT-4 & Nilesat-1

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

Hot Bird 4	**Downlink Frequency Assignments**
Ku-band	10700-10950/12500-12750 MHz

Nilesat-1	**Downlink Frequency Assignments**
Ku-band	11700-12500 MHz

SPDT-4	**Downlink Frequency Assignments**
L-band	1704.0 MHz
S-band	2218.0 MHz
C-band	5745.0 MHz
X-band	8253.0 MHz

List of Abbreviations and Acronyms

Argos	The Advanced Research and Global Observation Satellite will conduct global imaging of the ionosphere with eight experiments during a 3 year mission.
C-band	3700 to 6500 MHz.
CCAS	Cape Canaveral Air Station, FL
COMETS	Japanese Communications & Broadcast Engineering Test Satellite designed to demonstrate new high quality mobile, inter-satellite & broadcasting.
CRSS	Remote sensing satellite
DoD	Department of Defense
Eutelsat	European commercial telecommunications satellite.
GBS F8	Also known as UHF Follow-On, is a U.S. Navy communications satellite replacing the older Fleet Satellite Communications Network (FLTSATCOM).
GHz	Gigahertz
Globalstar	Globalstar is a low-earth-orbiting (LEO) satellite-based digital telecommunications system that will offer wireless telephone and other telecommunications services worldwide beginning in late 1998.
GPS	U.S. Air Force global positioning satellite for military and civilian navigation services.
Hot Bird	Will provide direct TV programming to 45 cm dishes across Europe.
Intelsat	Telecommunications satellite for the International Telecommunications Satellite Organization (INTELSAT). A non-profit organization based in Washington DC.
Iridium	The Iridium system is a planned commercial communications network comprised of 66 low earth orbiting satellites. The system will use L-band to provide global communications services through portable handsets.
JawSat	An educational project with the major goal of developing a 3-axis control system. It will also demonstrate a Pulsed Plasma Thruster for stationkeeping by using ionized Teflon.
L-band	500-1549 MHz
MHz	Megahertz
NOAA-K	A polar orbiting U.S weather satellite for the National Oceanic and Atmospheric Administration (NOAA).
Odin	A small Swedish Space Corporation (SSC) astronomical and atmospheric satellite.
ORBCOMM	Orbcomm will provide low-cost alpha numeric data communications and position determination for emergency assistance, data acquisition and messaging services using pocket portable and mobile subscriber terminals.
Orsted	This satellite from Denmark will map Earth's magnetic field and charged particle environment.
Progress	A unmanned supply ship used to bring food, fuel, water, and oxygen to the current crew aboard Russia's Mir Space Station.
S-band	2000 to 2300 MHz
SPOT 4	This earth observation satellite will help in accurate mapping and geologic studies.
STEX	Sensor Technology Experiment, demonstrates radiation measurement technology.
SUNSAT	A South African amateur radio satellite designed to provide Earth imaging, voice, and digital communications.
SWAS	Submillimeter Wave Astronomy Satellite will study how molecular clouds collapse to form stars and planetary systems.
TLM	Telemetry
TRK	Tracking
UHF	Ultra High Frequency (390 to 499 MHz)
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
X-band	8000 and 10,999 MHz
XL	Extra Large

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

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1997 Nov 2/1225			SCD 2A	115 kg
Failed to reach orbit				

First orbital launch attempt by Brazil using the Veiculo Lancador de Satelites (VLS). Satelite de Coleta de Dados 2A (Data Collection Satellite, SCD) carried a data collection transponder, a solar cell experiment and a reaction wheel experiment. Satellite was intended to reach a near-circular 16 deg, 750 km orbit (some reports suggest that a "polar" orbit was intended, but the SCD 2A brochure from the Instituto Nacional de Pesquisas Espaciais quotes an inclination of 16 deg). VLS-1 was destroyed 65 seconds after launch from Alcantara (2.3 deg South, 44.4 deg West) following a failure of one of the four S43 strap-on boosters.

1997 Nov 6/0030	1997-067A		Navstar 38 (USA 134)	1,881 kg
1997 Nov 5.88	35.01 deg	358.31 min	189 km	20,476 km

Final launch of a Block 2A GPS navigation satellite, using a Delta-2 (7925 from Eastern Test Range. Mass quoted includes propellant. Dry mass is 930 kg. Through to the end of November 1997 no orbital data had been issued showing the satellite in its operating orbit.

1997 Nov 8/0205	1997-068A		USA 136 (Trumpet 3)	5,000 kg?
1997 Nov 9.0	63.6 deg	713.8 min	1,100 km	39,060 km

Classified payload, believed to be an ELINT satellite nick-named "Trumpet." Previous launches are believed to have been USA 103 (1994-026A) and USA 112 (1995-034A). Satellite unfurls a large disk antenna in orbit for intelligence-gathering. Launched from Eastern Test Range using a Titan-4A/Centaur. All orbital data have been classified for this launch and the data shown are approximate.

1997 Nov 9/0134	1997-069A		Iridium 43	657 kg
1997 Nov 21.89	86.40 deg	100.39 min	774 km	780 km
1997 Nov 9/0134	1997-069B	Iridium 41		657 kg
1997 Nov 24.18	86.39 deg	100.39 min	772 km	782 km
1997 Nov 9/0134	1997-069C		Iridium 40	657 kg
1997 Dec 5.25	86.42 deg	100.22 min	768 km	770 km
1997 Nov 9/0134	1997-069D		Iridium 39	657 kg
1997 Nov 22.26	86.40 deg	100.38 min	773 km	780 km
1997 Nov 9/0134	1997-069E		Iridium 38	657 kg
1997 Dec 5.02	86.42 deg	100.23 min	768 km	771 km

Seventh launch of a cluster of Iridium satellites, the fifth to use a Delta-2 (7920) launch vehicle from Western Test Range. Dry mass of each satellite is 556 kg. Launch is co-planar with third cluster of Iridium satellites (1997-034).

Launch Date/Time Epoch	Int Des Incl	Period	Satellite Perigee	Mass Apogee
1997 Nov 12/1700	1997-070A		Kupon 1	2,500 kg?
1997 Dec 2.89	0.06 deg	1,445.34 min	33,849 km	38,086 km

First launch of a communications satellite in the Bankir system: it planned to have four satellites operating over 55 deg East, 86.5 deg East, 91.75 deg East and 350.5 deg East. Planned operational longitude is 55 deg East. Launched from Baikonur using four-stage Proton-K with Block DM-2 fourth stage.

1997 Nov 12/2148	1997-071A		Sirius 2	2,920 kg
1997 Nov 27.03	0.06 deg	1,435.92 min	35,763 km	35,803 km
1997 Nov 12/2148	1997-071B		Cakrawarta 1 (Indostar 1)	1,385 kg
1997 Nov 26.45	0.22 deg	1,437.30 min	35,753 km	35,867 km

Sirius 2 is a communications satellite, launched for NSAB, Stockholm. Mass quoted is at launch. At the beginning of operations in geosynchronous orbit the mass is 1,760 kg and the dry mass is 1,245 kg. Satellite located over 5 deg East. Cakrawarta 1 (also called Indostar 1) is a direct broadcast telecommunications satellite, launched for Media Citra Indostar, Jakarta. Mass quoted is at launch: at the beginning of operations in geosynchronous orbit is 802 kg, dry mass is 620 kg. Satellite to be located over 107.7 deg East. Launched from Kourou using Ariane-44L.

1997 Nov 18/1115	1997-072A		Resurs-F 21	6,300 kg?
1997 Nov 18.58	82.33 deg	88.66 min	180 km	236 km
1997 Nov 19.81	82.33 deg	89.03 min	208 km	245 km
1997 Dec 3.14	82.33 deg	89.59 min	238 km	270 km

First flight of the improved-performance Resurs-F1M remote sensing satellite. Spacecraft derived from the original Vostok manned spacecraft and Zenit photoreconnaissance satellite series. It is not certain whether the maneuvring engine at the top of the satellite carries two vanes of solar panels as did the Resurs-F2 satellites or whether the satellite does not require these like the Resurs-F1 series. Planned lifetime of the satellite is approximately 25 days. Launched from Plesetsk using Soyuz-U.

1997 Nov 19/1946	1997-073A		Columbia (STS-87)	102,717 kg
1997 Nov 20.13	28.46 deg	90.18 min	281 km	286 km
1997 Nov 27.03	28.47 deg	90.16 min	280 km	284 km
1997 Nov 19/1946	1997-073B		SPARTAN 201-04	1,352 kg
1997 Nov 22.06	28.47 deg	90.17 min	280 km	285 km

Six person shuttle mission, undertaking the USMP-4 (United States Microgravity Payload) mission: crew comprised K R Kregel (commander), S W Lindsey (pilot), K Chawla (born in India: mission specialist, MS-1), W E Scott (MS-2, EVA astronaut, EV-1), T Doi (born in Japan: MS-3 and EV-2) and L K Kadenyuk (Ukrainian cosmonaut: payload specialist, PS-1). Orbiter cargo bay carries USMP-4 module (mass 2,134 kg). Mass quoted is that projected for landing. Landed at the Kennedy Space Center on Dec 5, 1997, at 1220 UTC. Spartan 201-04 carried experiments to investigate physical conditions and processes of the hot outer layers of the solar corona: they were to investigate the heating of the solar corona and the acceleration of the solar wind which originates in the corona. It was deployed (a day later than planned) Nov 21, 1997, at 2105 UTC, but it had not been sent the correct commands for activation prior to deployment and remained non-operational. The following day it was recovered by hand during an EVA and capture was approximately Nov 25, 1997, at 0200 UTC.

Launch Date/Time Epoch	Int Des Incl	Satellite Period	Perigee	Mass Apogee
1997 Nov 27/2127	1997-074A	TRMM		3,620 kg
1997 Nov 28.32	35.00 deg	92.07 min	367 km	385 km
1997 Nov 27/2127	1997-074B	Hikoboshi+Orihime		2,900 kg?
1997 Dec 1.32	34.97 deg	93.76 min	379 km	538 km

Tropical Rainfall Measuring Mission (TRMM) is a joint NASA/NASDA project to monitor rainfall conditions in the tropics and the sub-tropics. Japanese payload comprises the two-part Kiku 7 (ETS 7 before launch) satellite, planned to perform rendezvous experiments (Hikoboshi/Kiku 7 Chaser satellite mass ~2,500 kg and Orihime/Kiku 7 Target satellite mass ~400 kg). The satellites had not separated through to the end of November 1997. Launched from Tanegashima using H-2. USSPACECOM has assigned the objects as follows: 1997-074B– Hikoboshi, 1997-074C–Orihime, and 1997-074D–H-2 second stage. However, is seems moire likely that A and B are as shown above, C is the H-2 second stage and D is the fairing covering the Japanese lower satellite assembly at launch.

Updates for Previous Launches

1982-110C Anik-C 3 has been drifting around the geosynchronous orbit band since Jun 17, 1997, and is therefore deemed to have been retired.

1987-062A Cosmos 1869 (an Okean-O oceanographic satellite) suffered a partial break-up in orbit between 0006-0040 UTC on Nov 27, 1997. Approximately 20 pieces of debris were tracked, although none have been officially catalogued.

1986-003B Satcom K1 has been drifting around the geosynchronous orbit band since Jul 2, 1997, and it is therefore deemed to have been retired.

1988-086A Sakura 3B was maneuvered off-station over 153 deg East during November 1997. The final set of two-line orbital elements to show the satellite on-station were issued on Nov 10, 1997, and the next set to be issued were dated Nov 26, 1997, and showed the satellite in a retirement orbit.

1989-101A The final station-keeping maneuver to be performed by Cosmos 2054 was during Dec 9-10, 1996. The satellite started an uncontrolled drift in March 1997 and therefore it is believed to be no longer operational.

1990-063A The two-line orbital elements indicate that TDF 2 is stationary over 35 deg East.

1991-055A During the period Nov 12-17, 1997, the orbital period of INTELSAT 605 was adjusted so that the satellite started to slowly drift off-station to the west.

1995-071A Cosmos 2326 decayed from orbit Nov 8, 1997.

1996-021A The two-line orbital elements have consistently showed Astra 1F slowly drifting to the east, reaching approximately 29 deg East at the end of November: however, it is believed that the data continue to be in error and that the satellite is really still located close to 19 deg East.

1996-031A MSTI 3 has lowered its perigee it accelerate the rate of orbital decay. Add the following orbital data:

1997 Dec 2.09 97.11 deg 93.01 min 416 km 428 km

1997 Dec 2.47 97.09 deg 90.95 min 226 km 416 km

1997-028A Cosmos 2344 is a photographic reconnaissance satellite, similar to a proposed civilian satellite with the code name Arkon-1. It is a stepped cylinder, approximately 2.3 meters base diameter and 7 meters long, plus two vanes of solar panels. Launch mass is approximately 6,000 kg. Identification of Cosmos 2344 with the Arkon-1 code name is based upon G. E. Perry, *And Whoever Heard About the Projects Zerkalo, Nord and Arkon-1 ?*, News Bulletin of the Astronautical Society of Western Australia, December 1997, pages 27-29.)

1997-056C Add the following orbital data for Iridium 36:

1997 Nov 5.17 86.39 deg 100.39 minutes 774 km 780 km

1997-062A Add the following orbital data for APStar 2R. The satellite is located over 76 deg East:

1997 Oct 30.45 0.10 deg 1,436.05 minutes 35,774 km 35,798 km

1997-065A The name of this satellite is DSCS-3B6. No "USA" number appears to have been assigned to this payload.

USA 135 Designator

The designators USA 133 (1997-064A); USA 134 (1997-067A) and USA 136 (1997-068A) have been assigned to payloads, but the designator USA 135 is not known to have been assigned to a payload. From previous launches one would have expected that both STEP M4 (1997-063A) and DSCS-3B6 (1997-065A) would each have received a "USA" number. Possibly STEP M4 has been omitted from the sequence because it failed to operate and USA 135 will be retrospectively assigned to DSCS-3B6.

Details on Russian Yantar Photo Recon Satellites

Recent issues of the Russian publication Novosti Kosmonavtiki (August 11-24, 1997, pages 57-64 and August 25-September 21, 1997, pages 91-99) have given the first details of some of the Yantar "fourth generation" photoreconnaissance satellites which started to orbit in 1974. The second article includes a list of the Yantar-2K and Yantar-4K1 series.

The satellites have a cylindrical service/instrument module with two solar panels attached, plus a conical descent module containing the reconnaissance equipment: the latter is normally recovered at the end of the mission. The satellites discussed in the article carry two small data return capsules which are returned to Earth while the main satellite remains in orbit. The maximum diameter of the satellite is 2.7 meters and the length is 6.3 meters: the mass of the Yantar-2K variant is 6.6 tons (Yantar-4K1 is probably similar).

The specific satellites identified in the article are listed below.

Design bureau name–Yantar-2K
Ministry of Defense name–Feniks, series serial number 11F624

1974 Cosmos 697
1975 Cosmos 758
1976 Cosmos 805 and Cosmos 844
1977 Cosmos 905 and Cosmos 949
1978 Cosmos 1028
1979 Cosmos 1079, Cosmos 1121 and Cosmos 1144
1980 Cosmos 1152, Cosmos 1208 and Cosmos 1236
1981 Cosmos 1240, Cosmos 1248, Cosmos 1270, Cosmos 1274, Cosmos 1282, Cosmos 1296, Cosmos 1318 and Cosmos 1330
1982 Cosmos 1336, Cosmos 1350, Cosmos 1384 and Cosmos 1407
1983 Cosmos 1439, Cosmos 1454 and Cosmos 1471

There were Yantar-2K launches which failed to reach orbit on May 23, 1974, and March 28, 1981.

Design bureau name–Yantar-4K1
Ministry of Defense name–Oktan, series serial number 11F693

1979 Cosmos 1097
1980 Cosmos 1177 and Cosmos 1218
1982 Cosmos 1377, Cosmos 1399 and Cosmos 1424
1983 Cosmos 1442, Cosmos 1457, Cosmos 1466, Cosmos 1489, Cosmos 1496 and Cosmos 1511

There is one other series of satellites which accounts for the remaining western classification of "fourth generation, close look" satellites: the Ministry of Defense name is Kobalt and the serial number is 11F695, but the exact Yantar-4 designator has not been officially published. The French publication Air Et Cosmos (December 5, 1997, page 40) has claimed that there have been Yantar-1 (11F622) and Yantar-2 (11F623) series of satellites: since the known Yantar 1KFT (see below) 2K, 4K1 and 3/4 series account for all of the fourth generation flights, either Yantar-1 and Yantar-2 never existed or they never reached flight status.

There is one other group of fourth generation satellites which have been identified in the West as being lower-resolution topographic and mapping missions: the Yantar-1KFT series. These satellites are probably similar to the Yantar-2K satellites, but might not carry the small data return capsules: suggestions in the Air Et Cosmos article noted above that Kometa uses a Soyuz instrument module and a Vostok/Zenit class spherical descent module are probably incorrect and are based upon a drawing of a design concept published in a Russian book.

Design bureau name - Yantar-1KFT
(Ministry of Defense names–Siluet/Kometa, series serial number 11F660)

1981 Cosmos 1246
1982 Cosmos 1370
1983 Cosmos 1516
1984 Cosmos 1608
1985 Cosmos 1673
1986 Cosmos 1784
1987 Cosmos 1865 and Cosmos 1896
1988 Cosmos 1944 and Cosmos 1986
1989 Cosmos 2021
1990 Cosmos 2078
1991 Cosmos 2134 and Cosmos 2174
1992 Cosmos 2185
1993 Cosmos 2243
1994 Cosmos 2284

Cosmos 2243 exploded at the time of orbital injection: there was a Yantar-1KFT launch failure on May 14, 1996.

THE BEGINNER'S COLUMN

By Ken Reitz, KS4ZR
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The Rip Van Winkle Effect

Suppose you just stumbled out of the wilderness after a ten year search for the origin of that ringing in your ear and the first thing you want to do is "veg out" in front of the tube and surf the TV dial. You might dust off the phone number of that friendly guy in town who sold satellite TV systems before you disappeared. You dial the number and you hear the grating tones of the phone company and a synthesized voice says, "...Welcome to SouthWest Bell Atlantic Nynex Lucent Systems National Bank and Discount Broker Cable Programmers. We're sorry, but, that number is no longer in service..." You drag out the Yellow Pages and look under Satellite Systems. It says, "See National Discount Department Store Chains or Gas Stations, Retail."

