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Volume 2, Number 4 March/April 1996

SPECIAL EDITION

Global Positioning System

Satellite Times

Cover Story

Cover: The cover photo for this issue of Satellite Times is an artist's rendition of a NAVSTAR satellite orbiting 11,000 miles above the Earth. (Painting courtesy of Phil Chien and Rockwell International)

NAVSTAR — A History and Evolution of Navigation Satellites

By Len Losik

Man has looked to the stars to navigate throughout known history. Now, he has put a constellation of stars into space just for that purpose. Len Losik takes a look at the history of all the United States' navigation satellite programs in this feature story starting on page 10.

GPS SPECIAL EDITION

Vol. 2, No. 4 — March/April 1996

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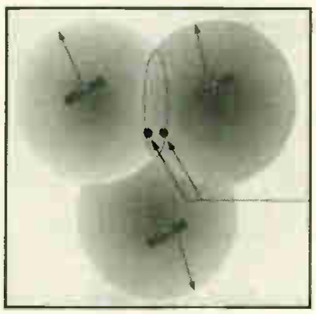


GPS Explained

By Steve Dye

Pseudo-Random Codes, Rubidium Atomic Clocks, and Selected Availability. This is just some of the terminology you will encounter when you use the Global Positioning System. What is GPS and how does it work? *Satellite Times Navigation Satellite* columnist Steve Dye sorts through the GPS lingo in his story starting on page 14.

GPS — Putting it to Use

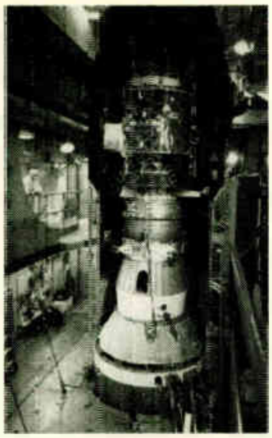
By Haskell Moore

A major revolution is underway in the GPS consumer market, as new receivers become affordable for almost anyone. New applications for using the GPS system are developed every day. Author Haskell Moore looks at some of some of these applications and the equipment you will need to enjoy the benefits of the Global Position System. Story starting on page 18.

GPS in Space

By Philip Chien, Earth News

One of the more obvious applications for a GPS receiver is onboard a spacecraft. Author Philip Chien shows how a constellation of spacecraft in orbit is helping other satellites navigate through space. Story on page 22.



ST Satellite Profile

The NAVSTAR Global Positioning System is a constellation of 24 orbiting satellites that provides navigation data to military and civilian users all over the world. Philip Chien of Earth News takes a detailed look at these navigation beacons in the sky in this issue's *ST Satellite Profile: Precision Signals from Space — The GPS satellites* starting on page 90.

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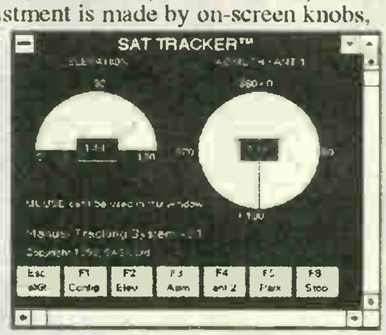

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DOWNLINK

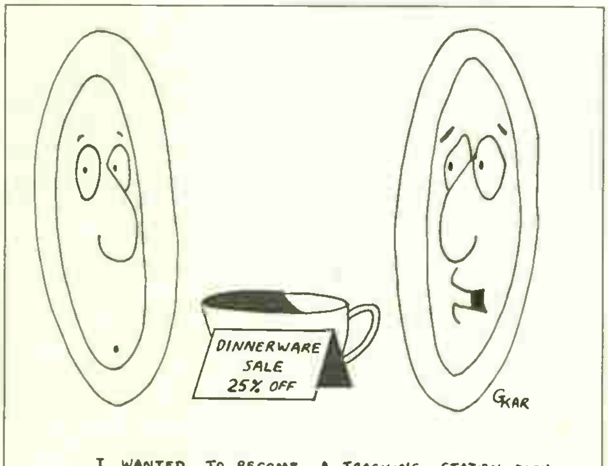
By Larry Van Horn
Managing Editor

Grove Communications Expo

As I sit here in Brasstown and prepare this edition of *Downlink*, snow covers the ground and the worst winter cold in several years is finally starting to moderate. But as the cold weather disappears and the temperatures rise, I was prompted to remind you of one of the hottest radio events of the year — the Grove Communications Expo 96 on October 18-20, 1996.

For those of you who have never attended this event, a little explanation is necessary. In 1990, *ST*'s sister publication — *Monitoring Times* — sponsored the first annual *MT* radio convention at the Hyatt-Regency in Knoxville, Tennessee. It was an October weekend filled with seminars, tours, prizes, equipment exhibitors, demonstrations, and a great Saturday night banquet with a keynote address delivered by Richard Carlson of the Voice of America.

Intense discussions; good fellowship; DXing in rooms, on the balconies, and in the park — these were some of the best memories of that first year in Knoxville. It was a rare pleasure to be with other folks who share the same enjoyment in monitoring the radio waves.



I WANTED TO BECOME A TRACKING STATION DISH, BUT I NEEDED A DOCTORATE DEGREE FOR THAT!...

Those of us in attendance came home with the feeling we had attended the finest radio convention ever hosted. I guess what really made that weekend for me was the way Bob and Judy Grove put the weekend's activity together — it was truly a class act by the dedicated people here in Brasstown. The entire Grove staff did a fantastic job and set the standard for others to emulate.

It is now six and a half years later, and even though the name has changed, it's the same great staff of Grove Enterprises that will put on the 7th annual Grove Communications Expo.

If you are a space junkie, have an intense interest in monitoring satellites or fascination for the radio astronomy field, don't miss the third weekend of October in Atlanta. Quite a few of your favorite *ST* writers will be there and sharing their expertise all weekend long. The list of *ST* staffers is not complete yet, but here are the luminaries from the *Satellite Times* staff that have signed up thus far:

Donald Dickerson (Personal Communication Satellites), Steve Dye (Navigation Satellites), Bill Grove (SpaceNet), Dr. TS Kelso (Computers and Satellites), Jeff Lichtman (Radio Astronomy), John Magliacane (Amateur Satellites), Ken Reitz (Beginning Satellites), Keith Stein (Satellite Listening Post/Launch Schedules), and Dr. Jeff Wallach (Weather Satellites).

In addition to the *ST* staff, I have invited two special guests who will share their satellite expertise during the weekend. Keith Baker, Vice President for strategic planning from AMSAT, and Tom Taylor, columnist in the *Transponder* (a TVRO industry publication), will host forums in their areas of expertise.

A major event that will run concurrent with the Expo during the weekend is the fall conference of the Society of Amateur Radio Astronomers (SARA). If you have an interest in this field of space study, this is a great opportunity. SARA will be hosting seminars, demonstrations, and workshops throughout the weekend.