Changing Times

The emerging electronics technologies have been one of the biggest stories of the last ten years. A decade ago a 286 PC running at 30 MHz was considered a top grade computer; only businesses had facsimile machines; cassette tapes were still state-of-the-art in recording technology; cellular phones were years in the future; and the Internet was the private playground for the Department of Defense and Academia. There was one thing seen as *avant garde* which is still familiar today–satellite television.

Today, thanks to a relentless drum beat of advertising strategy, when you say "satellite TV" most people think of those cute little 18-inch dish systems which are so cheap they're often given away free with a big screen TV set or sold at virtually every retail outlet except, perhaps, shoe stores for under US$100.

Big dish satellite TV has fallen so far from current cachet that many people don't believe they are even sold today. It would come as a surprise to these people that an average of 20,000 "big dish" satellite TV systems are installed across this country every month. And, while the number pales in comparison to figures rung up by the little dish industry, it's still a significant amount. Even so, the threat to the cable industry has been widely overstated. With an estimated 65 million subscribers safely on their billing lists, there's little for the cable industry to fear.

What's making people take a second look at big dish satellite TV is two-fold. First is the fact that prices for complete systems have declined greatly. New, off-the-shelf systems can be bought for as little as US$500, while used systems can be found at half that price. Second is the fact that the bloom is off the small dish rose. While actual system prices have declined since their introduction just three years ago, many subscribers are grumbling about the increasing monthly viewing fees and lack of variety of programming when compared to big dish subscribers.

A Big Dish Educational Update

A number of inquiries from *ST* readers has drawn my attention to the fact that many who looked into satellite TV years ago are slightly out of date with regard to current technology. This *Big Dish Educational Update* is aimed at all of you Rip Van Winkles who were asleep for the duration and, just like our fictitious example above, much of what you previously knew is wrong. Those of you who never knew anything about satellite TV before should read this column for historical and educational purposes only.

For the first five years of satellite TV in this country (from roughly 1978 to 1983), the technology was mostly comprised of commercial cable-TV equipment sold to individuals. The prices were steep unless you were capable of "home brewing" the equipment yourself. Entire systems retailed for over US$5,000.

The period from 1983 to 1987 was one of sweeping technological change. The biggest change came when manufacturers finally got into production quantities that made price reduction possible. By this time there were typically 90,000 systems per month being sold nationwide. The technology changed from systems which were a series of stacked control boxes to an all-in-one receiver. A very thick cable connected the low noise amplifier (LNA) at the feed horn to a box on the mounting pole, called a down converter, which converted the C-band frequencies (at 3.7-4.2 GHz) down to 70 MHz which was then routed to the house and plugged into the receiver. The reason 3.7-4.2 GHz was not sent to the house from the dish is that frequencies that high don't travel very far without getting lost. This is called (surprise, surprise) signal loss.

Now the LNA and down converter are in one unit at the feed horn called a low noise block down converter (LNB), which converts C-band to a block of frequencies from 950 to 1450 MHz which are routed into the house to your receiver. The original 120 degree* LNA, which was standard then, has been replaced with a 20 degree LNB which typically sells for under US$100. LNAs for older systems are still available for around US$150. Careful shopping could bring you a new LNB for as little as US$20.

Let's Do Dishes!

Original C-band dishes from the late 70s were typically made of steel petals bolted together and were 16-feet in diameter. Later fiberglass dishes as small as 12-feet in diameter were considered improvements. By the late 1980s, black, 10-foot aluminum mesh dishes were the new standard. Contributing factors in reducing the size of the receiving dish has to do with higher powered satellites (C-band birds are four times as powerful as they were 10 years ago) and improvements in receiver component design.

Current standard for dishes in most areas of the country is 6- to 7.5-feet in diameter. If you live on the fringes of the North American continent (Canada or southern Florida), you'll still need a 10-foot dish for perfect pictures. Smaller dishes are technically feasible in the middle of the country (where the center of the satellite signal or "footprint" falls) but may not be advisable. In the old days, satellites might be 20 degrees apart or more in the sky. Today, thanks to FCC rules, they're packed in like sardines just two degrees apart. One of the vagaries of the parabolic design is that the smaller the dish, the broader the beamwidth. This means that a 4- or 5-foot dish which might otherwise receive good signals from a 16-watt satellite will also tend to pick up the signals of adjacent satellites. This "ingress" shows up as interference in the picture you're trying to watch. Just about the only thing that hasn't changed in the last 10 years is the actuator motor. You may or may not have noticed, but all of our geosynchronous satellites are lined up along the Earth's equator at a distance of approximately 36,000 km or 23,000 miles above the Earth. This is exactly the circumference of the Earth and is referred to as The Clarke Belt in honor of scientist/author/techno-guru Arthur C. Clarke. Clarke originated the theory of geostationary orbiting satellites which bring us so many new sitcoms and police docu-dramas every fall. We are all truly grateful.

The beauty of the big dish satellite system is that, with a motorized polar mount, all the satellites lined-up on the Clarke Belt can be programmed into the receiver and in just seconds the dish can be pointed at any one of them. These actuator motors are DC driven and last forever. I've never known one to break down; they are a miracle in this age of fallible electronic gizmos. It's the one thing on a big dish system which has not needed to be updated or made to look slick, and it's what sets these systems apart from their little dish buddies.

Feedhorns have undergone modest changes in the last 10 years. Early feedhorns were C-band only and current ones feature C/Ku and even DSS capability. Yes, some big dish feed horns come with a DSS LNB attached! There are also circularly polarized C/Ku-band feeds which allow better reception of Intelsat satellites over the Atlantic ocean.

One of the more interesting developments in the last 10 years has been the introduction of the low noise block down converter feedhorns (LNBF). It's an all-in-one unit with no moving parts. No servo-motor to switch polarities: It's done electronically, switching between two probes spaced 90 degrees apart. That also means only one cable for the entire dish, if it's a stand-alone system. The LNBF has made installation much more demanding, but the result is fewer parts to replace or break down. It has also reduced the price considerably. A C-band feed horn with LNB will cost about US$150. A C-band LNBF goes for about US$90 (the same in used condition would be about half price).

Receivers and Other Attachments

After 1986, the year of infamy for the big dish satellite TV industry, when standard encryption via the Videocipher II system became a reality, receivers were known as IRDs. That stands for Integrated Receiver Decoder. Now all receiver, actuator, audio, decoding and power supplies would be housed in one unit. It's still the standard.

NextLevel, son of General Instrument, is selling the very latest IRD known as 4DTV, which is one box that does it all, even digital signal reception. 4DTV not only does the receiving, it also interfaces with your VCR to run the dish around the Clarke Belt and turn your VCR on and off while you're away. It has an extensive built-in satellite guide which tells you what's on hundreds of video and audio channels and gets updated every day while you're asleep. It also down loads your Pay-Per-View tally each month for billing purposes.

There are lots of other goodies which set big dish satellite TV apart from its smaller brother. Here are a few of them.

DMX is the digital music service which brings nearly 100 channels of CD quality music formats into your home for US$15 a month. Single channel per carrier or SCPC radio reception allows you to tune into virtually all professional and college sports networks around the country and audio subcarrier receivers such as the Universal SC-50 tunes the audio subcarriers below the normal subcarrier frequencies of most IRD receivers.

There's a world of difference between the big and small satellite TV systems, but the biggest of all could be in the price you spend per month to watch your favorite shows. Competition in the small dish market ends after you've purchased your system. Since none are compatible with each other, you've given them little incentive to keep subscription prices low. On big dish systems there are a dozen or more program providers all trying to win your business. The result is competition for your annual subscription.

Programming packages via C-band are almost always cheaper than little dish systems. What's more, you pay for only what you want to watch. In addition, there are many free channels on C-band and more that aren't even offered on the little dishes. And, with a design life-span of 15 years, today's C-band satellites will let you go back to sleep for another 10 years and you won't have missed a thing!

Note: *The 120 degree noise temperature is a figure used to indicate the amount of noise present in a device such as a LNA. The lower the figure the better the performance of the device.

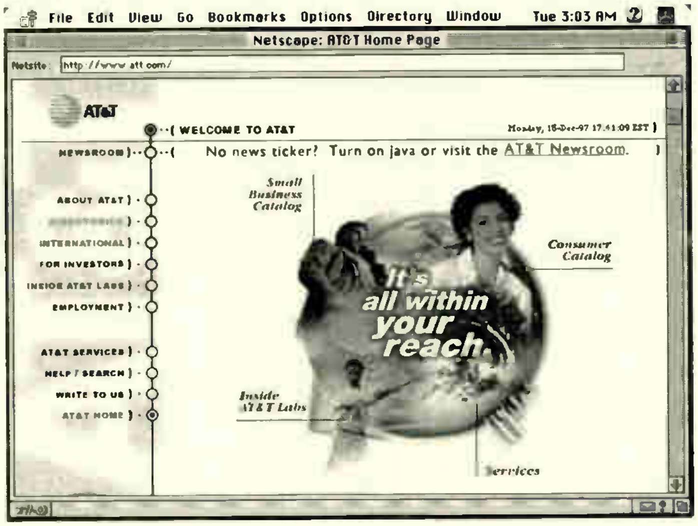
By Doug Jessop

Top of the News

AT&T ponied up a fairly large hunk of change for a partnership with DirecTV that allowed them a percentage of the business as well as the opportunity to market the DSS system to the rather large base of phone customers throughout the United States.

Now AT&T has decided to part company with the folks at DirecTV.

AT&T and DirecTV entered into their original marketing agreement on March 25, 1996, to enable AT&T to provide its customers with special incentives on DSS equipment purchases. Under this agreement, AT&T invested US$137.5 million for a 2.5 percent equity stake in DirecTV and options to purchase up to an additional 27.5 percent equity stake. Well, right before presstime AT&T announced that they were bailing out of the deal.

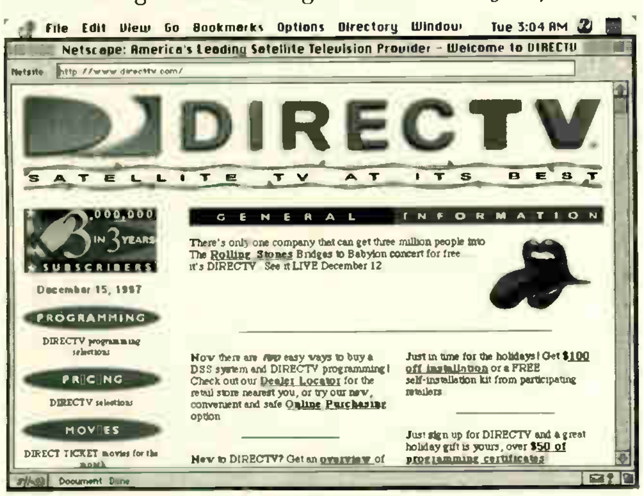


With the termination of the agreement, AT&T is selling back its 2.5 percent equity stake for US$161.8 million. The remaining equity options and exclusivity provisions of the original agreement have been canceled.

The two companies have entered into a new arrangement through which all DirecTV customers who are or become AT&T customers will be entitled to one free, specially designated pay-per-view event each quarter in 1998.

"DirecTV has been a big hit with the AT&T customers who subscribe to it," said Donald E. Herr, vice president of alternate channel development and direct-broadcast satellite marketing in AT&T's consumer markets division.

"However, we found that the vast majority of consumers prefer to purchase the DSS equipment directly through consumer electronics retailers. Now they will be able to do so and still get special benefits for being customers of DirecTV and AT&T." DirecTV and DSS equipment are available in more than 26,000 retail outlets nationwide, including Circuit City, Best Buy, K-Mart, and Radio Shack.



"Today's announcement is part of our aggressive effort to focus on businesses central to our strategy of providing people with 'any distance' communications services–long-distance, wireless, on-line, and local," Herr said.

"AT&T has provided significant promotion of the DirecTV brand and helped spread the word about the advantages of satellite television to its customers," said Lawrence N. Chapman, executive vice president of DirecTV, Inc.

"This new arrangement will enable DirecTV to continue building its subscriber base by strengthening our sales and distribution channels, while AT&T customers who subscribe to DirecTV will continue to get special benefits for doing so through 1998," he said.

DirecTV is the United States' leading direct-to-home satellite television entertainment service. DirecTV delivers 175 channels of entertainment, sports, news and family programming to more than three million subscribers nationwide.

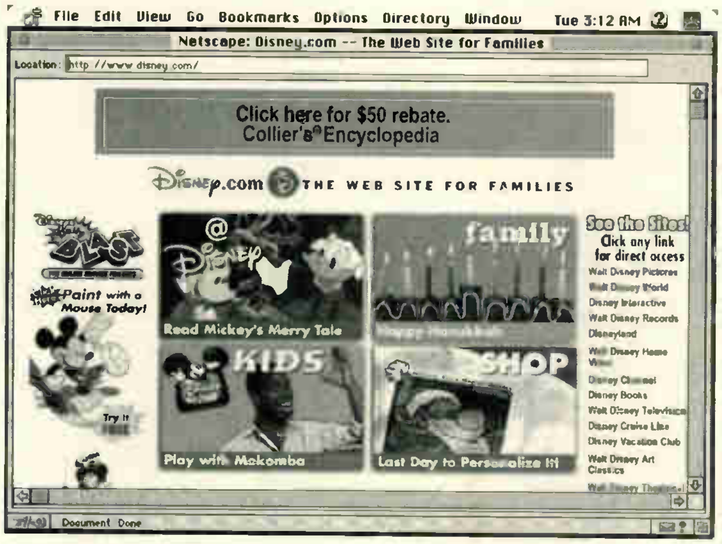
Word on the street is that AT&T is still very interested in the opportunities with DSS, but not necessarily with DirecTV. Rumors are buzzing around with the possibility of AT&T taking their clout, not to mention money and potential customers, to one of DirecTV's competitors in exchange for more control and a bigger piece of the pie.

Chalk One Up for the Mouse

Walt Disney's ESPN Sports Network (Galaxy 5 at 125° W transponder 9) announced that it will create a regional sports network in Southern California in 1998. ESPN West will televise games of hockey's Anaheim Mighty Ducks and baseball's Anaheim Angels, the two professional sports franchises owned by Disney.

The move, which had been anticipated by industry insiders, will pit Disney directly against News Corp.'s aggressive Fox Sports operations as the teams' games are currently broadcast on two regional sports channels operated by Fox–Fox Sports West and Fox Sports West 2 (Satcom C1 at 137° W transponder 7 and 22 respectively).

Following a bitter battle earlier this year between the two media giants, an agreement was finally reached in which ESPN West would carry Might Ducks games beginning with the 1998-99 season, with the Angels showing up in 1999.



New Toons Channel

Disney has announced plans to introduce Toon Disney–a cable channel that will draw from the studio's library of animated TV programming. The network will launch in April, coinciding with the Disney Channel's 15th anniversary.

Toon Disney will join the Fox Family Channel (which the studio recently acquired and is converting into a children's network) and Time Warner's Cartoon Network in seeking to siphon audience away from Nickelodeon, the established children's programming leader. Disney will package the new network with the Disney Channel (Galaxy 1R at 133° W transponder 7) in an effort to secure space on cable systems.

Coming to a Bird Near You

Turner Entertainment Report (TER), Turner Broadcasting System's show business newsfeed for local broadcast stations, has expanded its service. Numerous enhancements to the service were introduced shortly before press time, including an additional feed time and more natural sound pieces.

With more than 90 worldwide affiliates, TER will remain a market-exclusive service and distribution will continue to be managed by CNN Newsource Sales. Offering the latest news from movies, music, television and the world of entertainment, the enhanced TER service will consist of two 15-minute news feeds daily at 3:15 p.m. and 2 a.m. (ET). TER will continue to be carried on G-Star IV transponder 3.

Actor Ted Danson has taped a guest appearance on NBC's *Veronica's Closet* (Satcom C1 at 137° W transponder 8) matching him once again with his former *Cheers* co-star, Kirstie Alley. In the episode, scheduled to air in February, Danson plays a high school flame of Ronnie's (Alley) who she hasn't seen in years. The two renew their romance following the accidental meeting.

Executives at Warner Bros. Studio have kicked off a search for the next *Wonder Woman*. The lucky winner will play the superhero in a two-hour movie (which could lead to a full-time series, yippee!) slated to air next season on NBC.

Following the announcement that ABC (Telstar 4 at 89° W transponders 21 and 22) would move *20/20* from Thursday nights to Mondays, industry sources were awaiting an announcement that CBS would return

48 Hours to Thursday nights from Tuesdays. With ABC deciding to shift its successful newsmagazine and *48 Hours* earning third-place ratings on Tuesdays, CBS executives said it makes sense for the program to make the jump to Thursdays.

Rumors were buzzing at press time that fraternal teen rockers Hanson are in talks to develop (be still my heart) a sitcom. The show, sources said, would star the three young men from Tulsa, in a *Monkees* meets *Larry Sanders* type program. There is no word yet on potential studios or networks for the Hanson series.

MTV (Satcom C4 at 135° W transponder 17) has renewed its steamy call-in show, *Loveline* for a third season. Production on 65 new episodes of the program will begin shortly, said sources. No decision has been made yet on whether a second season of *Oddville MTV* a bizarre variety show hosted by Frank Hope, will be ordered.

NBC and the United States Golf Association have committed to a new, four-year television contract extension beginning in 2000 and ending in 2003. Under the new agreement, NBC will keep major USGA championships like the U.S. Open, as well as retain U.S. broadcast rights to the U.S. Women's Open, U.S. Senior Open and U.S. Amateur championships.

The syndicated magazine show *Strange Universe* has been canceled. According to sources, the series has halted production with the last episode scheduled to air in the next few months. *Strange Universe*, which focused on bizarre and paranormal people and phenomena, premiered in September 1996.

News from the Windy City

NBC's number one late night talk show *The Tonight Show With Jay Leno* will hit the road to Chicago, Illinois, for a week of broadcasts scheduled for May 4-8, 1998. This is the second time the show has telecast out of the windy city (the first time was April 27-May 3, 1996). *The Tonight Show* will originate out of the Rosemont Theatre, in Rosemont, Ilinois.

Among others, these are the Chicago highlights to which Leno is looking forward: "Deep dish pizza, thin crust pizza, Mr. Beef sandwiches, sausages, peppers, steak, chicken, pasta, roast beef, cheesecake and something to drink." Watch for feeds of the show on the Ku-band side of GE-1 at 103°W.

Bob Bell, who delighted generations of Chicago youngsters as Bozo the Clown on WGN-TV (Galaxy 5 transponder 7), died shortly before press time (mid-December) after a long illness. Mr. Bell, who was 75, retired to San Diego in 1984 after 23 years as the beloved star of the longest-running and most successful children's show on WGN-TV.

Larry Harmon began to market Bozo nationally in the mid-1950s. In 1959, Bozo came to WGN-TV; Bell portrayed the clown on a 30-minute show consisting of one-man sketches and cartoons. The program went off the air in 1960 and returned as *Bozo's Circus*.

Bell donned ample circus greasepaint, a fiery red wig and flashy clothes for the character. He brought the clown to national prominence when WGN began broadcasting via satellite in 1978 and continued until his retirement in 1984. Bell once said, "I love my work and enjoy making children laugh. Laughter cannot be imitated. It comes from the heart." He is survived by his wife Carol, three sons, a daughter and several grandchildren.

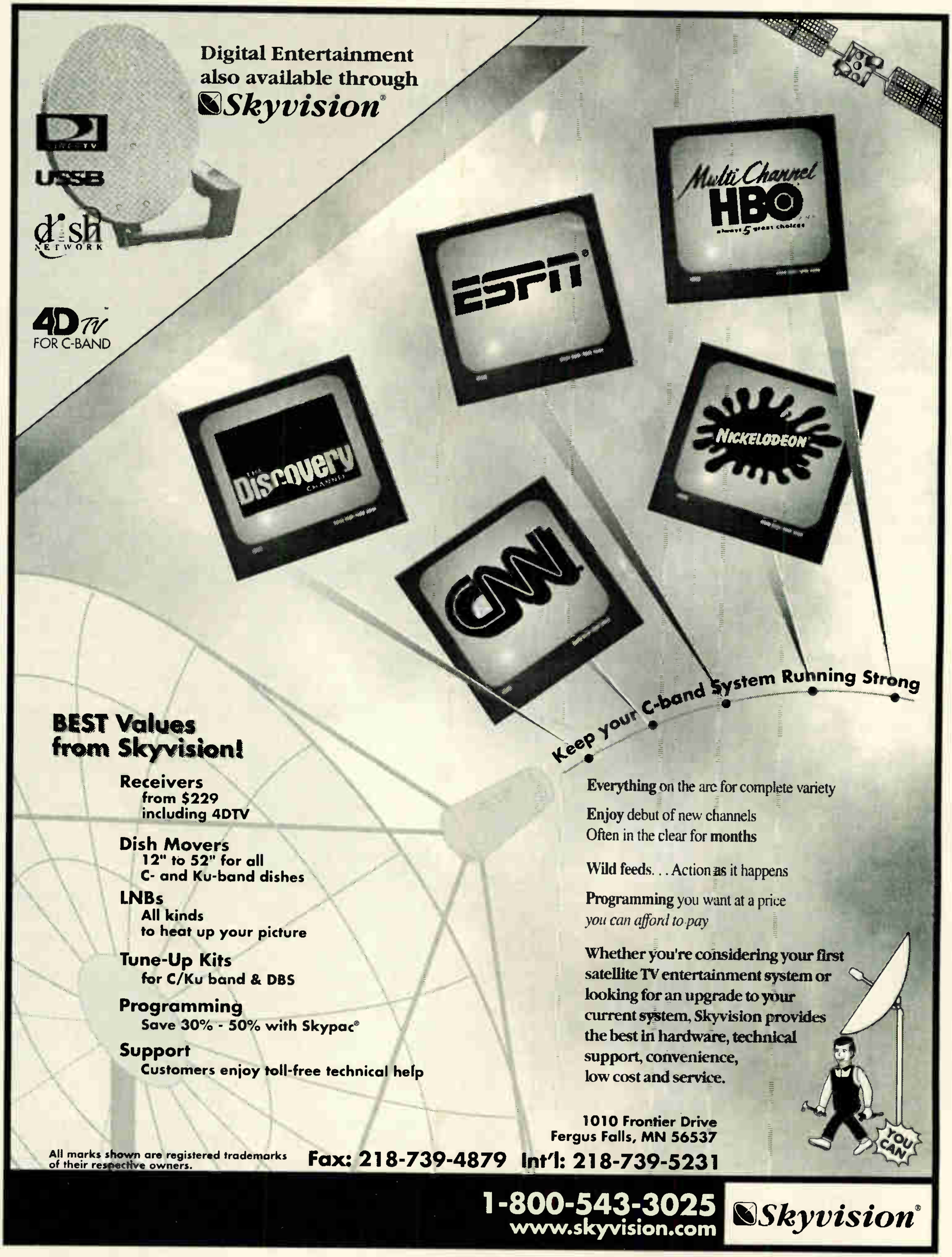
Coming Next Month

The biggest news brewing in the TV business is the story of infomercial giant, Paxson Communications. Word on the street is that they are investing a quarter of a billion (yes, with a B) dollars on programming and starting a family oriented network. I think you'll be surprised with the coup that they have apparently pulled off. More on that next month.

Sources for this issues article include a number of great friends in the broadcasting industry as well as: *Chicago Sun Times, Cowles/Simba Media Daily, LA Times, NY Daily News, NY Post, Reuters, Wall Street Journal.*

As always your comments are welcome through e-mail at **http://www.searcher.com/STcomments.html**.

Doug Jessop has been in the broadcasting industry since 1979 and was the original creator and editor of the "North American Satellite Guide."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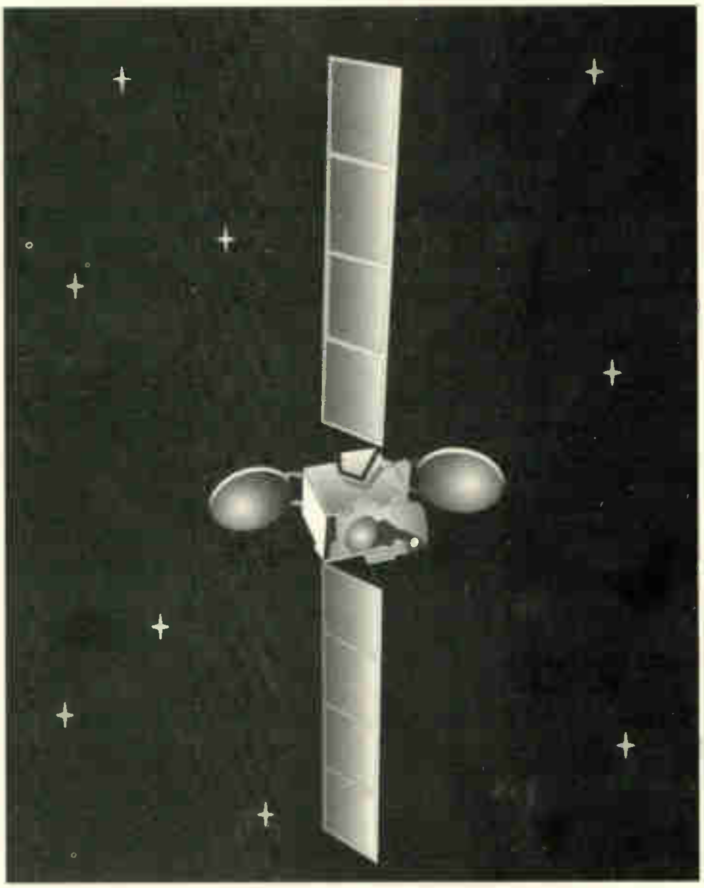
By George Wood
wood@rs.sr.se

Digital Scandinavia

In some ways satellite TVRO is much easier in Europe than in North America. (In others it's been a lot harder.) Here's what we have to deal with ...

On the easy side, virtually all European satellite broadcasting has been in the Ku-band, above 10 GHz, rather than in the 4 GHz C-band. (The only C-band transmissions have been from Russia, and on Intelsat satellites aimed at Africa and the Middle East.) The higher band means that European TVRO enthusiasts need smaller dish antennas and LNBs. Also, because the experimental stage was relatively short in Europe, mass produced consumer receivers appeared early, also keeping prices down.

But the most brilliant innovation in Europe was Astra's decision to place all its satellites at one single position in the Clarke Belt. When Astra 1A launched, viewers had access to 16 transponders at one spot in the sky.



Sirius 2, covering Nordic and European regions.

Successive launches meant those same viewers, with small (2- to 3-foot) fixed antennas, could look at 32, then 48, and later 64 transponders, with only a minor upgrade needed to see the channels above 48. (The recently launched Astra 1G brings the transponder count up to 120, but everything above 64 is for digital broadcasting, which requires new receivers.)

The simplicity has meant that several competing dish-receiver systems have been available in Britain for just under the magic price of 100 pounds (around US$150). Compare that to your average American C-band system, a motorized six foot monster costing ten times as much, or more.

The bad news is the plethora of standards and encryption systems found in Europe. Like baseball, the North American NTSC standard for ordinary TV has spread only to Japan (and South Korea) and parts of Latin America. Europeans developed instead the PAL system, before the go-it-alone French invented a similar, but mostly incompatible, alternative called SECAM. This has spread to the former French colonies in Africa and Asia, as well as the former Soviet Union, while the rest of the world has adopted PAL.

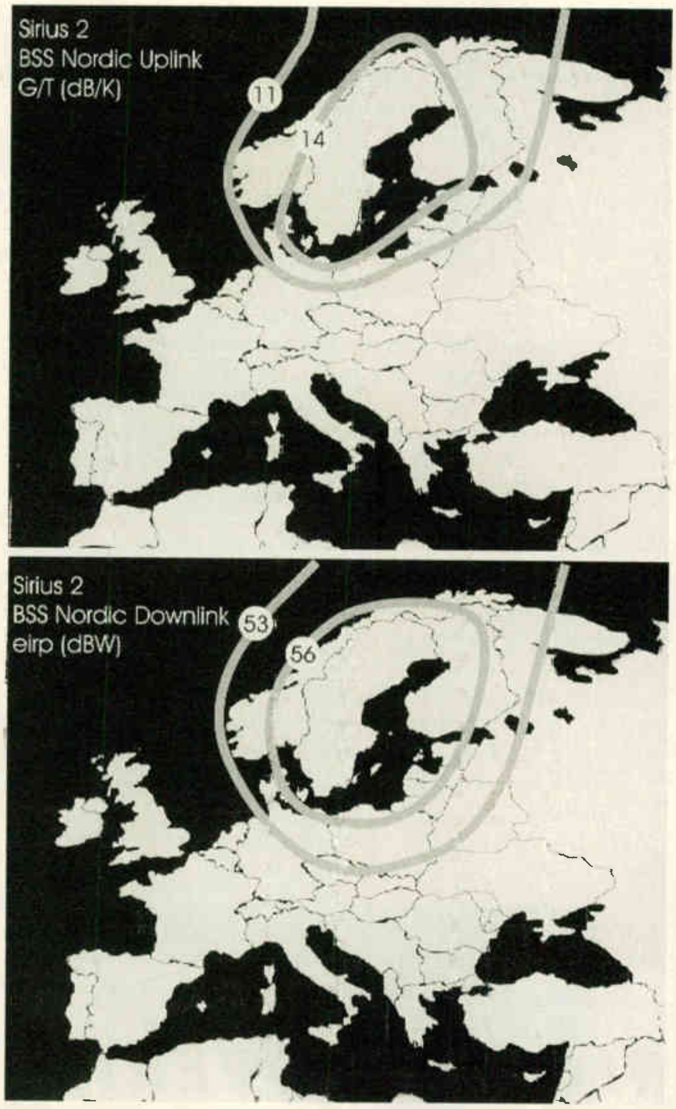
As a result, both PAL and SECAM have been carried on European satellites from the beginning. Fortunately the two systems are similar enough, and enough people live in border areas, so that dual standard TV sets have not been expensive. What has been a much harder problem has been Europe's varying encryption systems.

The original Astra promise was for uncoded channels. This has been kept by the Germans, but few others. Germany has many TV networks, both public and commercial, national and regional. As Astra capacity has increased more and more of these have put their signals on satellite, most of them free commercial broadcasters. The other extreme is Britain. With the exception of the recently launched Channel 5, none of the terrestrial British TV channels has put its domestic signal on satellite. Instead, media tycoon Rupert Murdoch has turned his original, free, satellite-based Sky Channel into an empire and virtual monopoly called British Sky Broadcasting.

A Murdoch subsidiary developed a PAL encryption system called Videocrypt, which was used when Sky Channel was split into new channels as it moved to Astra. Moreover, Sky's dominance and the availability of Videocrypt on virtually every satellite receiver sold in Britain, meant that many other English-language satellite broadcasters have allowed themselves to be distributed as part of Murdoch's Sky Multichannels package. This includes Discovery, MTV, VH-1, Nickelodeon, CMT, National Geographic, and new channels from the BBC, Flextech (TCI), and Granada Broadcasting.

The frustrating thing has been that virtually all of these channels which have signed up as part of a pay package also carry as many commercials as they can get away with. Many feel a channel should be either commercial or subscription, but being both is adding insult to injury. And, despite European Union guarantees that services available in one member country should be available in any other member country, Murdoch steadfastly refuses to sell subscriptions to anyone outside of Britain and Ireland.

Ethnic broadcasters in Japanese and Hindi, as well as softcore channels like Playboy, the Adult Channel, and Television X, have also chosen Videocrypt, while not formally part of Sky Multichannels (since they serve viewers across Europe). A few channels, like Britain's new Channel 5, have chosen Videocrypt "soft encryption,"



Sirius 2 footprints showing (top) BSS Nordic uplink, and (bottom) downlink.

which means anyone with a Videocrypt decoder can watch, without an activated subscription smartcard.

An alternative called Videocrypt 2 was developed to distribute channels to other parts of Europe, but this has been largely a failure, with only VH-1 and MTV UK still using the system.

Only one Sky channel is still available uncoded, Sky News. There has been a single defector from the Videocrypt camp–the shopping channel QVC–which apparently decided a mass audience was preferable to the small pay-off from subscriptions. A few English-language broadcasters have also remained outside the encoded Murdoch orbit: CNN, TNT, and Cartoon Network (Ted Turner and Rupert Murdoch are outspoken rivals), NBC Europe and CNBC, BBC World, and Animal Planet.

The new Fashion TV, which has no spoken word at all to accompany its images of models on the catwalks, and the multi-lingual Eurosport and EuroNews are also in the clear. EuroNews has relied on soundtracks in various languages to accompany news stories without studio anchors. It has maintained the mediocre standard of something created by a multinational committee, and consequently low viewership, but recently the day-to-day running of EuroNews has been taken over by Britain's Independent Television News, and the quality seems to be improving. I actually saw a studio interview in English the other day, which must have created new challenges for the multi-lingual structure.

The Dutch channels on Astra used a different encryption system which was easily cracked, and pirate decoders have been readily available. But the Dutch channels have disappeared from the analog satellite airwaves. Spanish channels, which have moved from Astra to Spain's own Hispasat satellites, have used a system called Syster. France, which has its own space industry, has never been part of Astra, using instead its own Telecom satellites. Some French channels have been in clear SECAM, with subscription channels using an encryption system called Nagravision.

Except for Scandinavia, most other European countries (such as Turkey, Greece, Croatia, Serbia, Poland, and Arabic-language broadcasts to Europe) have satellite broadcast in clear PAL.

The Wacky World of MAC

Much to the confusion of many (and joy of computer hackers) Scandinavia has complicated the whole picture by widespread use of a transmission standard called D2-MAC. This goes back to the days before Astra, when the European Union bureaucrats in Brussels sought to determine the fate of European satellite television. Their choice was for each country to have a single direct broadcast satellite with four or five transponders. They also mandated a mixed digital-analog standard called D-MAC which they decreed should be used by all European satellite broadcasters.

Unfortunately for the Eurocrats, and fortunately for the rest of us, before the very complicated D-MAC standard could be translated into actual consumer receivers, Astra came along with its concept of offering many pan-European channels from one spot in the sky, each using the existing PAL standard. The only country to try to put Brussels' vision into practice was Britain (ironic, since Britain today is often the odd country out at the EU), whose British Satellite Broadcasting offered four channels in D-MAC over the Marco Polo 1 satellite. Unfortunately, the long delay before D-MAC receivers actually hit the market forced BSB to sell out to Rupert Murdoch's Sky Television (creating British Sky Broadcasting). The BSB channels were assimilated into Murdoch's Astra offerings, there was a trade-in offer for the handful of D-MAC receivers that had been sold, and Marco Polo and its in-orbit back-up were sold to Norway and Sweden.

The only Scandinavian station to actually use D-MAC has been Norway's public television channel NRK. Had things stayed there, the BSB failure might have ended the MAC saga for good. Instead, when Scandinavia's first satellite-only broadcaster, TV3, started, it chose a cut-down version called D2-MAC. This may have been because at the time private satellite broadcasting was illegal in Sweden. TV3 broadcast from London to get around the Swedish law. The use of D2-MAC may have been an attempt to give some smidgen of legitimacy to what was then regarded by governments in Scandinavia as a pirate operation.

D2-MAC has become the standard for virtually all of the Scandinavian stations, first on Astra, and then among the Nordic satellites at 5 degrees East and 1 degree West. There are a handful of clear PAL transmissions: the Swedish private terrestrial broadcaster TV4 (started largely in response to the success of the unregulated TV3), Sweden's Kanal 5 and Norway's TV Norge (both owned by a subsidiary of ABC/Disney). Most of the D2-MAC stations have encrypted using a European standard called Eurocrypt M. The Norwegians (who have had an eclectic approach to satellite broadcasting), chose to go their own way with a locally-developed variation called Eurocrypt S. Nowadays decoders (usually built into receivers) cover both systems, but for many years there was incompatibility, and widespread irritation, especially after the Norwegians signed up channels like CNN, Discovery, Eurosport, and MTV for their offbeat system.

The emergence of D2-MAC encryption in Scandinavia has also sparked a cottage industry and hackers' movement in prudish Britain, where hardcore pornography is completely banned. (The adult channels that Britons can subscribe to carry the same kind of softcore that is available in clear PAL on a number of German channels ... one reason why Astra systems became popular in the UK so quickly.) Both of Scandinavia's pay film rivals, Filmnet (now Canal Plus) and TV1000, routinely include hardcore films after midnight several nights a week. There was been a flourishing business in D2-MAC decoders and pirate smartcards in Britain.

Digital Daze

Into this complicated mix of PAL, SECAM, Videocrypt, Syster, Nagravision, D2-MAC, and Eurocrypt in various flavors comes digital satellite television, which is just getting started in Europe. European broadcasters succeeded in agreeing that Digital Video Broadcasting (DVB) would use a standard called MPEG-2. At that time those of us who followed the satellite TV scene but didn't quite understand all this digital stuff, thought that DVB meant a Golden Age with a single encryption system for all of us. Reality has taken a different path.