Finally, the highlight of the weekend for me will be the opportunity to meet and hear NASA Astronaut Dr. Ron Parise. Dr. Parise is a noted astronomer and has participated in two space shuttle missions (both were Astro astronomy missions). He will be the keynote speaker at the Expo Saturday night banquet, and his after dinner speech is sure to be enlightening and entertaining.

But there is more to the Expo than just space related events — much, much more. Because of this, both Grove publications have started a regular column that will provide you with updates on Expo activities and speakers. Be sure to check it out in each issue of *MT* and *ST* to find out the latest details of the communications event of the year — the Grove Communications Expo 96.

As Stu Gurske of Swagur Enterprises after last year's Expo put it, "We drove over 28 hours and 2,116 miles to attend the Expo and felt it was well worth it."

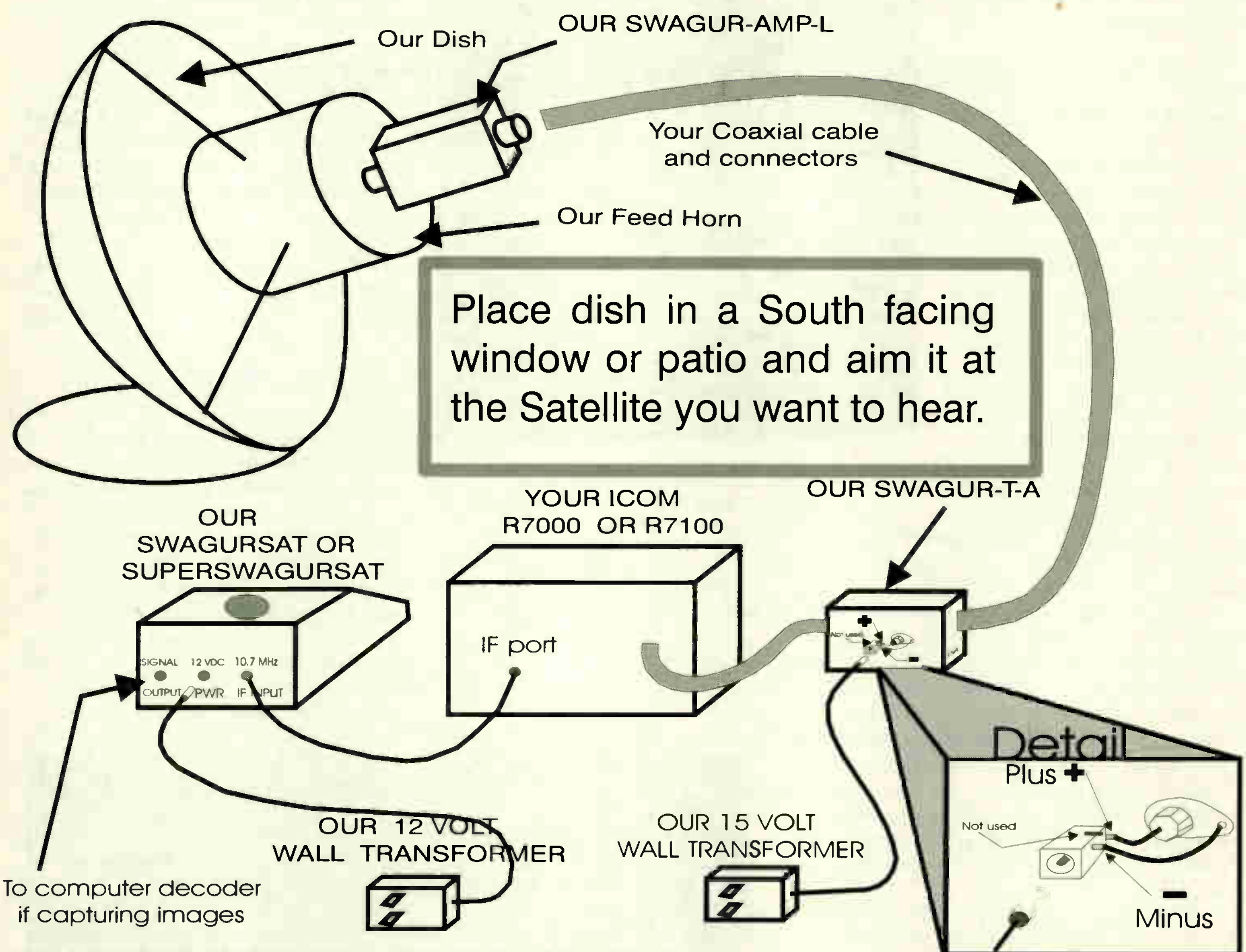
I would like to take this opportunity to welcome a new writer to the *Satellite Times* family of writers. Steve Dye is our new Navigation Satellite columnist and you can see some of his handiwork starting on page 14 in this issue.

Now it's time to turn the page and launch into this special edition on GPS satellites from your space magazine of record — *Satellite Times.*

SWAGUR ENTERPRISES ANNOUNCES

A BREAKTHROUGH IN GOES INMARSAT RECEPTION

THE APARTMENT DWELLERS' SPECIAL



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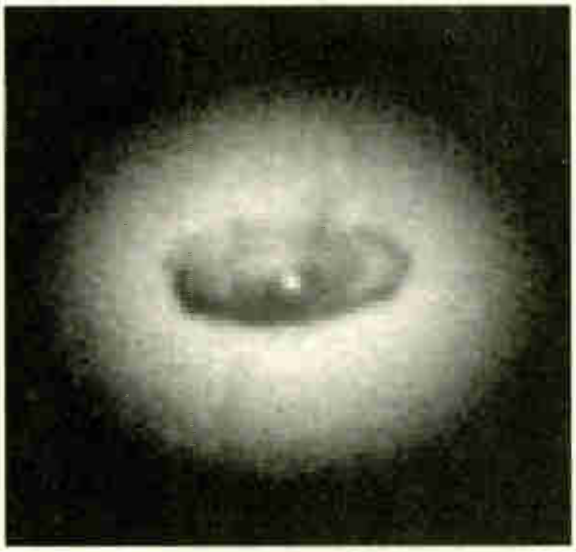
By Wayne Mishler, KG5BI

Hubble confirms new black hole

Sleep well. We're all passengers aboard a planet that's drifting with our solar system amidst astronomical whirlpools called black holes that swallow galaxies alive.

That seems to be supported by recent findings of the Hubble Space Telescope, which has confirmed yet another massive black hole — and a cloud of space dust 800 light years wide spiraling into the hole's voracious appetite, according to a December report by the European Space Agency.



This is a Hubble Space Telescope image of an 800-light-year-wide spiral-shaped disk of dust fuellng a massive black hole in the center of galaxy, NGC 4261, located 100 million light-years away in the direction of the constellation Virgo. (Photo courtesy of L. Ferrarese, Johns Hopkins University and NASA)

But don't run out and double your life insurance just yet. The hungry monster is 100 million light-years away from earth in a galaxy called NGC 4261 in the direction of the constellation Virgo.