Digital transmissions are easily encrypted (one reason why one standard still permits many different subscription systems). But as digital broadcasts began to each country, the companies offering DVB services each seemed to have their own encryption system. Worse yet, the first generation of receivers to appear were all single-system. If you bought a box to watch Canal Satellite in France, you were stuck with its Mediaguard system, and couldn't use it to watch one of that channel's local rivals, let alone much from anywhere where else in Europe.

Fortunately a number of broadcasters chose to broadcast in clear MPEG-2, like Germany's public stations, and Turner Broadcasting continued its tradition from the analog world by relaying CNN, Cartoon Network, and TNT in the clear.

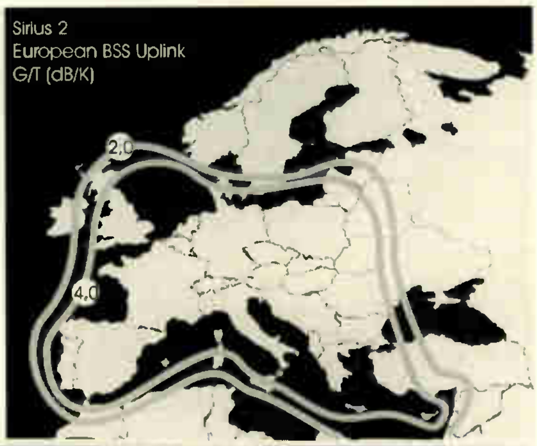
DVB was not an instant success. Viewers with an investment in analog equipment were reluctant to buy a new expensive box, especially one that restricted them to just one program supplier. National governments and the European Commisson have acted to require some measure of compatibility, which in the case of France has resulted in two of the three digital satellite broadcasters agreeing to provide separate transmissions using each other's systems. Second generation DVB receivers have included what is called a "common interface." This is essentially a hole in the receiver where users plug in the specific decoder (conditional access module) for the system they wish to watch. Into this you still have to plug the correct, activated smartcard (a laptop style PCMCIA card). There certainly aren't any receivers yet with twin CA sockets, so switching to a different service provider can be a cumbersome experience.

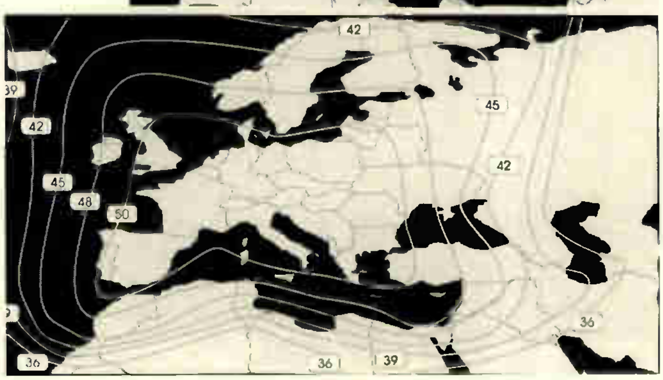
Viewers are still hoping that European broadcasters will agree on a single Conditional Access system. The most common of the multitude of CA systems in Europe is Viaccess, which is actually the same as the D2-MAC system Eurocrypt M. Just as Eurocrypt was supposed to be a European standard, there are hopes most broadcasters will settle for Viaccess. The system is used by France's TPS (and consequently Canal Plus), Switzerland's SBC, and Sweden's NSAB packages.

But there are numerous rivals. The Norwegians have Conax, which is the same as their Eurocrypt S system. France's Canal Plus has Mediaguard. This has caused a problem for the major Scandinavian digital operator Canal Digital, jointly owned by Canal Plus (who want to use Mediaguard) and Norway's satellite operator Telenor (who favor Conax, which seems to be the final decision). There's also Cryptoworks (used by Viacom and RTL), PowerVu (Discovery, AFRTS and a number of other services apparently intended for for cable feeds and not home viewing), and something called DMV (used by Italy's RAI, which otherwise is in the clear).

Then there's the problem encountered by Germany's Kirch Groupe in launching its DF-1 digital offerings. Both DF-1 and the Filmnet/Multichoice systems in the Benelux, Scandinavia (via Astra), Italy, and Greece, since acquired by Canal Plus, all encode in a system called Irdeto. Kirch subsidized the special D-Box receivers, but apparently didn't require buyers to actually sign-up for subscriptions. According to *Elektronikvaerlden* magazine, many of these receivers were then shipped off to the Netherlands and Belgium, where they could be easily modified to receive the digital channels available there. (The lack of subscribers has forced Kirch to merge with its bitter rival Bertelsmann-CLT, a move towards a unified standard ironically being blocked by the European Commission, which may delay digital satellite TV in Germany for years.)

Rupert Murdoch's British Sky broadcasting has delayed announcing its digital plans, but this spring or summer, Sky's 200 channel digital package will launch on the upcoming Astra 2A satellite. Sky has kept its Conditional Access standards secret, but *What Satellite TV* magazine has reported that in true Murdoch style it will be using his own NDC system. The start of DVB has also meant having to learn a few more numbers to dial in on receivers. Most European digital broadcasters are SR27500 FEC 3/4. Sky, however, will use an





Sirius 2 European BSS uplink (top) and overall European coverage.0

FEC of 2/3, meaning one-third of the data stream will be used for error correction, enabling the use of smaller dishes (45-50 cm instead of the typical 60-90 cm today). Unlike other systems, however, the Sky box is supposed to be upgradable for reception of coming digital terrestrial TV. (Which makes sense, because BSkyB has close contacts with the company that won the terrestrial digital license, and which will be relaying Sky channels as part of the service.)

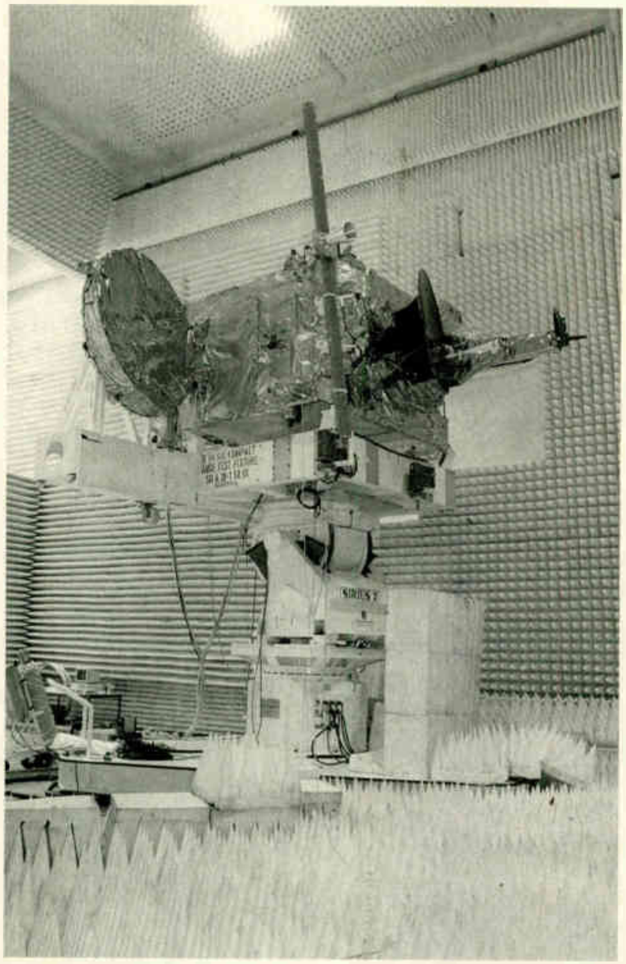
Internet

Lagging even farther behind BSkyB is Sweden's MTG, which operates a number of Scandinavian channels at both 1 degree West and 5 degrees East and distributes many others. MTG has yet to announce any digital plans, although it has been quietly relaying its channels in clear MPEG-2. But MTG is stealing a match on the digital services by offering rapid Internet access, a promised future component of the DVB services. Frank Oestergren writes in the Stockholm daily *Aftonbladet* that MTG's satellite distribution subsidiary Viasat will offering this service to its subscribers using existing analog transponders.

The idea seems far-fetched, but not so long ago MTG experimented in offering text-based Web browsing using the Tele-Text on its TV3 channel. (Tele-Text is a widespread and useful European system of sending numbered pages of information, from station schedules to news, using the unviewed lines that make up the top and bottom of a TV screen image.) All you had to do then was dial a particular telephone number, tune to the Tele-Text page indicated by the voice mail response, and then use the telephone touch tones to activate hyperlinks or type in the URL addresses to new Web pages. It was cumbersome and lacked images or audio, but it worked.

News

On December 21, 1997, the European Ariane rocket successfuly orbited Intelsat 804 from French Guiana. The new satellite will provide voice, data, and video services to the Indian Ocean region.



Sirius 2 under construction.

AsiaSat 3 went into a useless orbit, following a booster failure with a Russian Proton rocket on Christmas Day. The Hughes-built satellite was to have joined AsiaSats 1 and 2 in beaming broadcasts to Asia, the Middle East, and parts of the former Soviet Union.

Some of the (digital) services on the new Astra 1G satellite are Germany's ARD (tranponders 111 and 120), ZDF Vision (transponder 115), Pro Sieben Digital Media (transponder 120) and Austria's ORF and Switzerland's SRG (transponder 117). Beta Teknik is replacing ARD on transponder 101.

The Travel Industry Channel has started in clear PAL on Astra transponder 35 (shared otherwise by the teenage channel Trouble and the gameshow outlet Challenge TV) for two hours each morning.

Following an agreement between NBC and Dow Jones, European Business News is merging into CNBC Europe.

The Danish sports channel TVS has closed down, after failing to attract enough subscribers. The Swedish entertainment channel TV6 is becoming a pay channel, after failing to attract enough advertising.

RIK from Cyprus has begun broadcasts from Sweden's new Sirius 2 satellite, in clear PAL on 12.265 GHz. This is the first customer for the Sirius 2 transponders distributed by General Electric to Europe.

Finally, congratulations are in order to space visionary Arthur C. Clarke, who shortly after his 80th birthday was knighted by Tony Blair's British government, in its first New Years honors list since taking office in May. In 1945 Sir Arthur proposed the wild and crazy idea that artificial satellites at just the right distance from the Earth would orbit at the same speed as the planet's rotation, making communications relays possible.

Congratulations as well to Christian Lyngemark of Helsingborg, Sweden, and his Satco DX website, which has just celebrated its second anniversary. Satco DX is an incredible encyclopedia of satellite broadcast news, which on its second birthday listed 160 satellites, 4504 TV channels, 1992 radio stations, with links to 4168 other satellite-related webpages. It's the first place I check when I log-on, and is obviously popular...During 1997 there were more than half a million visitors to **http://www.satcodx.com.**

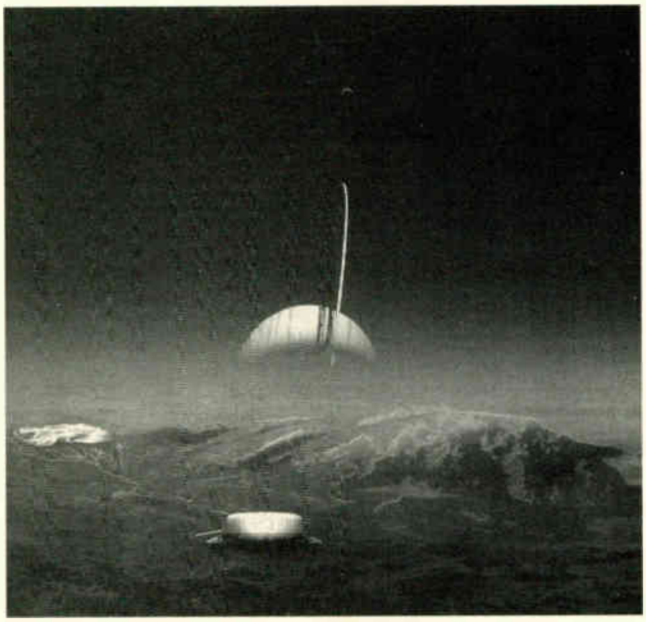
ST On The Air

By Steven J. Handler

NASA, Launch Time

This summer the biggest event in the history of space exploration is scheduled to begin and, courtesy of NASA, C-band satellite viewers will have a front row seat. If all goes well, this June a Proton rocket will lift off from Russia carrying the Functional Cargo Block, the first component of the International Space Station (ISS), into orbit.

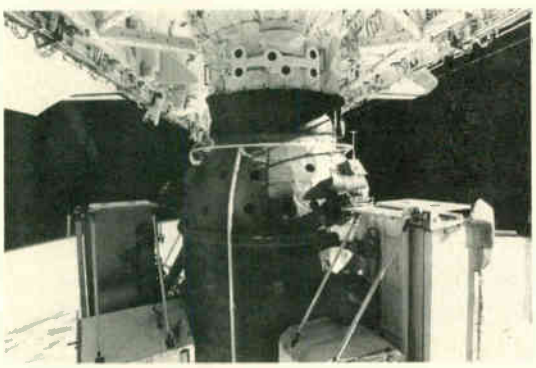
Rather than a single country's effort, the ISS will pool the resources of countries around the globe. Participants include Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Russia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.



Artist's Impression of the Saturn Probe Huygens. Expect the landing to be covered live by NASA TV. Photo :ESA

It's estimated that a total of 44 launches will be required to complete the ISS. The ISS is planned to orbit at an average altitude of 220 miles, and an inclination of 51.6 degrees to the equator. A detailed launch schedule is available via the web at **http://station.nasa.gov/station/assembly/flights/chron.html.**

The ISS is scheduled to be manned in early 1999, with an initial international crew of three. The initial crew is scheduled to spend five months aboard the ISS. Ultimately the station will be home for up to seven astronauts and scientists. It will be spacious compared to the space shuttle. The pressurized living and working space aboard the completed ISS will be more than 46,000 cubic feet, roughly equivalent to the passenger cabin volume of two 747 jumbo jets.



Mir Docking Module carried into space on space shuttle mission STS-74. The docking was broadcast live on NASA TV. Photo: NASA

C-band viewers can follow the progress of the ISS via NASA Television (NTV) carried on the General Electric's GE-2 satellite located at 85 degrees West longitude; NASA TV can be seen on channel 9. Just what is NASA TV? Formerly known as NASA Select, this C-band channel is operated by the National Aeronautics and Space Administration. Its programming provides real-time coverage of NASA activities and missions, such as the space shuttle.

Shuttle Scenarios You Might See

Shuttle coverage typically begins several hours prior to the scheduled launch. The entire mission is then broadcast live, around the clock, until after the shuttle lands and the astronauts depart.

Launch control for the space shuttle is handled by the Kennedy Space Center (KSC). Video of the space shuttle at the launch site, as well as the pre-launch and launch air-to-ground audio communications are provided. In addition to live air-to-ground communications, NASA public affairs officers (PAO's) provide viewers with narration and commentary.

If the shuttle encounters problems during launch or ascent to orbit, you may hear talk about abort options and potential landing sites. Hopefully, none of these maneuvers will ever have to be executed, but you may want a brief description just in case. Depending on how soon after launch a problem arises, the shuttle has several options. A failure or premature shutdown of one or more engines early in the ascent could result in a maneuver called return-to-launch-site. This procedure is referred to as an "RTLS." To accomplish this feat, the shuttle would pitch around and, using available engine thrust, head back and land at the shuttle landing facility located at KSC.

In the event the shuttle lost one or more main engines midway through powered flight, the shuttle might attempt a transatlantic abort landing (TAL), in NASA jargon called "TAL." Three TAL sites are available to the shuttle. One is in Europe in Moron, Spain, and the other two are located in Africa, one at Banjul, The Gambia, and the other at Ben Guier, Morocco.

If the main engine shuts down later in the ascent phase but still earlier than expected, another option that may be available to the shuttle is an abort-once-around (AOA). In this procedure, the shuttle would make a single orbit around earth and then descend and land at Edwards Air Force Base, California.

Lastly, if the shuttle sustained only a partial loss of main engine thrust late enough in the ascent to allow it to reach a minimal 105 nautical mile orbit using the orbital maneuvering system engines, an abort-to-orbit (also called "ATO") might be attempted.

After the launch, control of the space shuttle shifts to the mission control center (MCC) at Johnson Space Center (JSC) in Houston, Texas. When NASA TV's cameras at the Kennedy Space Center lose visual site of the space shuttle, they switch to live coverage from the MCC. Throughout the mission, NASA TV broadcasts the air-to-ground audio communications between the shuttle and the MCC as well as the PAO's narration and commentary.

Astronaut Chris Hadfield on the Shuttle Atlantis during STS-74. The Mission was covered live on NASA TV. Photo Credit: NASA

The shuttle's callsign is its name, either Columbia, Endeavor, Discovery or Atlantis. The standard callsign for the MCC is Houston. Most communications between the MCC and the shuttle are with the spacecraft communicator, who in addition to the Houston callsign may use the callsign CAPCOM. The spacecraft communicator is traditionally an astronaut. The CAPCOM callsign appears to date back to the first manned space flights of the Mercury series and is an abbreviation for capsule communicator.

Within the MCC are many key officials whose voices may also be heard. Among these officials is the flight director (callsign-FLIGHT), with overall responsibility for the conduct of each shuttle mission. The flight activities officer (callsign-FAO) is responsible for the mission's timeline. The FAO may be heard during discussions about flight timeline checklists. The integrated communications officer (callsign-INCO) is responsible for the shuttle's communications systems, including voice, video and telemetry.

During launch phase, another of the key officials is the flight dynamics officer (callsign-FDO). The FDO has the critical responsibility of monitoring the performance of the space shuttle during the ascent portion of the flight. The FDO and staff also calculate orbital maneuvers as well as monitor the flight during re-entry. While the FDO monitors the performance of the shuttle spacecraft, the flight surgeon (callsign-SURGEON) monitors the health of the astronauts and crew. It is the surgeon's job to provide guidance on all health related matters.

Some shuttle flights carry specialized payloads, including satellites for launch, spacelab missions, and scientific experiments. Portions of those flights may be controlled from other NASA facilities such as the Goddard Space Flight Center in Maryland, the Marshall Space Flight Center in Alabama, and the Dryden Flight Research Center in California. When NASA facilities other than the mission control center at JSC take control of the specialized operations of the space shuttle, NASA TV broadcasts remote from their facilities rather than from Johnson .

Broadcast During Down Time

Don't expect round the clock non-stop action if you tune into a shuttle mission. Remember that sometimes astronauts are in a sleep or rest period. When there are no particular activities in progress aboard the shuttle, the NASA TV camera often focuses on the mission control center orbital map which shows the orbital progress of the space shuttle, with TDRS (Tracking Relay and Data Satellite) and ground station coverage maps plotted on the orbital map.