"This new discovery should lead us to a new understanding of black holes," says Holland Ford of John Hopkins University, in Baltimore. "The new Hubble observations have moved us beyond the question of whether black holes exist. Now we can work on the demographics of black holes and address a number of other questions." Ford and other scientists want to know if every galaxy has a black hole. They also want to know how black holes work.

Predicted by Einstein's general theory of relativity, a black hole is believed to be a compact and massive object with such powerful gravity that nothing — not even light — can escape its pull.

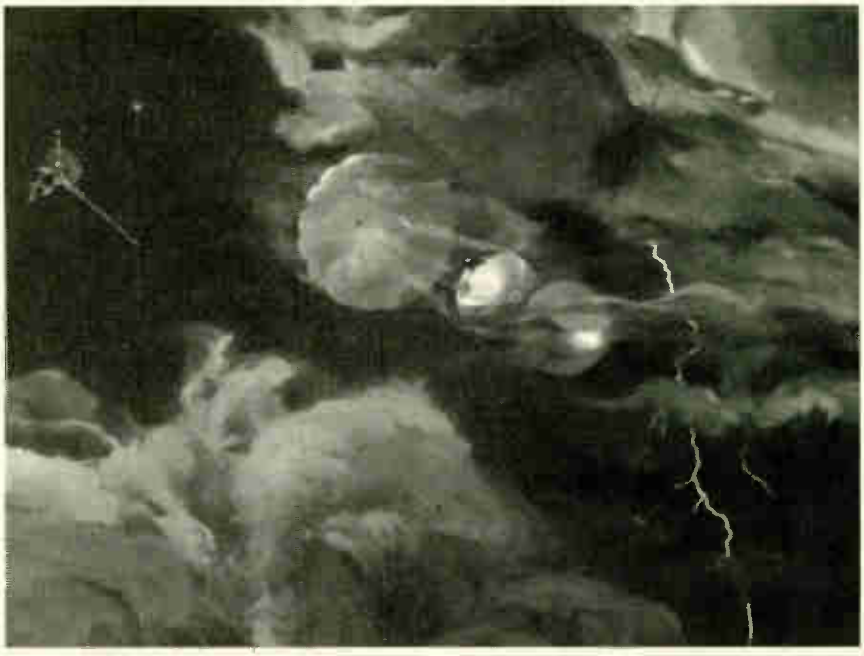
By measuring the speed of gas swirling into this newly confirmed black hole, astronomers calculated its mass to be 1.2 billion times that of our Sun, condensed into a region not much bigger than our solar system. The dust cloud, which in the telescope looks like a spectacular geometric disk, contains enough mass which, if squeezed together like snowballs, would make 100,000 stars the size of our Sun.

Prior to Hubble, astronomers doubted the existence of dust in elliptical galaxies like NGC 4261, thought to have stopped making stars for lack of interstellar gas and dust, the essential ingredients in a star recipe. But Hubble is showing dust to be common in the centers of elliptical galaxies. Astronomers believe the dust may be debris from another galaxy which collided with NGC 4261. Over the next 100 million years or so the black hole is expected to feed on the debris and spit out spectacular fireworks.

Scientists believe that the universe is expanding, becoming ever larger, and that collisions between galaxies may have been more common in the past when the universe was smaller. But in simulations astronomers have had difficulty getting model galaxies to collide with each other, because of the dynamics involved.

There is another mystery associated with the discovery. The black hole is offset from the center of the galaxy, and from the disk's center as well. The consensus is that the black hole once was at the center of its galaxy, but something pulled it 20 light-years to the side.

Which of course prompts the question: How do you move a black hole? Some believe that it might have moved itself. They theorize that debris sucked



The Galileo probe parachuting into the Jupiter atmosphere. (Painting by Ken Hodges) into the core is heated to tens of millions of degrees by gravity and spewed out as hot gases which push the core like jet blasts from a rocket engine.

One of the ways astronomers locate black holes with Hubble is by measuring the rotation of gases with spectrographs. Like water spiraling into a drain, gases rotating into a black hole display an unmistakable signature. The speed of gases orbiting a black hole increase as they move nearer the center.

The search for more black holes continues.

Jupiter probe's last words may change history

The Galileo probe's final words to the mother ship while plunging to destruction into the clouds of Jupiter may cause scientists to rethink their assessment of how earth was formed.

The composition of Jupiter's atmosphere was different than expected. "The data we gathered may change the way we look at our own beginning. It is especially significant for scientists, educators and theologians," one analyst told reporters, without elaborating.

During its voyage, the Galileo spacecraft was not without problems, even though NASA gave it a clean bill of health just before the launching of its Jupiter probe last summer.

The mission was delayed several times between 1978 and 1986 as different launch vehicles were considered. The 1986 explosion of the space shuttle Challenger complicated matters and set nerves on edge. Cautious engineers launched Galileo in 1989 from the shuttle Atlantis with an under-powered rocket to avoid damage to the shuttle. Because the rocket did not have enough power for a direct flight to Jupiter, scientists had to improvise. They used the atmospheric pull of a nearby planet in a Star-Trek "sling-shot" maneuver. This gave Galileo enough momentum to reach Jupiter, but required an angled approach like a pool-room billiard shot.

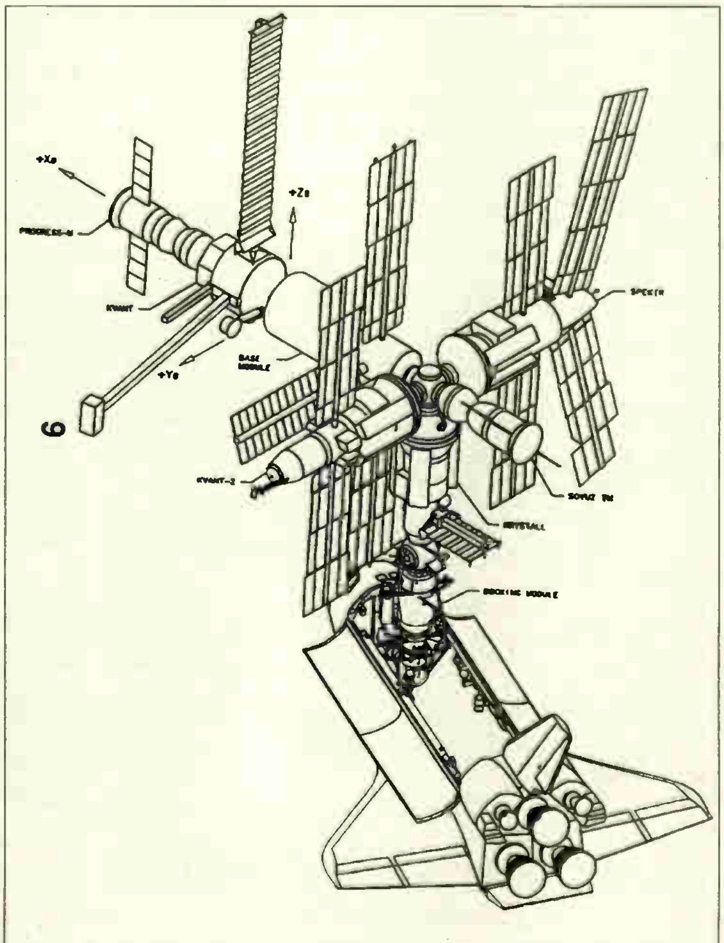
No sooner had they solved that problem when others appeared. Galileo's main antenna failed to deploy, preventing transmission of data. And at a crucial moment the onboard tape record stuck in rewind mode. Even so, enterprising scientists were able to pull essential data from the ship.

Galileo released its probe last July 12 about 50 million miles from Jupiter. The probe coasted quietly to a spot just north of Jupiter's equator. About six hours before entry, an onboard timer activated the probe's lithium/sulfur dioxide battery necessary to power the six onboard science instruments. The probe then began its descent.

Within the first minute of entry, the heat shield began to erode. Aerodynamic forces slowed the probe to about the speed of sound. An explosive charge in the rear heat shield fired, deploying a pilot parachute. This pulled off the back cover and deployed the 8-foot-wide main parachute. Additional explosive charges fired, releasing the forward heat shield.

Two minutes later the science instruments inside the descent module began reading atmospheric temperature, pressure, density, and composition. The data was radioed back to the Galileo spacecraft 125,000 miles away, which relayed it hundreds of millions of miles to earth.

Moments later the probe was destroyed by heat and pressure. But its last words will live forever in the archives of science.



Atlantis gets its own MIR parking spot

The U.S. space shuttle is getting to be a regular visitor to the Russian MIR space station. The shuttle even has its own parking spot.

During the last U.S. visit, Atlantis commander Kenneth Cameron attached a docking module permanently to the Krystall module which attaches to MIR. He made the connection even though his view was blocked by the docking module. The design of the two modules connected end to end provides safe clearance between the shuttle and MIR. The docking module will serve as the designated parking spot for all future space shuttle missions to the Russian space station.

Atlantis also delivered two folded 18 meter solar arrays to MIR.

U.S. military sends first message through space

The U.S. Joint Chiefs of Staff have opened a new age in satellite communications by sending a message halfway around the world using Milstar's crosslink antennas.

A spokesman for Lockheed Martin Missiles and Space says this marks the first time in history that a communications signal has been sent over such a long distance through more than one satellite without the use of ground relay stations.

The message was uplinked to Milstar DFS-1, which processed and relayed the signal to Milstar DFS-2, via the crosslink antennas on both spacecraft. The transmission was then downlinked to the U.S. Pacific Command, Camp Smith, Hawaii, and to the U.S. Atlantic Command, Norfolk, Virginia.

This type of military communication is more secure and reliable. "Milstar's satellite to satellite crosslinks ensure secure, survivable, worldwide communications," says Lockheed, primary contractor for the project. "It reduces the Pentagon's reliance on vulnerable and expensive ground relay methods."

All Milstar satellites incorporate two crosslink dish antennas located at opposite ends of each spacecraft. These antennas are unique to Milstar. Eventually they will be used to connect all four Milstar satellites and be controlled from a fixed or mobile control station.

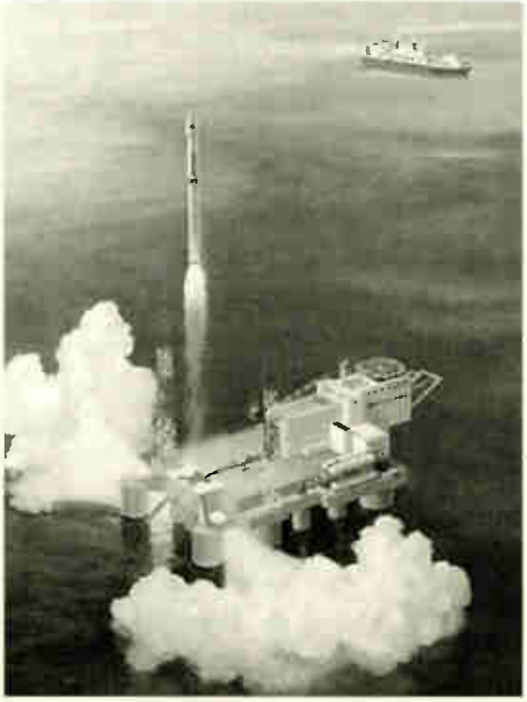
Security is assured by beaming narrow transmissions from one satellite to another at frequencies that would be absorbed by the earth's atmosphere. This means that the transmissions between satellites could not be intercepted by earth stations. And Milstar's signal processing and encryption prevents interception in space.

Milstar's "switchboard in the sky" concept is a departure from all current communications systems. Operating primarily in the high frequency (EHF) and super high frequency (SHF) bands, the Milstar system is designed to provide adaptable, secure, and survivable communications between fixed or mobile terminals. They are for the sole use of the U.S. Air Force, Army and Navy.

The system employs five technologies not found in any previous military satellite communications system.

- On-board signal processing
- On-board signal routing.
- On-board resource control.
- Crossbanding (the ability to receive a signal through one antenna at one frequency, and process and relay it through a different antenna at a different frequency).
- Specially designed crosslink antennas.

These technologies make the system immune to jamming and interception. They provide exceptional mobility. And they make it possible to "frequency hop" across a 2 GHz bandwidth – a first for communication satellites.



Artist rendition of the Sea Launch system. (Painting courtesy of the Boeing

These new technologies also eliminate the need for bulky, immobile, high-maintenance and vulnerable ground stations. This enables theater commanders to establish and control their own customized networks from a single location using one or more satellites as the network's processing hub. Set-up takes minutes instead of weeks.

The Milstar satellites were launched separately in 1994 and 1995 from Cape Canaveral Air Force Station, Florida. Launches of four additional satellites are scheduled in 1999 with capabilities for improving the tactical utility of the system. Each satellite has an expected life span of 10 years.

World's first graphite fuel tank to be installed in Clipper

The world's first graphite composite tank designed to hold liquid hydrogen at 423 degrees Fahrenheit below zero has been built by McDonnell Douglas and tested for installation aboard that company's Delta Clipper advanced reusable launch vehicle. Testing was done by the NASA Marshall Space Flight Center in Huntsville, Alabama.

The Delta Clipper (DC-XA) single-stage vertical take-off, vertical-landing vehicle is to undergo continued flight tests at the U. S. Army White Sands Missile Range in New Mexico, in mid-1966.

"This will be the first graphite epoxy cryogenic fuel tank to undergo flight testing," says McDonnell Douglas DC-XA program manager Dave Schweikle. "The tank was designed and fabricated by our company to (contain liquid hydrogen) and serve as an intregal part of the DC-XA's structure."

Commercial satellites to be launched from floating platform at sea

A new launching system called Sea Launch will boost commercial satellites into space from a platform in the Pacific Ocean. Hughes Space and Communications International has signed up for at least 10 launches from the floating launch site over the next five years. The first launch is planned for mid-1998.