Shuttle press conferences are also broadcast live via NASA TV. Before each shuttle mission, a pre-flight press conference is aired. In addition, after each flight NASA TV broadcasts the post-flight press conference. During each mission, commencing after launch, a series of live press conferences is held to discuss the details of the mission. Since reporters covering shuttle missions are located throughout the country, many of NASA's facilities have press rooms where reporters from that area can gather. These sites are connected by NASA TV to the press conference which is usually held at Johnson. Reporters located at the other NASA facilities are able view the conference live, as well as ask questions in real time along with the reporters physically at JSC.

When NASA TV is not broadcasting live missions, it is used for media communications and educational purposes. To assist viewers, throughout each broadcast day NASA TV airs the schedule of upcoming programs and events. Several programs may be of interest to *ST* readers. The NTV video file is broadcast primarily for the news media. It alerts them to the most current audio and video resource material of NASA events. NTV airs weekdays at noon (EST) with replays at 3 p.m., 6 p.m., 9 p.m. and midnight EST.

NASA also provides programs of special interest to educators and teachers. *NASA Gallery* provides a retrospective of the early years of the U.S. space program as well as more recent achievements. *NASA Gallery* airs weekdays at 1 p.m. (EST), with replays at 4 p.m., 7 p.m., 10 p.m. and 1 a.m. the next morning (EST).

Another program *The Education File*, is specifically designed to be viewed by students as well as teachers. It airs weekdays at 2 p.m. (EST), with replays at 5 p.m., 8 p.m., 11 p.m., and 2 a.m. the next morning (EST).

NASA provides launch status reports prior to each space shuttle launch. A recorded program information line at 281-483-8600 is maintained at the Johnson Space Center.

For those with a secret desire to be an astronaut rather than simply watching space activities via TV, there is hope. Astronaut recruiting occurs periodically. According to a FAQ (Frequently Asked Questions) posted by NASA on its internet site, any adult man or woman in excellent physical condition and who meets the basic qualifications can be selected to enter astronaut training.

For mission specialists and pilot astronauts, the minimum requirements include a bachelor's degree in engineering, science or mathematics from an accredited institution. Three years of related experience must follow the degree, and an advanced degree is desirable. Pilot astronauts must have at least 1,000 hours of experience in jet aircraft, and they need better vision than mission specialists. Competition is extremely keen, with an average of over 4,000 applicants for about 20 openings every two years. For more information, write to the Astronaut Selection Office, NASA Johnson Space Center, Houston, TX 77058.

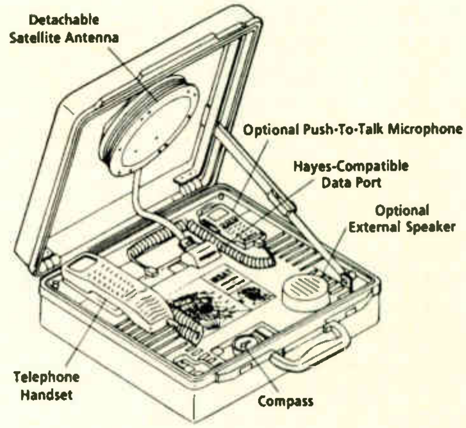
So crank up the DISH network 18-inch dish or point your C-band dish to GE-2 and tune into NASA TV for some entertainment that is out of this world. Why miss history when you can catch it *On The Air*!

ST

ST PERSONAL COMMUNICATIONS

By Donald E. Dickerson

AMSC Skycell



You may think you have to wait for the deployment of one of the planned Big LEO (Low Earth Orbit) satellite systems in order to get the advantages of a satellite based system of portable telephone service for yourself, your company or your humanitarian mission into the wilds to deliver food stuffs to the local peasantry. But you'd be wrong. If you need reliable, mobile and portable voice or data communications services that only satellites can provide in a variety of formats and equipment packages, and you are in North America, why wait? Skycell has been providing just such a service for over two years now.

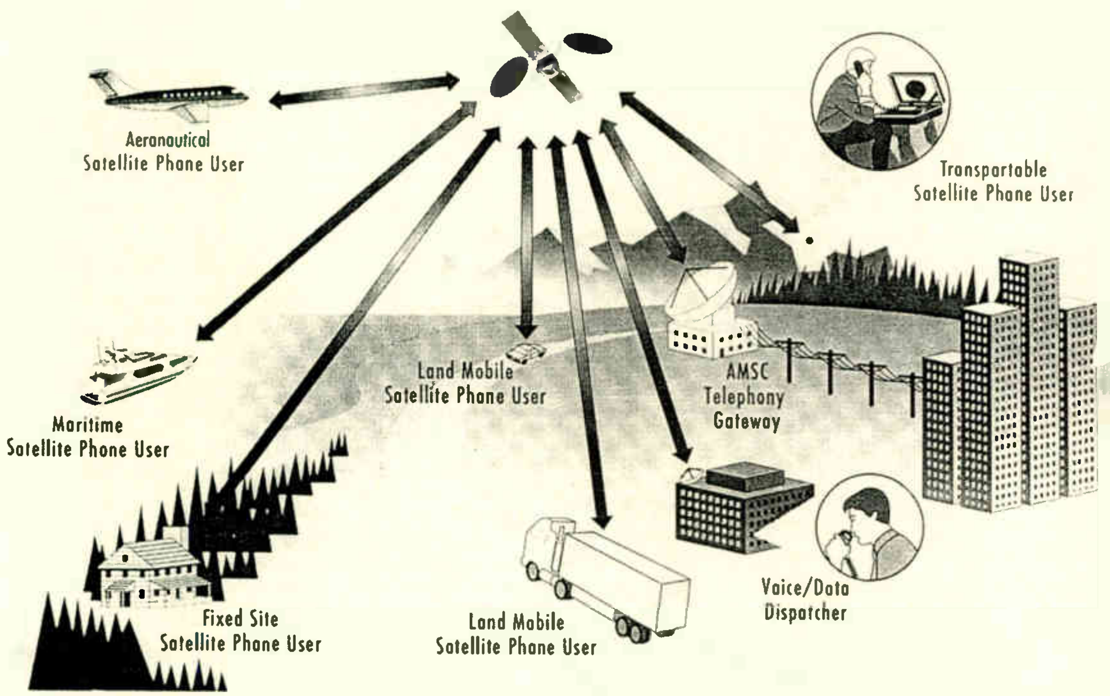
Skycell is the product of American Mobile Satellite Corporation (AMSC), pioneers in the geostationary communications satellite (PCS systems). AMSC was formed in 1988 and is located in Washington, D.C. Their satellite control facility is located at Reston, Virginia.

AMSC was formed by four companies: McCaw Cellular Communications, Mtel Corporation, Hughes Communications, and Singapore Telecomm. They began to work on establishing a satellite communications system largely based on the research done using NASA's ACTS (Advanced Communication Technology Satellites) program of the mid 80s. AMSC launched its first spacecraft, AMSC-1, in April of 1995. It was launched atop an Atlas 2A launch vehicle and was placed in the 101 degrees west slot in the Clark Belt.

The spacecraft design is based on the Hughes 601 bus. It is 68-feet across with its antennas deployed and weighs in at 3,655-lbs. AMSC-1 uses three-axis stabilization for attitude control.

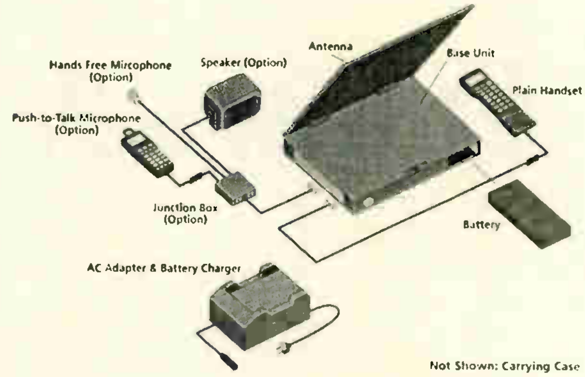
Mobile units for the Skycell system use the L-band frequencies of 1631.5 to1660.0 MHz for downlink and uplinks from 1530.0 to 1559.0 MHz. Fixed ground stations use Ku-band and receive on 13.0 to 13.25 GHz. Transmissions to the spacecraft are uplinked in 10.75 to 10.95 GHz spectrum.

The spacecraft can support 2000 simultaneous phone calls (each channel is 12 kHz) with a total of 450,000 watts RF on L-band. AMSC-1 carries two L-band antennas, both 16- by 22-foot elliptical, mesh, springback antennas. Five spot beams cover the U.S., Alaska, Puerto Rico and the Virgin Islands. The spacecraft also carries a single 30-inch shaped reflector antenna for Ku-band operation.



Skycell service can provide you with full or half-duplex communications links. Either way, you can talk directly one-on-one with any other station you wish or as many as 10,000 other users at a time. Talk groups similar in setup to those you would find on a trunking system are used. Skycell phones use a digital FDMA format.

AMSC Skycell can provide a wide range of services for portable, mobile, commercial transportation, shipping and aviation. Other services using Skycell satellite systems include off-shore oil rigs, trucking companies, local and federal



law-enforcement agencies, FEMA, and even Amtrak. Services provided include 24 hour a day directory, operator and customer service, voice mail, call waiting, call forwarding, conference calling, no answer transfer, international calling, call-barring capability, and talk group ultra-wide area voice paging and dispatch capability.

The Skycell Plus nationwide dispatch service allows virtually any service to contact entire groups of users or individual users with priority messages.

Commercial maritime satellite phone equipment was designed to withstand the vigors of life at sea. This system uses a stabilized dome antenna which comes in several designs for both commercial and private vessels. The mobile messaging system uses Global Positioning System (GPS) reporting and position location, as well as two-way messaging.

There are four companies now providing telephone equipment to AMSC to support the Skycell system. Westinghouse, Mitsubishi, Cal Corporation and KVH Industries are producing equipment for a wide range of services. The Mitsubishi ST-151 portable satellite phone has three speed-dialing memory locations, 99 alphanumeric memory locations, any key answering, automatic answering capability, call timer and accumulated call time, compass, digital full duplex voice capability, electronic lock function, fax capability, speakerphone operation, internal battery charger, push-to-talk microphone for dispatch service, RS-232 port, and security functions for restricted calls.

Skycell also offers a 4800 bps data and fax service which will allow you to use your Skycell phone with your lap-top or PC for e-mail or internet online services.

For more information on Skycell systems and services call 1-800-872-6222 or look them up on the internet at their website, **http://www.skycell.com**

AMSC Leases MSAT-2 Satellite to New African Venture

On December 4, 1997, AMSC announced it will lease its MSAT-2 satellite to African Continental Telecommunications Limited (ACTEL) for deployment over sub-Saharan Africa. Through an agreement with TMI Communications of Ottawa, Canada, American Mobile Satellite will jointly own and operate the identical MSAT-1 satellite to continue to build its customer base for mobile communications services.

The African project is endorsed by key

business and political figures in the U.S. and Africa. ACTEL's board of directors and advisors includes such noteworthy figures as Andrew Young, former mayor of Atlanta and former US ambassador to the UN; Percy Sutton, former president of the Borough of Manhattan and founder of Inner City Broadcasting; and Babacar N'Diaye, former president of the African Development Bank.

"American Mobile Satellite is privileged to contribute to this worthy African venture," said Gary M. Parsons, president and chief executive officer of American Mobile Satellite. "The transaction is financially positive for our company, while accelerating development of the business and communications infrastructure of Africa."

"The new southern African communications system will bring much needed communications to mobile users and remote villages previously unreached by telephone service of any kind, helping to raise the standard of living and increase the economic development of the countries served," said James R. Walker, ACTEL chief executive officer.

Under the proposed arrangement, American Mobile Satellite will lease MSAT-2 to ACTEL for a five-year renewable lease with payments of $38 million per year. American Mobile Satellite will also license its ground station technology to ACTEL.

The lease income will be used by American Mobile Satellite to fund the purchase of its share of the MSAT-1 satellite and to further develop its core business by enhancing service offerings, developing more advanced customer equipment and adding additional customers.

INMARSAT's 100,000th Terminal Fitted on Fishing Vessel

INMARSAT has commissioned its 100,000th mobile terminal, an INMARSAT-C, for a French fishing vessel based in L'Orient, Brittany.

The *Rorqual IV*, a 112 ton boat with a crew of six, specializes in fishing for Dublin Bay prawns in the North Sea. The boat, which is owned by Fisher Bank, makes between 20 and 25 fishing excursions per year, each trip lasting 14 days.

The INMARSAT-C system provides two-way text and data messaging, data reporting and fleet broadcast communications through small, lightweight terminals. Fishing vessels can receive maritime safety information and communicate with customers, colleagues and suppliers while at sea.

According to Mr Gilbert Duduyer, the company's maritime expert, the prime advantage of INMARSAT-C lies in safety communications.

"If someone is injured on board or there is a safety problem out at sea, you can immediately alert the rescue services and take any necessary action a lot more quickly than using traditional radio communications," explained Mr Duduyer.

INMARSAT-C also gives Fisher Bank a commercial advantage. Using information transmitted via INMARSAT-C, Rorqual presells their catch before arriving at port, choosing the landing site and customer offering the best prices. They also make real-time decisions about which species to fish and which areas to work, based on market reports received from their offices via INMARSAT.

According to Mr Duduyer, "INMARSAT-C allows the boat to keep in contact with the fishing port and tell them how much they've caught. This enables them to select the date when the boat should return to the port to sell the catch.

"It can therefore be used to find out what the *Rorqual IV* has caught and maybe alter the date of the sale according to trends in market prices."

Furthermore, INMARSAT-C also offers considerable time savings in maintenance work on the trawler. A technical problem such as an equipment fault can be clearly specified to a head office by fax, so a solution, including spare parts, is ready as the boat approaches the port.

"So, in the event of a problem you can easily take preventive measures and, if necessary, order components to repair the boat while it's on its way. This saves time," explained Mr Duduyer.

And while traditional radio communications can be easily received by competing fishing boats, INMARSAT-C communications between the *Rorqual IV* and the shore remain strictly confidential.

The 100,000th INMARSAT terminal, a TT-3020C INMARSAT-C/GPS Maritime Capsat manufactured by Thrane & Thrane of Denmark, is fully compliant with GMDSS regulations. It was supplied by distributors TD COM, official importers of Thrane & Thrane equipment in France, French-speaking Africa, and the Middle East.

INMARSAT Launches INMARSAT-B Premier Service

INMARSAT, a global mobile satellite communications provider, recently unveiled the new name for its top-of-the-line communications service–INMARSAT-B Premier Service.

INMARSAT-B Premier Service uses digital technology and is ideal for land and sea communications where land-line telephone services do not exist.

Using INMARSAT's constellation of fixed geostationary satellites, INMARSAT-B Premier Service customers include the media, government personnel, remote office workers, offshore oil explorers, cruise ship operators and aid organisations. Users can speak to, fax or e-mail anyone anywhere in the world.

The INMARSAT-B Premier Service features high-speed digital data, operating at 64K/second. This service supports a wide range of demanding applications, including the rapid transmission of video footage–especially useful for media customers wishing to send videos back to the newsroom, making news stories available almost instantly.

A wide variety of applications are now supported as part of the INMARSAT-B Premier Service, including e-mail access, ship management solutions, remote LAN access software, videoconferencing, broadcast-quality audio, and video transfer. More information can be found on INMARSAT's website at URL **http://www.inmarsat.org**.

ST

Need to Communicate from Anywhere to Anywhere?

NOW YOU CAN!

Introducing the First Hand-Held WORLDWIDE SATELLITE COMMUNICATOR!

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

Over the horizon? Beyond the reach of civilization?

There are places in this world that few others have ever seen, or can even imagine. These places have no telephone lines, cell towers, couriers or mailboxes—only you and your need to communicate.

Despite this need, there has been no affordable or practical way to communicate from remote areas...until now.

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

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

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

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

Available in March 1998! Reserve yours now! Your credit card will not be billed until the unit is shipped! Phone access card required for operation.

All this—for only $1499.95 from Grove Enterprises!

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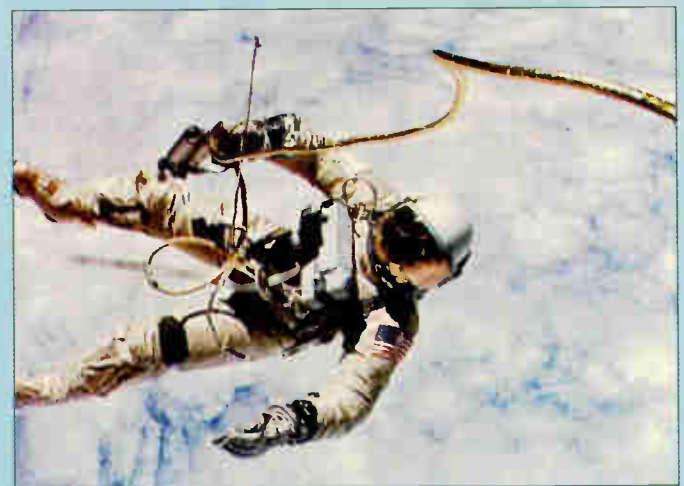
ST FINAL FRONTIER

By Philip Chien

Hitting the EVA Wall

NASA's high tech term for spacewalks is extra-vehicular activities, or EVA for short. The first U.S. EVA occurred in 1965 when Gemini 4 astronaut Ed White II made a 20 minute spacewalk out of his Gemini spacecraft. Since then dozens of astronauts have made spacewalks during the Gemini, Apollo, Skylab, and Shuttle programs. So why is NASA suddenly so concerned about the EVAs which will be needed to assemble the International Space Station?



Photos of the first U.S. spacewalk–Ed White II on Gemini 4

Consider that in the first four decades of space travel the U.S. has accumulated a total of 765 hours of spacewalks. But in the next five years another 900 hours will be needed to assemble the space station and that doesn't even include 200 additional hours for maintenance or the additional spacewalks which will be performed by American and Russian space travelers wearing Russian ORLAN spacesuits.

NASA engineers talk about hitting the EVA wall, and that's exactly what it looks like–a steep wall which has to be climbed over.

When is a Spacewalk not a Spacewalk

When an EVA starts and stops–or even which astronauts get credit for performing a spacewalk–is rather confusing. It seems simple, but it isn't. If a spacesuited astronaut sticks his head out of hatch and looks around, has he done a spacewalk or not? How about his partner who's also spacesuited and in a vacuum environment, but who remained within the spacecraft?