"Sea Launch is another solution to what we see as a need for assured launch slots over the next few years," says a Hughes spokesman. "Hughes has a backlog of 41 satellites (as of December 7) to be launched. Most of them are our large HS 601 and 702. We need a varied supply of rockets so our customers can be assured of getting into space on time to meet their business plans."

The three-stage Sea Launch vehicle is capable of carrying both satellite models into low, medium or geostationery earth orbits. The satellite processing facility is planned to be developed in Long Beach. The launch platform and accompanying command ship will depart from that port.

PanAmSat to expand services throughout Americas

PanAmSat has asked the federal government for approval to operate several new international communications satellites that will expand its broadcast and telecommunications services throughout the Americas by the year 2000.

The Federal Communications Commission is considering the request to operate the satellites in orbital locations in space that traditionally have been reserved for domestic U.S. satellites. The two orbital slots — 79 degrees West and 103 degrees West — would be used for international communications in the C-band and Ku-band frequencies.

In addition, PanAmSat has asked for FCC approval to operate two additional satellites in the K-band frequencies. These would be located at 58 degrees and 79 degrees West, and would enable the company to provide commercial video and data communications services by the end of the decade.

Satellite worldwide fax service planned

TMI Communications of Canada plans to develop a facsimile service for use on the MSAT Network. This new service would store and forward error-free fax messages via satellite to and from any MSAT Communicator located anywhere in North America to anywhere in the world. Subscribers would have access to a variety of fax mailbox features including retrieval of messages at public switched telephone network locations, delivery status of sent messages, and the ability to broadcast a single message to multiple addresses.

The MSAT (mobile satellite) communications network is operational and plans to be in commercial service by the end of this year.

And finally ...

It doesn't seem to be a problem for dogs. Finding fire hydrants, that is. But most firefighters aren't built that way. Dalmatians maybe. But they don't count. Although one wonders why they couldn't be trained for the job.

"This business of standing up in the seat of your pumper and looking to the left and then looking to the right (for a fire hydrant) is no good," says a disgruntled firefighter in Braintree, Mass. Especially when the owner of a burning house is screaming at you to do something.

The fire department of nearby Marshfield has a solution. No, not Dalmatians. The Global Positioning System.

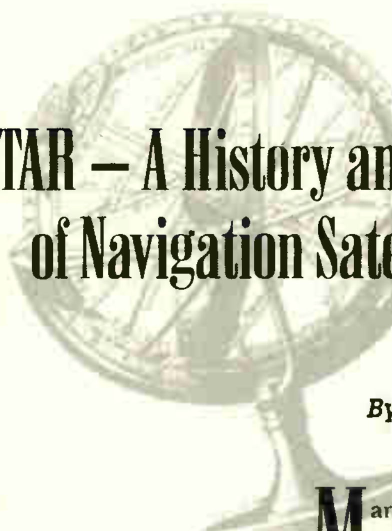
GPS, as you know, was developed by the Pentagon as a navigational tool. The system relies on satellites that transmit continuous signals around the world. GPS receivers on the ground compare signals from three or more of these satellites to provide ground coordinates.

The Marshfield fire department solved their hydrant location problem by purchasing a handheld GPS receiver. When dispatching units to a fire, the dispatcher gives both the address and the coordinates of nearby hydrants. Firefighters enter the coordinates into their new GPS receiver, and follow it to the nearest hydrant.

Alas, it's a dog's life. ST

Sources:
Energia LTD, European Space Agency, Hughes Space and Communications Company, Lockheed Martin Missiles & Space, McDonnell Douglas, PanAmSat, Patriot Ledger-Quincy, Mass., TMI Communications.

NAVSTAR – A History and Evolution of Navigation Satellites

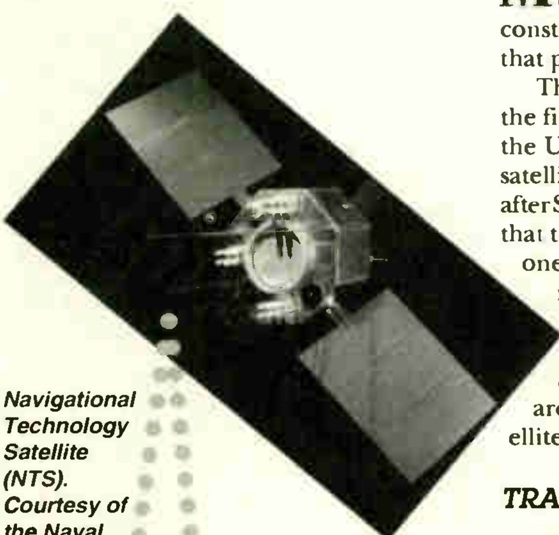


By Len Losik

Man has looked to the stars to navigate for all known history. Now, man has put a constellation of stars into space just for that purpose.

The Soviet Union may have launched the first man-made satellite in space, but the United States was the first to launch satellites to navigate by. It wasn't long after Sputnik successfully orbited the Earth that the U.S. Navy began to use space for one of their most important needs — navigating.

The constellation of stars is called GPS, short for Global Positioning System and these man-made stars are called NAVSTAR (Navigation Satellites for Timing and Range).



Navigational Technology Satellite (NTS). Courtesy of the Naval Research Laboratory

TRANSIT Satellites

NAVSTAR is the result of almost 31 years of satellite evolution beginning with the U.S. Navy TRANSIT satellites. TRANSIT satellites were the first satellites in space dedicated to navigation.

Satellite navigation was invented and patented in 1958 at John Hopkins University Applied Physics Laboratory (APL). It was created after APL personnel observed and identified the phenomenon of Doppler shift on the Russian Sputnik downlink frequency as it orbited over American ground stations.

Realizing that Sputnik's position in space could be calculated from its Doppler shift alone, APL sought out funding from the Navy to prove the concept of satellite navigation. The Navy and the APL were both working on the Polaris submarine program at that time.

Polaris lacked a system that could provide fast and precise navigation for Navy submarines that needed to remain underwater to avoid detection. The Navy quickly funded the TRANSIT program and the system concept was tested, designed, developed, built, and launched by 1960. The program became operational in 1964 and were made available for public use in 1974.

Each TRANSIT satellite's orbit was calculated from Doppler measurements taken at TRANSIT groundstations located around the world. Orbit predictions, based on the recent orbit characteristics, were generated and uploaded to each TRANSIT satellite. This information is then rebroadcast to Earth for the user equipment to update with local Doppler measurements. The TRANSIT user equipment needed a close guess of its location at the start.

Today, the TRANSIT system consists of seven operating satellites orbiting at 600 nautical miles. Navigation solutions are not available continuously. A user may have to wait up to eight hours with intervals as long as 24-hours to get an accurate fix. This has been highly satisfactory for most TRANSIT users needs which tend to be ships at sea. TRANSIT has been an extremely successful program for the Navy. There has been over 80,000 user receivers sold since the inception of the program.

NAVSTAR has taken over for TRANSIT and the program will come to the end in 1996. The program consists of over 50 satellites built and launched over the 31 years of service. Many of the people that designed and developed TRANSIT satellites remain at APL and will participate at the end-of-the-project's celebration planned for 1996.

The TIMATION Satellites

The development of the concept for TIMATION satellites began in the spring of 1964 at the Naval Research Laboratory (NRL). TIMATION I and II were used to validate NRL's concept of position determination (navigation) using clock synchronization between the user and a satellite. That concept required accurate time transfer to different points around the world.

TIMATION I was very small, it weighed only 86 pounds and used six watts of electrical power. TIMATION II was launched in 1969 and it was just a little larger at 125 pounds with 18 watts of power. TIMATION I and II were launched into a 500 nautical mile orbit inclined 70 degrees. The third satellite in the series, TIMATION III, was later renamed the Navigation Technology Satellite I, and launched on July 14, 1974.

One of the early successful projects with the TIMATION series of satellite involved a moving vehicle on the ground. Signals in the UHF spectrum from TIMATION I were used to successfully navigate a truck around the Washington D.C. beltway in 1964.

Experiments conducted on TIMATION satellites included:

- Using space based rubidium and cesium frequency standards
- Measuring relativistic effects on navigation solutions
- Isolating ionospheric and multi-path errors
- Using a laser reflector for independent satellite range measurements
- Multiple types of solar cell panels for measuring long term degradation and output performance
- Time synchronization tests with the Naval Observatory and Royal Observatory in England
- Multiple orbit altitude tests
- Side-tone ranging tests.

In 1968, the Joint Chiefs-of-Staff directed the Navy to combine TIMATION with an Air Force system named "621B," and develop a system that would meet all the military services needs. The outcome of this merger was the NAVSTAR GPS.

The Air Force 621B project was studying geosynchronous, inclined orbits at 22,000 mile altitude. NRL maintained that a small number of satellites in several orbit planes with lower orbits for NAVSTAR's, would yield more 4-satellite position solutions to users. This concept survived great scrutiny and forms the basic structure of the NAVSTAR constellation in use today.

The NTS Satellites

After the TIMATION program, came the Navigational Technology Satellites (NTS) in 1968. NTS I and NTS II were built and launched by the Naval Research Laboratory. Both satellites were proof-of-concept platforms that pre-dated the NAVSTAR satellites.

NTS I was the first satellite to use the rubidium frequency standard in space. NTS II was launched later and used 2 cesium standards for timing.

These frequency generators were built for ground use, but modified for operating in space. NTS II suffered a failure at launch and so it's cesium standard never operated in orbit, but NTS I had several weeks of on-orbit operations validating both the on-board pseudo-random, noise signal assembly (PRNSA) design for space operations, and ground-user equipment performance.

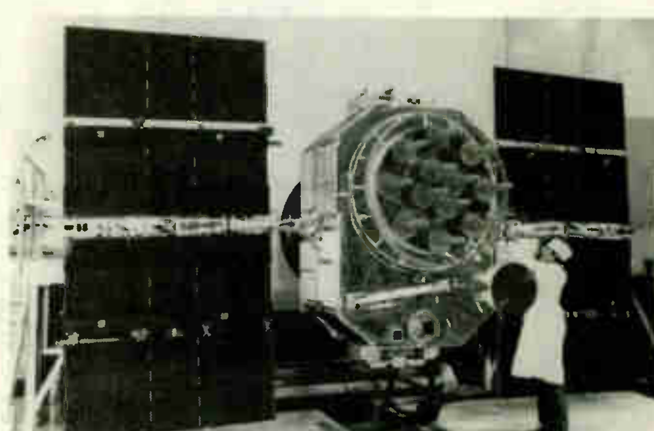
The NTS user equipment receivers acquired and locked onto the PN spread spectrum signal. Once lock-on was achieved the equipment demodulated, and decoded the signal resulting in a position solution. The solutions from NTS I were extremely accurate. So accurate, that many people informed of the performance doubted the results.

NTS III was planned by NRL, but Rockwell International, the supplier of Block I NAVSTAR satellites was finishing the last Block I NAVSTAR at the same time that the spacecraft was planned to be used for testing. The Air Force decided to use Block I NAVSTAR to test the same items that was to be tested on NTS III, so it was not launched.

As the combined NRL-NTS and the Air Force-621B projects renamed NAVSTAR GPS progressed, NRL redirected its activities to research, evaluate and develop new timing technologies suitable for GPS. One of those technologies that was found to have potential was the hydrogen maser.

The hydrogen maser was being tested by the Air Force for it suitability and on-orbit characteristics and performance. One Block II NAVSTAR was converted to a test satellite in the late 1980's for just this purpose. It was renamed and provided to the test branch of the Air Force for launching into space.

NAVSTAR Block I and Block II below– Built by Rockwell International. Courtesy of the Air Force Space and Missile Systems, Public Affairs

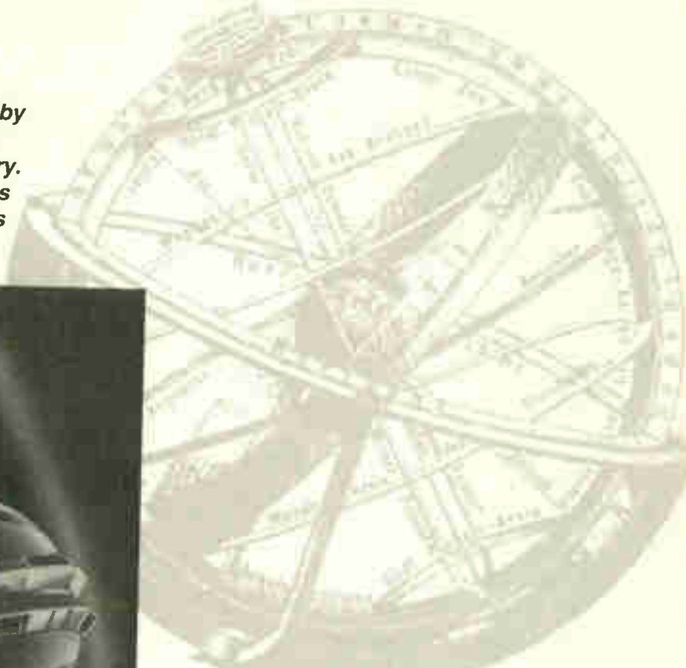


The NAVSTAR Satellites

NAVSTAR is the space segment of the Global Positioning System. The GPS acronym is from the days when the only mission envisioned for these satellites was to provide the world's only space-based user positioning system.

Using a pseudo-random, time division multiple access (TDMA) spread-spectrum downlink, each NAVSTAR's orbital position and time is sent to anyone with GPS user equipment. PN spread spectrum has unique qualities that are advantageous to NAVSTAR users. User receivers need a very low signal-to-noise ratio so they can be inexpensive. The RF power to the user can be extremely low (about -166 dBm). This results in a less expensive, less powerful satellite.