The exact definition of spacewalks has varied over time and is partially a function of spacecraft design. During the Gemini and Apollo programs the entire spacecraft was depressurized for spacewalks. So all of the astronauts had to be suited. For the Gemini spacecraft, power, air, and communications were all contained within the umbilical which connected the spacewalker with his spacecraft. Apollo introduced self-contained spacesuits–basically miniature spacecraft with their own self-contained power, air, radios, and cooling systems.

Skylab featured the first airlock. While two of the Skylab astronauts were spacewalking the third astronaut remained inside in the docking adapter. Until recently the shuttle's airlock was inside the crew cabin, but NASA is moving the airlock into the cargo bay during each shuttle's major maintenance period. Besides giving back additional space within the crew cabin the external airlocks will have two hatches–the normal hatch to the shuttle's cargo bay and the upper hatch which will have the space station docking adapter installed.

For early space station assembly flights the U.S. spacewalkers will exit from the shuttle's airlock. Space Station is scheduled to get its own airlock in mid 1999. In addition, the Russian side of the space station will have its own airlock which is compatible with the Russian ORLAN suits.

For the Gemini and Apollo missions the definition of a spacewalk was the amount of time your torso was outside of the crew cabin. The Apollo lunar spacewalks can be considered a special case, because they took place in a partial gravity environment.

But for Skylab and the shuttle, a spacewalk occurs when the suited astronauts are exposed to the vacuum. Technically, a shuttle spacewalk starts and ends when the astronaut is on battery power and independent of the shuttle's systems.

So, by current shuttle definitions none of the Gemini spacewalks ever took place–because the astronauts were always attached to their spacecraft! On the other hand, if you use exposure to vacuum as the definition, then all of the Gemini and Apollo astronauts on each spacewalking mission made a spacewalk since the entire crew cabin had to be depressurized!

There are two special cases in the shuttle program where the definition gets really murky. On the STS-4 mission, commander Ken Mattingly got to test out the shuttle spacesuit. But he was only in the depressurized airlock and didn't open up the hatch. He had performed a spacewalk during the Apollo program. While he didn't get a chance to fly on Apollo 13 (you may remember a movie a couple of years ago which featured him as a fictional character), he did fly as the Apollo 16 command module pilot. On the way back from the moon he exited the Apollo Command

Dr. Owen Garriott during Skylab 3

Views of Bruce McCandless II during the STS 41-B mission, including freeflights with the Manned Maneuvering Unit

module to retrieve film from the outside of the Service Module.

On the STS-80 mission a jammed airlock hatch caused the planned spacewalks to be canceled. But astronauts Tammy Jernigan and Tom Jones were fully suited and on battery power while they tried to open the stubborn hatch. So did they make a spacewalk or not? NASA managers consider the two to have spacewalk experience–since they went through all of the training, and were exposed to the vacuum environment.

Suiting Up

For earlier programs spacesuits were custom built to the astronaut's dimensions. Each astronaut got three suits–the actual flight suit, the backup suit, and a training suit. Ironically the training suits are in the worst condition. They were used the most and were exposed to harsh environmental conditions during training.

The shuttle program features more generic Hard Upper Torsos (HUTs). They come in Xtra-Small to Xtra-Large sizes. Most male astronauts fit into the Large or Xtra-Large size and females range from Xtra-Small to Medium. The spacesuit gloves are still customized for each astronaut's hands, though.

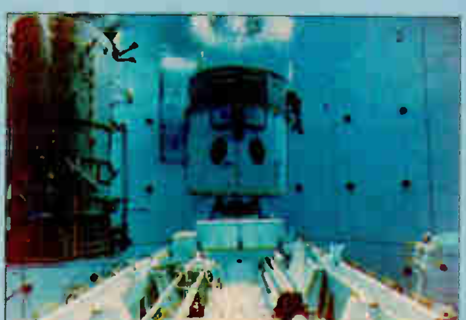
Spacesuits can be resized slightly in space which gives a little more flexibility. For example, on the STS-82 second Hubble servicing mission only three spacesuits were carried for the four spacewalkers. Mark Lee, Joe Tanner, and Steve Smith wore Xtra-Large suits. Greg Harbaugh wore a Large. However, Joe and Steve could have worn the Large if necessary. So two Xtra-Large and one Large suit were carried and resized as necessary for the spacewalkers. The three suits provided enough flexibility so if any one suit didn't work they could still do all of the spacewalks. Alternately if there was a health problem and one of the astronauts couldn't do a spacewalk another could substitute.

Each astronaut candidate is checked out during their early training. It quickly becomes obvious that some of the smallest women will not have the opportunity to do spacewalks due to their size. Upper body strength is an important factor for spacewalks, and about half of NASA's female astronauts don't meet the physical requirements.

Spacewalk training takes place in many forms from classroom instruction to virtual reality. The primary trainers are the Neutral Buoyancy Laboratory, air bearing floor, and the KC-135. Each one has its own limitations and advantages.

Strangely the best tool for spacewalks is underwater. An astronaut in a spacesuit is similar to a diver underwater. Properly weighted, a diver is neutrally buoyant and won't sink or rise. The Neutral Buoyancy Laboratory (NBL) is a 6.5 million gallon "swimming pool." It replaces the previous WET-F pool at the Johnson Space Center and the Neutral Buoyancy Simulator (NBS) at the Marshall Spaceflight Center in Alabama. A squadron of divers assist the astronauts in the NBL, including two safety divers for each astronaut, utility divers who bring over equipment as required, camera operators, and safety divers who monitor the entire operation. Once the astronauts are submerged, weights are added to their spacesuits to balance them so they're neutrally buoyant.

All of the tools and spacecraft mockups which they use underwater have weights or pieces of foam to make them neutral, too. But the key limitation underwater is the water's viscosity. Anybody who's ever been swimming realizes it's more difficult to move through water than through air. If you shove something underwater it quickly slows to a stop. But the same object in space would continue to move until it ran into something. But, even with its limitations, underwater training is the most realistic training available on the ground. Astronauts have commented that if actual spacewalks had bubbles rising and safety divers hanging around to assist them it would be identical to their training.



Training for the first Hubble Servicing mission at the Neutral Buoyancy Simulator at the Marshall Spaceflight Center

A better simulation for drag is an air bearing floor. Basically, it's a fancy giant air hockey table, with platforms for the astronaut and their mockups. The disadvantage to the air bearing floor is that gravity is still present.

The KC-135 has been used for spacesuit tests as well as acclimating new astronauts to the weightless environment. But the plane is always moving forward so there's never a completely realistic simulation of the space environment.

Virtual Reality has also been used to a limited extent as a training tool. The accuracy of the simulation is only as good as the accuracy of the programming. But it's a decent tool for describing how something should work.

On the recent STS-87 mission ground controllers sent up an MPEG video movie showing the spacewalkers what the spinning Spartan satellite should look like from their point of view. That movie's available on the Internet at **http://shuttle.nasa.gov/sts-87/video/daily/Flightday14/87d14c5.mpg.** While a very accurate depiction of the actual events, there is one important thing missing in the simulation–the astronauts don't have any arms!

If you have a radio with UHF coverage you might want to try for direct communications during EVAs from the astronauts. Tune that radio into 279.000 MHz (AM mode) and you might get lucky and hear the astronauts working in the shuttle cargo bay.

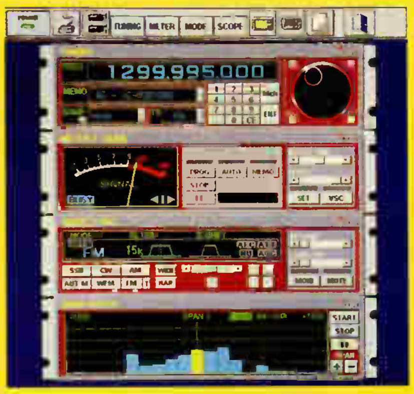
Managers are nervous about the upcoming EVA wall but are confident that they're ready. There are nineteen current astronauts with EVA experience, and additional astronauts will get experience on each of the upcoming space station missions. The wall's here and dozens of astronauts are ready to climb over it. ST

ST WHAT'S NEW

by Wayne Mishler, KG5BI

Worldwide Radio Comes to the PC

If you think the Internet is the last word in communications, ICOM America, Inc., has news for you.



In the words of ICOM, it goes a little something like this: "Fasten your seat belts for exciting discoveries beyond the Internet."

Meet the IC-PCR 1000, a little "black box" from ICOM that turns your computer into a high quality wide band receiver.

We're talking reception of not only local radio and television broadcasts, but HF through EHF transmissions of data, news, music, and events worldwide. You can listen in on world news from the BBC, or a rugby match in Australia–right on your PC. Ditto for fire, police, search and rescue, commercial, military, aircraft, and marine communications.

The unit is a little black box, about the size of a small hard-cover novel, that connects externally to your 486DX or better desktop or laptop computer.

Okay, I know what you experienced radio enthusiasts out there are saying: "It'll never work because computers interfere with radios."

Not so, says ICOM. The company promises "exceptional receiver and scanner performance" from the IC-PCR 1000.

"The PCR 1000 puts exciting world-wide reception at the finger-tips of anyone with a computer," says Ron Spencer, ICOM's Sales Manager.

With a good antenna attached, the PCR 1000 covers the globe, enabling a computer with Microsoft Windows 3.1X or Windows 95 to become a superb receiver. You can even use it in a car by plugging into a cigarette lighter and hooking the unit to a laptop computer.

This new "virtual receiver" covers a vast frequency range from .01 to 1,300 MHz with all mode capability including WFM, FM, AM, SSB, and CW.

It works in the background while your other programs are running. Imagine being a reporter listening to a high-speed car chase on police channels while pounding out a front page story on the keyboard. Satellite sleuths should be especially interested in this receiver given its wide frequency coverage and selection of transmission modes.

There are three interface screens. One displays a typical receiver front panel with S-meter for signal strength, a large frequency readout, and a keypad. Another screen offers tuning, mode, meter, and band scope functions. And there's third screen with simple controls like the typical stereo tuner.

Now hold on to your hat. This virtual receiver has an unlimited number of memory channels. Unlimited. These channels are grouped into "banks" of 50 channels each, and are stored on your computer's hard disk or floppy. Each memory can store frequency, mode, memory name, tuning step, attenuator, and filter settings.

I've saved the best part for last. The suggested retail price of this little black box miracle is ... are you ready? ... US$499.95 plus $9.50 shipping from Grove Enterprises (RCV21). You could easily spend twice that for a top of the line communications receiver that does less.

To find out more, visit the Grove Enterprises website at: **http://www.grove.net**.

Arm-Chair Horse Race Wagering Comes to Cable and Satellite TV

It was bound to happen: Interactive horse racing featuring in-home wagering from your easy chair.

That's right, the Television Games Network (TVG) with interactive betting will launch on a grand scale late next year, says Mark Brenner, TVG president.

"This is an entirely new category of entertainment programming," Brenner says. "You can wager on TVG in real time with real odds and have immediate feedback and gratification from this thrilling and fast-paced sport."

In tests at Louisville, Kentucky, more than 1,000 subscribers are averaging more than 200 transactions per household per month, using TVG technology.

"This product has been in place for more than two years in Louisville, and has provided an excellent customer experience," Brenner says. "Independent research confirms demand for TVG with 17 percent of satellite and 15 percent of cable customers across the United States saying they would likely subscribe to the service."

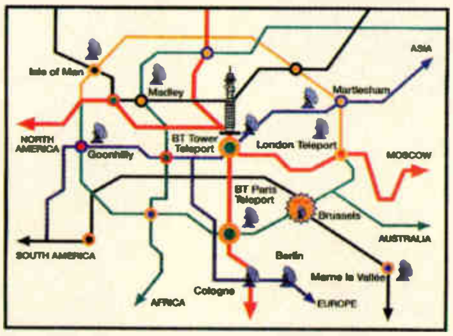
TVG has acquired exclusive rights to the live racing content from nine of the nation's premier horse racetracks: Arlington International Racecourse, Churchill Downs, Gulfstream Park, Hollywood Park, Laurel Downs, Lone Star Park, Pimlico, Santa Anita, and Turfway Park.

Currently, using a remote control device, subscribers are navigating easily through a series of on-screen menus to view racing information and place wagers in real time on live races directly into the racetrack systems. Soon TVG will be delivering its service to cable set-top converters and personal computers.

Plans call for expansion to a continuous schedule including international racing; inserts for local tracks' races; features about racehorses, jockeys and trainers; handicapping guides and tutorials; interactive advertising; and merchandising.

"Cable operators are going to want this service," Brenner says. "Once customers get a taste of it, they will choose their video provider on the basis of whether TVG is available in the lineup."

BT **European Teleport Network**



International Teleport Facility Launches in Brussels

BT Broadcasting Services is expanding its global broadcast network with the launch of an international teleport in Brussels, the heart of NATO and the European Parliament.

Brussels Teleport will offer digital and analog satellite transmission services into and out of Brussels, and in-house production and business multimedia solutions.

Established microwave links provide terrestrial connectivity between the teleport and key broadcast sites around the city, including the country's main switch at Madou Tower.

"Brussels is an integral part of our ongoing, worldwide expansion program which has, in the past 12 months, seen similar transmission services launched in France, Germany, Italy and the United States," says Tony Rybacki, head of BT commercial services.

The teleport will feature on-site decoder systems, capable of transmitting and receiving signals to and from any other teleport within BT's network and from its digital transportable earth station fleet all over Europe. Multilingual, 24-hour booking and customer services hotlines provide the capability to book services to and from anywhere in the world with a single phone call.

Christine Leurquin of SAIT Videohouse says that pooling the resources of her company with those of BT will provide a range of cost effective broadcast solutions. "From media support to satellite transmission services, Brussels Teleport will be a one stop shop for domestic and international broadcasters," she says.

Kmart to Carry RCA DSS systems

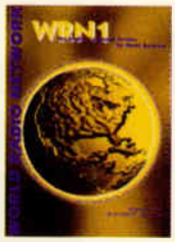
DIRECTV and Kmart are teaming up in distributing RCA-brand DSS systems to more than 2,000 participating Kmart, Super K and Big Kmart stores in the continental United States.

"Kmart customers will now be able to experience what our more than 3 million DIRECTV subscribers already receive–access to more than 175 channels of superior quality home entertainment with digital picture and sound," says Bill Casamo, DIRECTV executive vice president.

Kmart will market the RCA systems and DIRECTV programming via print advertisments in Sunday inserts in newspapers across the nation. You will also see in-store displays, point of purchase materials, and signs to promote DIRECTV.

There are 2,122 Kmart stores in the United States.

World Radio Network Available by Satellite



WRN1 radio is now available across North America on the Galaxy 5 satellite at 125 west. Program schedules are available on the Internet at **http://www.wrn.org/.**

The satellite's footprint covers the continent and extends into Mexico and parts of the Caribbean.

The service is free. You can find WRN1 by switching your satellite receiver to transponder 6 (TBS television) at 3.820 GHz and the audio subcarrier to 6.8 MHz.

To make listening easier, connect the satellite receiver's audio output (located on the rear panel of the receiver) to your stereo amplifier. Then switch off the television set and listen to the radio through the high quality loudspeakers of your stereo system.

WRN1 features programs from public service radio stations worldwide and delivers them to listeners on a single radio channel.

Merger Will Create Giant Satellite Products Company

GPS technology developer and manufacturer Ashtech is merging with the Orbital Sciences Corporation Magellan subsidiary to form a $125 million satellite access products company.

Operating under the Magellan banner, the new organization will offer advanced GPS positioning, navigation and timing solutions, satellite telephony, and data communications products for industrial, commercial and consumer markets worldwide.

Recent statistics project that global sales for GPS products will reach $8.5 billion by the turn of the century.

Specializing in advanced satellite technologies, Magellan plans to benefit from several trends driving this growth, such as safety and collision avoidance, proliferation of hand-held devices, navigational needs and other such markets.

The merger will be accomplished through the exchange of stock and cash between the privately held Ashtech, Inc., and Orbital, a commercial space products and services company. The Ashtech stockholders will receive $25 million and 34 percent ownership in Magellan Corp., while Orbital will own the remaining 66 percent.

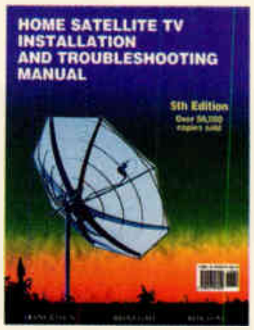
Magellan expects to employ about 500 people. They expect combined 1997 revenues to top $100 million.

Magellan-Astech products will be sold in more than 12,000 retail outlets in more than 100 countries through a network of dealers, distributors and agents.

Baylin Announces New Installation Manual

Baylin Publications has released the 5th edition of the *Home Satellite TV Installation and Troubleshooting Manual* covering the transition from analog to digital C-band, large-dish technology.

This 326-page, 8 1/2 by 11-inch book is an invaluable working tool with illustrations and tables for installing and maintaining trouble-free satellite systems. Written for laymen, the text contains over 300 up-to-date illustrations, photographs and tables.



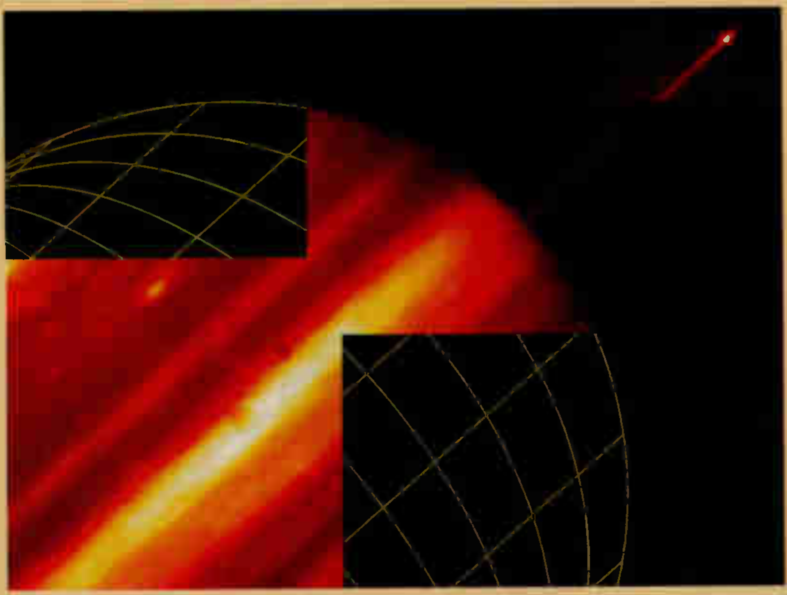
The fifth edition has been rewritten and reorganized. It includes background theory and details on how satellites and TVROs operate, how to select and judge satellite TV components, how to install and aim dishes (with accompanying tables), and much more including an explanation of video standards and methods.