The orbital position that each NAVSTAR satellite transmits to the Earth, is an orbit prediction of where the NAVSTAR was supposed to be from the last time that its navigational memory was updated. Ground software uses Kalman Filtering to evaluate past orbit position and frequency standard drift and predict future orbit and on-board clock behavior. This prediction is then uploaded to each NAVSTAR and retransmitted on the L-band navigation downlinks as NAVSTAR orbit position and time. All significant variables are compensated for in the prediction by ground software techniques.



TRANSIT (Series I) – Built by Johns Hopkins University Applied Physics Laboratory. Courtesy of Johns Hopkins University Applied Physics Laboratory.

NAVSTAR uses two L-band downlinks for GPS user equipment. L1 is at 1575.42 MHz and L2 is at 1227.60 MHz. Two frequencies are used so that atmospheric delay for each can be compensated for at the instant the data is taken for a position solution by the user equipment. L1 and L2 are uniquely effected by the atmosphere and the combined effects are cross correlated to determine actual delay for all NAVSTAR users.

The first GPS satellite was launched on February 22, 1978, and became the heart of the newest space-based navigation system. The Air Force named the first GPS satellite that reached its correct constellation position — NAVSTAR 1. Three more GPS spacecraft were launched in 1978. A complete launch history can be found in the *Satellite Services Guide* in this issue of *ST*.

NTS satellites were originally going to be compatible with the NAVSTAR system and be part of the first GPS constellation, but developmental evolution of the navigation package on BLOCK I NAVSTARs, prohibited it.

Conservative estimates made within the Air Force by their mission planners in the 1970's indicated that over the 30 years of planned GPS system use, life cycle (total project) costs could exceed US$30 billion. This analysis was done using an early 4 years of usable satellite life. Early estimates indicated that over 200 satellites would be needed to keep the GPS constellation full of working satellites for 30 years.

GPS satellite on-orbit life was dictated by the life of the rubidium frequency standards on each NAVSTAR. The NTS satellites had 2 rubidium standards. NAVSTAR 1, 2, and 3 carried 3 rubidium standards each. NAVSTAR 4 was first to carry 4 frequency standards, 3 rubidium and 1 cesium standard.

NAVSTAR IIR – Built by Lockheed Martin. Courtesy of the Air Force Space and Missile Systems, Public Affairs.

The Space Shuttle and NAVSTARs

The NASA space shuttle had an impact on the GPS constellation design. When the concept was first drawn up, the military was ordered to launch GPS on the space shuttle. The shuttle cargo bay could hold up to four NAVSTAR spacecraft.

A plan was developed to launch the entire GPS constellation of NAVSTAR using the shuttle in 18 months. This was faster than the previous plan of 5 to 7 years using expendable launch vehicles (ELV) launched from Vandenberg Air Force Base. However, the inclination that the space shuttle would go to with a full cargo bay of NAVSTAR's was only 28.5 degrees. Previous ATLAS E/F launches from Vandenberg injected a single Block I NAVSTAR's into 63 degree inclined orbit planes. The higher inclination was desired to improve polar coverage.

The STAR 37 Thiokol solid rocket motor would get over 28 degrees of plane change and could get the NAVSTAR to its proper orbit altitude, inclination and eccentricity. This plus the 28.5 degree inclination from the space shuttle meant that the NAVSTAR orbit plane inclination target was 55 degrees. However, after the space shuttle Challenger failure in 1986, the government decided to launch the NAVSTAR spacecraft using a special DELTA II rockets into the 55 degree inclined orbits. The NAVSTAR GPS system design had been completed with a 55 degree inclination as the target. The impact to change back to 63 degrees inclination was large, expensive and not justifiable.

NAVIGATION SATELLITE CHARACTERISTICS

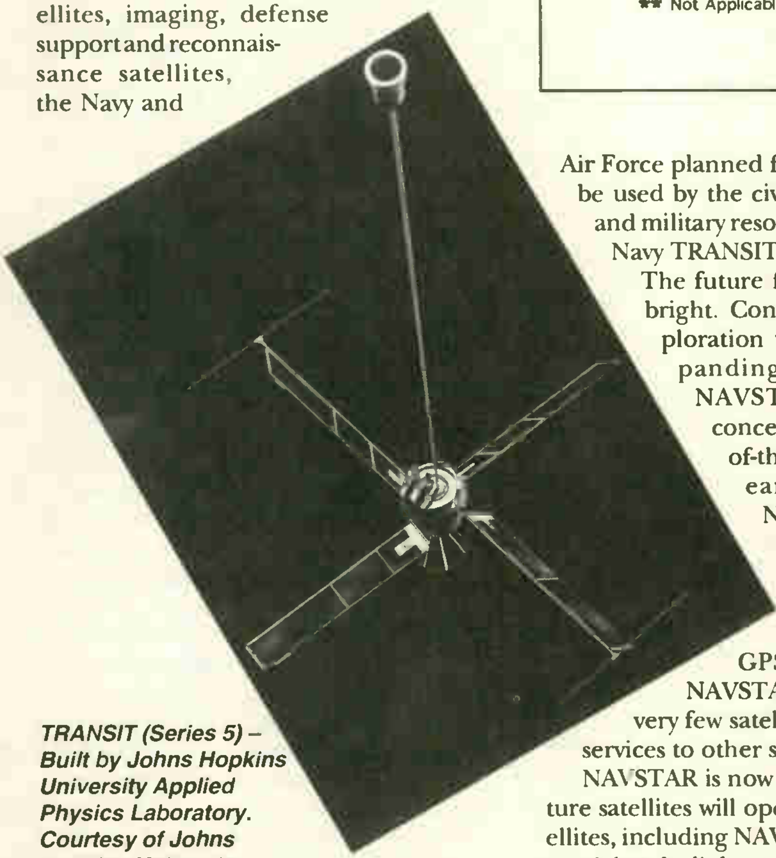
				NAVSTARS			
	TRANSIT	*TIMATION*	*NTS*	*BLOCK I*	*BLOCK IIA*	*BLOCK IIR*	*BLOCK IIF*
Orbit Altitude (nmi)	600	500	7.5K 10.9K	10.9K	10.9K	10.9K	10.9K
Inclination (Degrees)	90	70	125 63	63	55	55	55
Orbit Period (Hours)	1.5	1.5	6 12	12	12	12	12
Mean Mission Duration(Yrs)	**	**	**	4.5	4.5	7.5	10
Design Life (Years)	8	**	3	5	7.5	10	12
Weight (lbs)	270,190 130,165	85 125	640 950	1739	1739	4480	*
Size(ft)	3 ft dia ball 3.6 X 2.6 cyl 1.5 X 0.8 oct	very small small	5 X 3	8 X 5	8 X 5	6 X 5	*
Power (Watts)	3 10 20 35	6 18	100 400	410	700	970	*
Navigation Frequencies (MHz)	54/108 162/216 54/324 136/224 421/448 150/400	150 335 400 1580	335 1580	1227.60 1575.42	1227.60 1575.42	1227.60 1575.42	1227.60 1575.42 1227.60 +/-20.6

* BLOCK IIF NAVSTARS haven't been built yet, and so these parameters aren't known.