The manual is available from Baylin, 1905 Mariposa, Boulder CO 80302. Price is $34 including shipping.

SPACE WATCH

By Larry Van Horn

Jupiter's Ring and Clouds

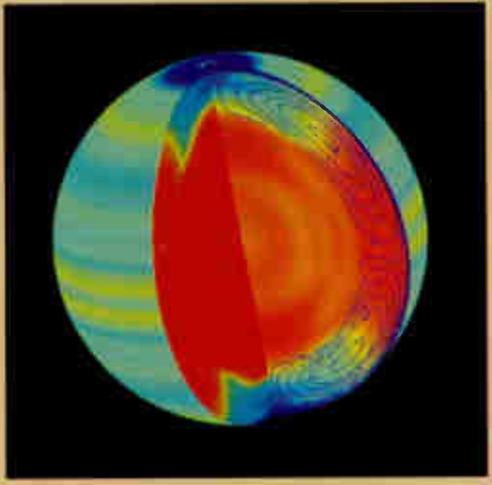


Probing Jupiter's atmosphere for the first time, the Hubble Space Telescope's new Near Infrared Camera and Multi-Object Spectrometer (NICMOS) provides a sharp glimpse of the planet's ring, moon, and high-altitude clouds.

The presence of methane in Jupiter's hydrogen- and helium-rich atmosphere has allowed NICMOS to plumb Jupiter's atmosphere, revealing bands of high-altitude clouds. Visible light observations cannot provide a clear view of these high clouds because the underlying clouds reflect so much visible light that the higher level clouds are indistinguishable from the lower layer. The methane gas between the main cloud deck and the high clouds absorbs the reflected infrared light, allowing those clouds that are above most of the atmosphere to appear bright. Scientists will use NICMOS to study the high altitude portion of Jupiter's atmosphere to study clouds at lower levels. They will then analyze those images along with visible light information to compile a clearer picture of the planet's weather. Clouds at different levels tell unique stories. On Earth, for example, ice crystal (cirrus) clouds are found at high altitudes while water (cumulus) clouds are at lower levels.

Besides showing details of the planet's high-altitude clouds, NICMOS also provides a clear view of the ring and the moon, Metis. Jupiter's ring plane, seen nearly edge-on, is visible as a faint line on the upper right portion of the NICMOS image. Metis can be seen in the ring plane (the bright circle on the ring's outer edge). The moon is 25 miles wide and about 80,000 miles from Jupiter.

Because of the near-infrared camera's narrow field of view, this image is a mosaic constructed from three individual images. The color intensity was adjusted to accentuate the high-altitude clouds. The dark circle on the disk of Jupiter (center of image) is an artifact of the imaging system. (Credits: Reta Beebe–New Mexico State University and NASA)

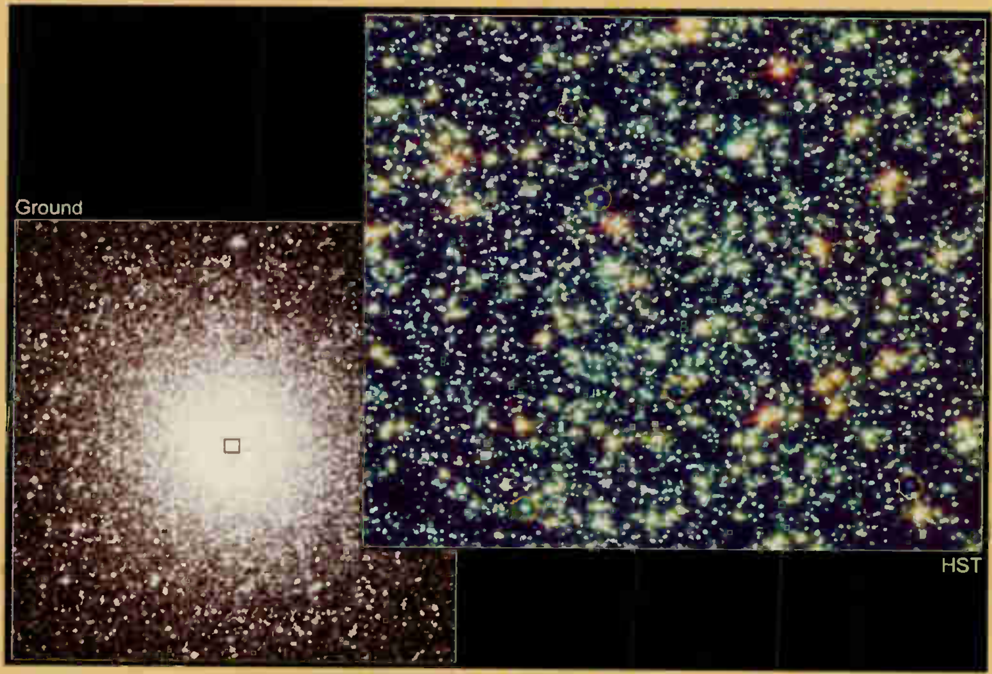


Jet Stream Runs Swiftly Inside the Sun

Scientists using the joint European Space Agency (ESA)/NASA Solar and Heliospheric Observatory (SOHO) spacecraft 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.

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 new observations are the latest made by the Solar Oscillations Investigation (SOI) group at Stanford University, Palo Alto, California, and they build on discoveries by the SOHO science team over the past year. (Credit: Philip H. Scherrer, SOI Principal Investigator, Stanford University)

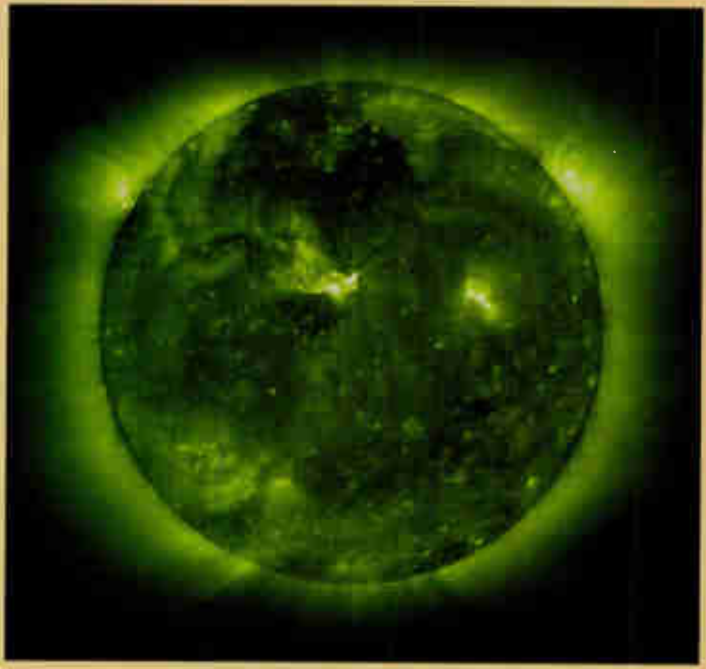
Blue Stragglers in Globular Cluster 47 Tucanae



The core of globular cluster 47 Tucanae is home to many blue stragglers, rejuvenated stars that glow with the blue light of young stars. A ground-based telescope image (on the left) shows the entire crowded core of 47 Tucanae, located 15,000 light-years away in the constellation Tucana. Peering into the heart of the globular cluster's bright core, the Hubble Space Telescope's Wide Field and Planetary Camera 2 separated the dense clump of stars into many individual stars (image on right). Some of these stars shine with the light of old stars; others with the blue light of blue stragglers. The yellow circles in the Hubble telescope image highlight several of the cluster's blue stragglers. Analysis for this observation centered on one massive blue straggler.

Astronomers theorize that blue stragglers are formed either by the slow merger of stars in a double-star system or by the collision of two unrelated stars. For the blue straggler in 47 Tucanae, astronomers favor the slow merger scenario.

This photo is a three-color composite of Wide Field and Planetary Camera 2 archival images taken with ultraviolet, blue, and violet filters. Green, blue, and red colors were assigned to the filters and scaled so that the red giant stars appear orange, the main sequence stars are white/green, and the blue stragglers are appropriately blue. (Credit: Rex Saffer–Villanova University and Dave Zurek–ST ScI, and NASA)



Solar Mystery Nears Solution

Scientists may have solved one of the major mysteries of the Sun. Recent observations with the joint European Space Agency/NASA Solar and Heliospheric Observatory (SOHO) spacecraft have shown that the transfer of magnetic energy, via a solar "magnetic carpet," from the Sun's surface to its outlying corona may explain why the Sun's coronal temperature is 300 times hotter than its gaseous surface.

These new observations are the latest made by the Solar Oscillations Investigation (SOI) group at Lockheed-Martin Solar and Astrophysics Laboratory and Stanford University. They build on discoveries by the SOI and SOHO science teams over the past year. (Credit: Alan M. Title, Solar and Astrophysics Department)

By Larry Van Horn

Bora Bora, French Polynesia

This radar image shows three of the Society Islands located 220 kilometers (136 miles) northwest of Tahiti in French Polynesia in the south Pacific ocean.

The twin islands in the center of the image, Raiatea (south, lower island) and Tahaa (north, the upper island) share a common lagoon fringed by a coral reef, which appears as the thin bright line surrounding both islands. Bora Bora, the island to the northwest (top of image) is also fringed by a coral reef. The deep bay on the eastern side of Raiatea (right side of image) is fed by the Faaroa River, the only navigable river in French Polynesia.

The volcanoes which created these islands were active 3 to 4 million years ago. The two "motus" (islands) southwest of Bora Bora, within the fringing coral reef, are remnants of the volcanic caldera rim that remain above sea level.

Ocean swell caused by trade winds are seen as the small ripples on the ocean surface around all of the islands. The local winds were blowing from east to west (right to left) when this data was collected; large dark areas are areas of low wind while the dark narrow bands just inside much of the reef likely indicate very shallow reef zones.

In addition to geological studies, scientists can use such images to study the extent and condition of coral reefs. The area shown is 39 by 67 kilometers (24 by 41 miles); north is towards the upper right.

Colors are assigned to the different radar frequencies and polarizations as follows: red is L-band vertically transmitted, vertically received (24 cm); green is C-band vertically transmitted, vertically received (6 cm); and blue is the difference between red and green.

The image was acquired by the Spaceborne Imaging Radar-C/X-band Synthetic Aperture (SIR-C/X-SAR) imaging radar when it flew aboard the space shuttle Endeavour on October 4, 1994. 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. ST

Beginning Satellite Sleuthing

By Larry Van Horn

Since I am editor of *Satellite Times* and resident satellite geek, I get to field all the satellite related queries that come to our technical support line here at Grove Enterprises. It can be a real challenge sometimes to answer this sort of technical call via the telephone lines. A couple of questions, though, are commonly asked, the most common being "Can you hear satellites on a scanner?" My patented answer is, "Yes, you can hear some of the satellites on your scanner provided they are transmitting in the FM mode." (More on that next time.)

This is usually followed by "where can I hear voice satellite transmissions?" That one is much easier to answer: "*Mir* and the space shuttle." The *Mir* is much easier to monitor now that we have a host of NASA ground stations communicating with that platform. Signals on the 143.625 MHz FM downlink are quite powerful, and I have even heard this voice downlink on a handheld scanner.

But there are a couple of things to consider when attempting to monitor *Mir*. This includes:

- Communications by the cosmonauts in their native Russian language will be the most common transmissions heard on the 143.625 MHz downlink.

- The work/sleep schedule of the cosmonauts corresponds to Moscow time (about eight hours ahead of the eastern time zone).

- Since the *Mir* is in a low Earth orbit, you won't have continuous communications from the space station, and what transmissions you do hear when *Mir* is visible will be brief and one-sided.

The U.S. space shuttle communications are even more difficult to monitor. Your best shot at hearing transmissions from the shuttle will be from one of the three UHF downlinks. First you will have to have a scanner that covers the UHF military aircraft band (225-400 MHz AM mode). Like the *Mir*, the space shuttle is in a low Earth orbit and will be a fast mover for tracking and communications purposes.

An interesting transmission trait between the two spacecraft is that the FM carrier signal from *Mir* appears to be turned on all the time, while the AM shuttle downlink is only keyed when the astronauts are talking (and they don't talk as much as their Russian counterparts).

Look for shuttle communications on the following frequencies: 259.7, 296.8 and during EVAs in the shuttle cargo bay) 279.0 MHz directly from the astronauts spacesuits transcievers. That last frequency has been logged from time to time by monitors, but you will have to have an excellent receiving post to hear this elusive catch. At the risk of being repetitive, I say again: all of these transmissions will be in the AM mode. Many monitors who couldn't hear anything have been quite embarrassed when they found out their mode switch was in the wrong position. They would change it to AM and get a room full of shuttle audio.

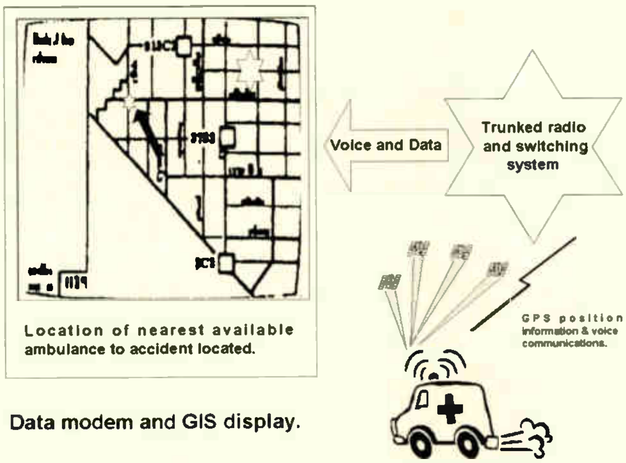
So, for your first adventure into *Satellite Sleuthing*, with the relatively easy to hear and understand manned spacecraft. You should also go to the SSG section in this issue of *ST* and check out the *Mir* amateur downlinks. Normally you will hear the station's packet signal on the 2-meter downlink, but sometimes the U.S. astronaut will be heard talking to U.S. and Canadian hams.

If you have a question for the *Satellite Sleuth* you can send it to P.O. Box 98, Brasstown, NC 28902 or email it to **steditor@grove.net**. Till next month, good hunting! ST

By Steve Dye, gpsyes@aol.com

2000 and Then? A Space Oddity

Automatic Vehicle Location (AVL) is one of the many GPS applications that have been discussed in this column in the past. AVL is one of two rapidly growing segments of the GPS industry. Taxi cabs, emergency vehicles, golf carts, and prisoners on parole are all being tracked by GPS these days. The other application surveying, using carrier phase techniques, allows for accuracy down to 5 mm or better.



Data modem and GIS display.

There is no world shortage of GPS-based surveying equipment, and many firms are offering low-cost startup kits that can be upgraded to more sophisticated setups. This month we are traveling to Canada to see how GPS is used in two civil applications, and how it has impacted life there.

Emergency Services in Toronto

If an emergency service knew the exact whereabouts of its rescue vehicles, then in the event of an emergency the closest appropriate vehicle could be alerted and redirected to the scene of an accident. That ability would require a setup consisting of GPS receivers, some wireless data communications equipment, and a GIS (Graphical Information System) that would display the location of its ambulances relative to streets, landmarks and buildings.With the advent of GPS this application is fairly straightforward and is a technology easily transportable around the world. Such a system has been installed in Toronto, Ontario, Canada.

AVL Vehicle Equipment

The location of each ambulance is calculated by an on-board positioning unit that uses a combination of GPS and dead reckoning technology. The dead reckoning segment consists of a turn rate sensor (solid state gyro) for heading estimation plus speed input from the vehicle's speed sensor. Constant GPS updates are used to reset the accumulated error of dead reckoning experienced when using gyros in this application.

On the other hand, dead reckoning is essential as well, since GPS signal blocking, particularly in down-town urban areas, will inevitably occur. Visibility to three satellites-which is needed for latitude and longitude readings, may not always be possible. Once the GPS signal is lost, the dead-reckoning system takes over until such time as GPS can return to correct it. The accuracy of the GPS receiver with selective availability (SA) is sufficient to provide accurate positioning without the need for an upgrade to differential GPS operation, which would add to the complexity and cost.

The location information is sent from the vehicle to the Metro Ambulance Communications Center in Toronto using an Ericsson 800 MHz trunking radio system as seen in figure 1. The system has eight channels in operation out of a single site; second site is planned for the near future. The trunked system works in a way that enables data and voice to share the same communications channel. Every repeater in the system is appropriately equipped to handle both data and voice.

The system is configured in such a way that voice messages are given priority over data messages. The 9.6-kbps data is repeated from the ambulance to one of a multiple of fixed host stations and vice versa. Data flow to and from the host control stations is controlled by a message switch integrated into the system. This system processes up to 80,000 data calls daily, consisting of remote and host originated individual calls averaging one second in duration. The exact same radio system is used to transfer vehicle status messages on a designated control channel back to base.

The AVL Display System

The AVL display system consists of a Pentium 200, an Ethernet 10BaseT network, and a large 21-inch color monitor. A monitor of this size is important in this application since information is communicated visually to the operators. Quantity, quality and clarity are essential to the smooth operation.

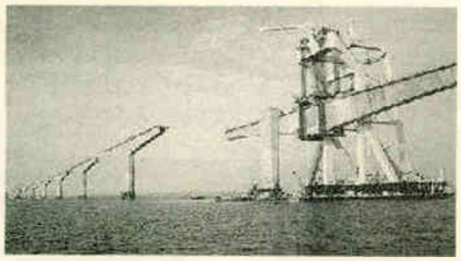
The software that drives the system uses popular, off-the-shelf graphics and programming packages. The graphic package uses its own basic programming language to display and control the GPS and user-input data. Data communications from the modems is read and interpreted by software written in Visual Basic.

The system displays ambulances based on their availability for assignment. Available ambulances are shown as green icons, and vehicles already on calls are shown in red. Emergency calls are displayed as a letter indicating the medical priority of the incident (A,B,C, or D, with D being the most critical class of call).

When the dispatcher is looking at his entire quadrant, the display shows only the major streets and geographic features for context. When the dispatcher is presented with a new emergency call to assign, the display automatically centers on the call and shows the closest ambulances to the emergency. As the dispatcher "zooms in" on an incident or vehicle, more and more detail is displayed. Street names can be turned on and off as required. Tools are provided for the dispatcher to accurately measure distances or change his view to see adjacent areas or the entire city as the need arises.

As can be imagined, this application really brings home the diversity and flexibility of GPS applications. In conjunction with wireless data communications and GPS, a space vehicle, an elephant herd in Africa, or a freight ship in the Indian Ocean can all be located with relative ease using a GPS receiver.

GPS Builds Bridges



GPS application in the world of civil engineering has seen a steady increase over the years. Recently, the world's first GPS-assisted bridge construction project was completed in Canada. The eight-mile-long span linking Prince Edward Island and New Brunswick cost in the realm of US$500 million–considerably less than it would have were it not for GPS.

The bridge consists of over 180 main structural elements that were actually built on land instead of being assembled over the water. The land-based assembly was performed using GPS surveying equipment that enabled placement accuracy down to millimeters.

GPS was then used to accurately determine the position and orientation of the ship that actually placed the girders in position as the bridge was slowly built. The girders themselves, as well as pier bases and shafts, also used GPS receivers. These receivers were attached to the structural elements to report their accurate positions during the assembly stages. By knowing the precise position of each support member and the ship, engineers can achieve an extremely high degree of precise engineering.

With appropriate software to process the GPS receivers' positions in real time, a computer display can instantly indicate to project managers and engineers the progress made and the status of each building phase.

As a bonus, GPS also provided environmental protection to the construction site. Any project on this scale will require dredging the river and dumping the spoil elsewhere. GPS navigation allowed the dredgers to dump this spoil safely away from lobster beds who's coordinates were already known.

An Overview of GPS Surveying

In general there are four types of GPS survey systems :

DGPS

DGPS systems employ carrier phase techniques and, if used with high quality receiving equipment, can achieve accuracy down to less than half a meter or better.

Static

Static surveying systems rely on GPS receivers being placed in separate locations for periods of time. Raw, pseudo-range data is collected during this period and local multi-path effects are gradually averaged out. The accurate baseline thus established provides a reference point (datum) for subsequent measurements. Generally, millimetric accuracy can be obtained, but this is dependent on the length of time over which the samples are taken.

Kinematic post-processed

Kinematic systems utilize the satellites' orbit information to improve the pseudo range measurements as calculated. A receiver is placed at a fixed site with a roving receiver traversing the survey path. The results are then post processed and an accurate trace of the path is plotted. centimeter accuracy is possible.

Real time kinematic

Real time kinematic systems provide real-time post processing–allowing the roving receiver's position to be simultaneously calculated and displayed. On the fly accuracy of around five centimeter can be achieved.

More information about GPS and its application in civil engineering and surveying can be found in my book, *The GPS Manual, Principles and Applications*, available from Grove Enterprises.

GPS behind bars

... Not those bars: I mean the steel vertical type. GPS has its application behind walls, as well. I have previously discussed GPS being used in conjunction with a light intensity meter,
to spatially map out dark and light spots in a prisons grounds. It seems there is a particular luminance threshold within which most escapes occur. According to research, the majority of night time escapes were assisted by the lack of illumination in certain prisons grounds. If the luminance can be raised above this escape threshold in areas that need it, prisoners will be deterred from further escapes.

In mapping out the levels of illumination using a DGPS receiver and a light intensity meter, prison officials can set to work to increase the light levels in dark spots that might entice an escape. So remarkable is our modern world: We have such wonderful satellite technology at our disposal that we can tell when our prisons walls are not only too low, but also too dimly lit.

GPS is also used to monitor the whereabouts of a prisoner on parole or probation. In conjunction with cellular radio modems, a frequency transponder, and Pentium technology, an offenders coordinates can be reported back to a monitoring base. Software parameters set for each parolee determine if he or she is outside a predesignated geographical area, and thus in breach of parole. We must be becoming a more civilized race if we can replace the ball and chain with a GPS receiver!

The Year 2000 Issue

The worldwide website of the U.S. Naval Observatory (USNO) has information regarding the year 2000 rollover that basically supports my observations made in last month's navigation satellite column and drives home some important facts as well.

As a refresher–or for those who didn't read the January column–the GPS week number count began at approximately midnight on the evening of January 5, 1980/ morning of January 6, 1980. Since that time, the count has been incremented by 1 each week and broadcast as part of the GPS message. The GPS week number field is modulo 1024. This means that at the completion of week 1023, the GPS week number will rollover to 0 on midnight of the evening of August 21, 1999/morning of August 22, 1999.

According to the USNO, "Once the rollover has occurred, it is the responsibility of the user (i.e., commercial equipment or software) to account for the previous 1024 weeks. Depending upon the manufacturer of your GPS receiver, you may or may not be affected by the GPS week number rollover on August 22, 1999. Some receivers may display inaccurate date information and some may also calculate incorrect navigation solutions."

ST's Navigation Satellite column will continue to keep you updated with information regarding which GPS receivers will account for the 1999 rollover and any which won't. Stay tuned! ST

ST RADIO ASTRONOMY

Jeff Lichtman, jmlras@juno.com

Build Your Own 12-foot Dish

The project described in this month's *Radio Astronomy* column will enable the amateur to build a 12-foot dish in about two days, with simple tools. If you have an electric drill, a hacksaw, a heavy pair of metal shears, and various screw drivers and nut drivers, these will be the only tools necessary for fabrication.

Things to Remember Before Starting this Project

Whatever surface material you use to screen the dish, the mesh should be at least 1/10th wavelength or smaller to keep the desired signal from falling through. For example, economical 1-inch chicken fence wire (spacing of about 2.5 centimeters) will make a decent reflective surface for signals down to about 30 centimeters wavelength.

When selecting a screening material, don't forget about wind loading (resistance). A 12-foot diameter antenna acts like a sail in high winds.

If you choose to use wire fencing or any other nasty-to-work-with material, wear a suitable pair of work gloves. These will save you from skin and blood loss.

This type of antenna is light in weight and, in the author's experience, can be mounted to a single heavy post sunk in ready mix concrete (azimuth/elevation mounting) or, if properly counter-weighted with coffee can filled with concrete, it can be easily moved in a declination-only mount.

To complete this project you should secure the following materials locally:

- Two square feet of aluminum sheet–1/8th inch thick
- 144 square feet of 1-inch mesh galvanized chicken wire fencing
- 50-feet of heavy aluminum clothesline wire
- 200-feet of 120 lb. Dacron (no stretch) fish leader line
- Several lengths of electrical conduit
- Eight 12-foot pieces of 3/8-inch aluminum rod (cut in two)
- About 50-6/32 machine screws with nuts
- Several 1/4-20 'U' bolts
- Two 3/4 conduit pipe flanges

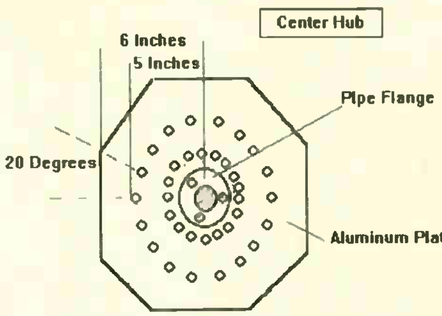
Sourcing

The aluminum sheet is an industrial hardware "house" item. Same with the aluminum rod. The aluminum clothesline is a KMart item. The Dacron can be bought from bait and tackle dealers. The electrical conduit and flanges can be purchased from electrical supply dealers or Home Depot The 'U' bolts and machine screws can be bought from any hardware dealer (brass preferred).

Putting it Together

The work begins by fabricating two hex shaped center support hubs from 1/8-inch aluminum sheet as shown in the figure below.

A light, strong dish may be made very economically by using 3/8-inch aluminum rod radials supported by two central 1/8-inch aluminum plates. Each radial is tied to Dacron (120 lbs) fishing line, and then each radial is stressed to a common point near the top of the antenna boom to form a parabolic surface. Each radial is also supported by very heavy clothesline wire, which is threaded through loops at the end of each radial, and also goes around the outer periphery of the dish. The surface is then covered with screening. Before you know it, an economical, highly efficient dish results.

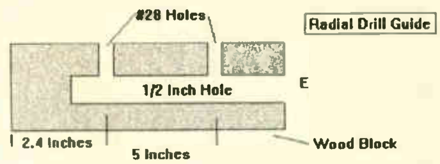


If the F/D ratio is selected to be 0.6, there is little to be concerned about in the event of any slight departure from a true parabolic surface.

The two octagonal aluminum plate central supports are locked together, and a total of thirty two-#28 holes are drilled to permit passage of thirty two-6/32 machine screws. Simultaneous drilling of the holes assures perfect alignment. A 1-1/4 inch pipe flange is also assembled to one support plate as shown.

In order to accurately drill corresponding holes in the radial aluminum rod spokes, a guide may be made from hard wood as shown in the drawing.

With the use of a drill guide, the sixteen 6-foot long radial spokes may be inserted at the entrance "E" and accurately drilled to match the holes in the central support plates.



A heavy wire ring (made up from extra clothesline wire) is fashioned and attached the end of each radial spoke. This serves two purposes: one is to provide the tie point for the Dacron line; the other is to guide the heavy clothesline all the way around the antenna's outer circumference. Lengths of 120-pound Dacron line are used for the stressing.

Dish Assembly Instructions

Tools Required: A 3/8th inch screw driver, a 5/16 nut driver or a pair of gas pliers, a pair of metal shears for final screening trim, and a pair of work gloves to protect the hands from injury from the dish reflector screening.

Space Required for Assembly: At least 20 by 20-feet square, preferably on flat ground. (The entire antenna assembly is quite light enough to be rope hoisted to a rooftop if such is required.)

Unroll the reflector screen and lay out flat. It can consist of two pieces 13 by 6-feet and one piece 13 by 2-feet. Using metal shears and work gloves utitize the 2-foot width piece in the center of the two 6-foot width pieces by bending wire tabs over from the 2-foot piece, with about a 6-inch overlap. The finished product should be a single reflector screen approximately 13 by 14 feet square, with the central screening securely affixed.

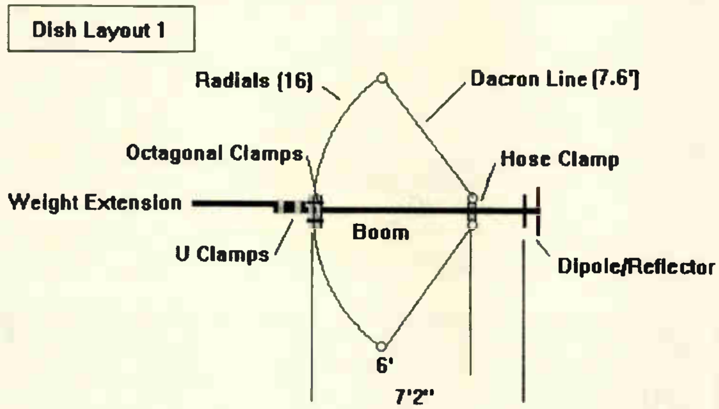
Assemble 16 radial elements to the two 8-inch aluminum circles, such that the disk with the flange is *down* and such that each radial element has its wire loop outer termination *facing up*.

Lay the completed assembly down on the 13-foot screen reflector.

Using the 50-foot roll of aluminum wire, pass about 40-inches of this through the outer peripheral rings such that, there is a wire overlap of about one foot, allowing for expansion as the dish is stressed. (This is permanently secured only after the dish is stressed.).

Make certain that the radial assembly is centered in the screen; bend approximately six inches of the screening towards you, over the outer peripheral support aluminum wire. Use a pair of metal shears to trim off excess screening where it meets the radial rods.

Slide the 7-foot antenna boom conduit through the central central disks such that 12 inches extend from the rear of the disks. Temporarily lock the disks onto the conduit with the bolts in the rear flange on the disk.



Assemble a hose clamp with the 16 Dacron strings to the other end of the 7-foot boom, such that 8-inches extend at the pipe end. Lock it permanently in place.

Make sure that the Dacron is not crossed. Bring each Dacron stress string down to the outer peripheral support rings and secure with "S" elements to the outer rings.

Slide one foot of the antenna boom (rear) end into central U bolts of the altitude bearing support.

Also slide a 5-foot rear conduit boom element through the U bolts of the standard elevation bearing and assemble a single hose clamp about halfway up the five foot conduit. Assemble the five foot antenna cross arm to the antenna assembly. Now bring the entire dish assembly to the alt az mount and slide the entire antenna assembly down vertically into the alt az mount using an 18 inch vertical pipe extension. Lock it in place temporarily with the screw on the alt az mount.

Assemble two counter weights on the 5-foot rear boom member and slide another hose clamp onto the bottom of the assembly. These two hose clamps lock the counter weights into place when the final balance adjustment is made.

Using hose clamps and a third counterweight, assemble the horizontal cross arm, inserting approximately 8-inches of the end into the cross arm.

The elevation is locked by securing the gland ring at the right side of the aluminum plate bearing assembly.

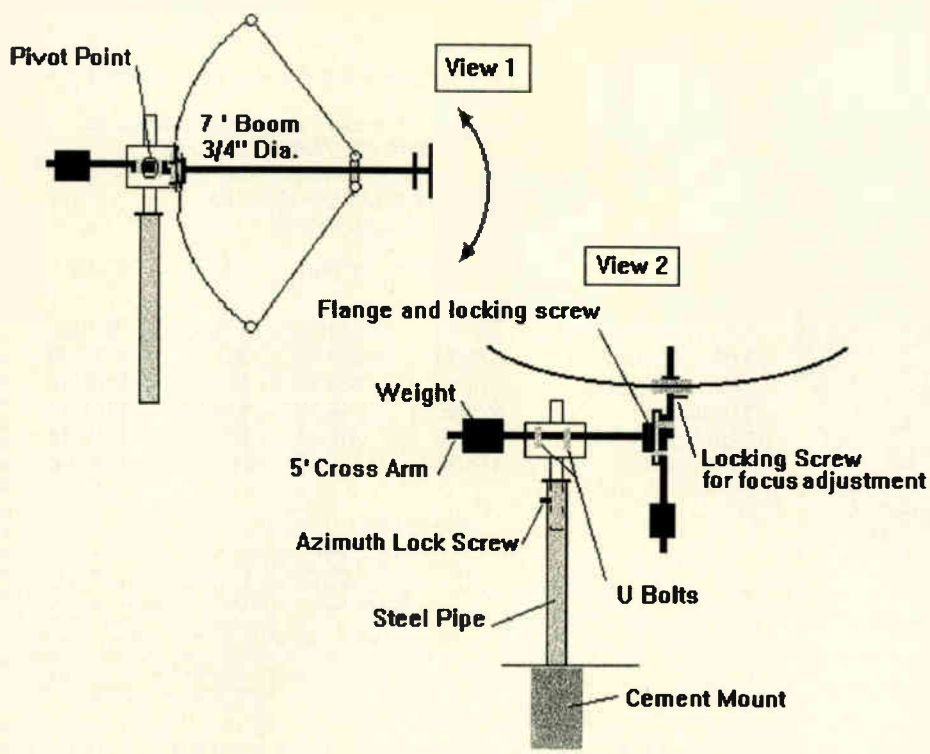
Last, assemble the antenna feed at the dish focus with the bar built to it. Vertical polarization is the most desirable generally, but either polarization may be used. Extraterrestrial radio sources are–in the main–randomly polarized and may be received in either polarization plane. Selection of polarization therefore is dependent upon the least local interference encountered.

Connect amplifiers to the antenna.

Final focusing of the dish should be done with an operating receiver and with the sun in the antenna beam. The dish is focused by loosening the screws in the rear 8-inch disk flange and sliding the disks along the boom, in the same manner that an optical eyepiece is "racked."

This dish, as built, will operate with a beam pattern of approximately 3.65 degrees of arc seconds, which is equivalent to a little more than six moon diameters.

The above piece was originally published in the *Radio Astronomers Handbook* by Robert M. Sickels, copyright 1989, 1992. This book is available from Radio Astronomy Supplies (see ad in this issue) in a reprinted updated version.



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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.

UPLINK

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A Tempest in Transit

With the conclusion last November of the World Radiocommunication Conference (WRC '97), it became apparent that radio interference concerns have reached new heights–literally. One of the chief objections raised by the U.S. contingent was the potential interference to the Global Positioning Satellite (GPS) proposed by the European Low-Earth-Orbiting (LEO) lobby who wanted their share of that spectrum for the explosive proliferation of Personal Communications Service (PCS).

But the Europeans weren't alone; they were joined in their effort by none other than the giant communications conglomerate, Motorola. High level diplomacy temporarily shelved the controversial proposal by INMARSAT proponents, but the specter still looms for the 1999 conference.

Safety was the key issue raised by the International Civil Aviation Organization (ICAO) which was quick to point out that there is a rapidly-growing use of GPS in aeronavigation. While there is still the possibility that INMARSAT could revive their shared-GPS-band application, officials say they will explore other alternatives, such as non-GPS L- and S-band spectrum.

The 24-satellite-constellation GPS system was developed and is owned by the U.S. military, but its adoption by civilian, commercial, and scientific interests for navigation, location, and altitude determination is a multi-billion dollar industry which is unilaterally opposed to spectrum intrusion by other users.

Unquestionably, PCS's mobile satellite service needs will outgrow the present frequency allocations by the year 2000. The first wide-scale implementation of the giant Orbcomm and Iridium platforms has yet to begin, and that's just the icing on the spectral cake.

Digital technology with its inherent capability of bandwidth compression is certainly part of the answer, along with narrower bandwidths, time sharing, spread spectrum, orbital coordination, and more rigid frequency tolerance requirements.

But to complicate things further, not all frequency applications are legitimate. Just as spectrum auctions drew thousands of speculators who had no intention of ever putting a signal on the air but who knew they could profit by reselling their awarded spectrum, the paper trail of speculative satellite applications is enormous.

There are nearly 4000 applications on file for satellite constellations; there aren't enough launch vehicles to handle all these proposed systems, much less frequencies to support them.

The responsibility for coordinating and awarding these slots is that of the Radiocommunication Bureau of the International Telecommunications Union (ITU), a conglomerate of representatives from the United Nations (UN). But the sheer numbers of prospective profiteers has overwhelmed the ITU which apparently has neither the resources nor the expertise to discern between the legitimate entrepreneur and the enterprising opportunist.

While tough standards are obviously necessary to separate sincere applicants from frivolous, who is going to set those standards? The present industry with their vested interests? Newcomers who want their turn, possibly at the expense of the establishment? Lobbyists for emerging, competitive technologies and constellations? The countries who have the greatest investment?

It will be difficult to find the golden mean, but procrastination by the ITU is definitely not the answer.

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