** Not Applicable

Conclusion

NAVSTARs are very different among military satellites. Unlike military communications satellites, weather satellites, imaging, defense support and reconnaissance satellites, the Navy and Air Force planned for NAVSTARs to be used by the civilian community and military resources just like the Navy TRANSIT system.



TRANSIT (Series 5) – Built by Johns Hopkins University Applied Physics Laboratory. Courtesy of Johns Hopkins University Applied Physics Laboratory.

The future for NAVSTARs is bright. Continued space exploration will mean an expanding role for NAVSTAR. Originally conceived for surface-of-the-Earth and near earth navigation, NAVSTAR can be modified to provide navigation service above the NAVSTAR GPS constellation. NAVSTAR is one of the very few satellites that provide services to other satellites.

NAVSTAR is now effecting how future satellites will operate.. Future satellites, including NAVSTAR could cost much less, be lighter and use less power because the attitude and orbit control subsystems can be replaced with simple algorithms for using NAVSTAR data.

NAVSTAR will continue to lead space-based navigation into the next century. The Air Force has now been joined by the rest of the world in using this fantastic system and this makes the NAVSTAR satellites shine even brighter. ST

GPS

Without doubt, the Global Positioning System (GPS) has made an enormous impact on the way navigation and tracking is performed. The applications, whether commercial or recreational have created a billion dollar industry, that will surely continue to grow.

Photo courtesy of Magellan

Explained

By Steve Dye

The GPS system is owned and financed by the U.S. Department of Defense (DoD), and consists of a constellation of 24 satellites, orbiting the earth. The system has both military and civil applications, and has proven itself to be the most reliable form of navigation and location finding ever. So, how does the system that gives every square meter on the planet a unique address, and tell a lost climber in the middle of nowhere what his location is work?

The way in which GPS calculates the receivers position on earth is based on a few very simple geometry principles with some clever computing algorithms that determine the distance of the receiver from the satellites. These, among other principles will be described in this feature and will provide a lot of answers as to the way in which just a receiver, and one with an extremely small antenna for satellite signals, can actually fix your position, with surprising accuracy.

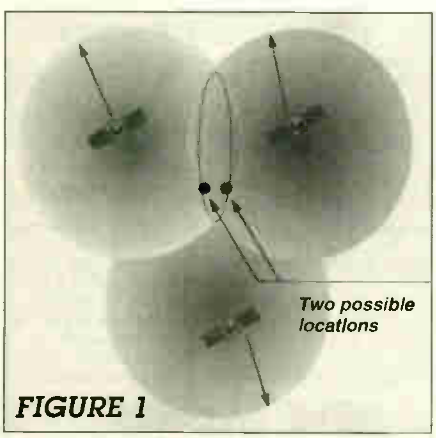


FIGURE 1

Intersecton of three spheres providing a location fix.

Location in Two and Three Dimensions

The means by which GPS locates the receivers position on the earth's surface is in essence, triangulation. There is a lot more to it than this of course, but triangulation, the age old method of navigation, is the basis by which GPS provides a location.

In space, we have three dimensions, and in reality, we would need four reference points to fix a location, giving altitude as well. Consider being positioned on the earth, 16,000 km from Satellite A, 17,000 km from Satellite B and 18,000 km from Satellite C. In a three dimensional scenario, we have to approach things differently. A satellites signal in three dimensional space, would form an imaginary sphere with the satellite at the center. The outer surface representing the point where the signal is received. This would pinpoint the location of the receiver to somewhere on the surface of this imaginary sphere. If it were known that we were a certain distance from another satellite, the imaginary sphere this signal produces would intersect, the first sphere, forming a circle. The position of the receiver has now been narrowed down to somewhere on the circles circumference. If a third range was introduced from another satellite, then the location could be narrowed down to one of two places: the intersection of the second circle on the first.

Figure 1 illustrates this. To be absolutely correct, we would need a fourth satellite to finally locate our position in three dimensional space. However, one of the intersection points, though existent of course, has a value not considered practically possible. The satellite receiver can actually calculate which reading to determine as the correct one, based on an algorithm that determines which intersection point to select. So, as can be seen, in terms of locating a point on the earth's surface, three satellites and some decisive algorithms in the receiver will produce the location on the earth's surface.

Calculating the Distance

Now that we have established the rather elementary methods of locating ourselves, a method of calculating the real distance from these satellites needs to be found. GPS again, adopts a widely used principle of science; the velocity of electromagnetic radiation and time taken for a signal to reach a position, thus yielding a distance. The equation is simply

Speed = Distance/Time. Giving Distance = Speed * Time.

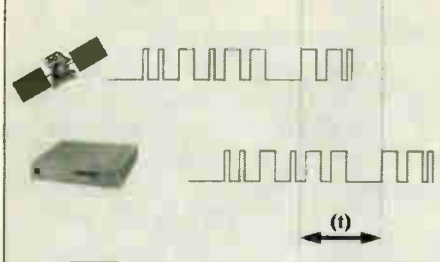
This straightforward principle incorporated in the receivers algorithms will utilize the finite time it takes from each satellite to reach the location of the receiver, and multiply it by the constant velocity of electromagnetic radiation to return a distance value. So far, the above descriptions have spared the critical element that enables GPS to accurately locate a position — timing. The very essence of this all is the timing. In short, the receiver determines its distance from the satellite by timing the signals arrival time, and calculating the distance from that.

Pseudo-Random Codes

If a GPS satellite transmitted a known signal at a known time, then the receiver, having received and decoded the signal would be able to calculate the time it takes for the signal to arrive and derive a distance value from the satellite. The actual signals the GPS satellite transmits are a set of codes that are also generated by the receivers. The receiver compares the received code to the transmitted code and after some processing, is able to determine the signals time lag from the satellites, once both satellite and receiver are synchronized.

To illustrate this with a simple analogy, imagine two persons on a football field, with each standing at the opposite ends of the field, watching for a signal they both

FIGURE 2



A pseudo random code with the time lag (t) between satellites transmitted and receivers generated code sequence.

can see that orders them to start counting. When they start counting, (in seconds) "one, two, three" etc., one pesron will, for instance hear "one" when the other has reached three shall we say. This is due to the time interval caused by the sound traveling the length of the football field.

Thus in our analogy, one person represents the GPS satellite, transmitting its timing signal, the second person represents the GPS receiver, transmitting the same code. Now, as the receiver shouts say "three", it heard "one" , meaning it took 2 seconds for the other persons counting to reach him.

As you can see, synchronization is the key to accurately measuring the timing. Rather than using a simple code as in the analogy above, GPS actually uses a complex series of pulses that look almost random. They are in fact a sequence that repeat every millisecond, forming a pseudo-random code sequence. Figure 2. shows a pseudo-random code and the receiver measuring the time lag.

This code is sent by the satellite at known times precisely so that the patterns occur at set times. When the receiver generates its code, (the same code the satellite generates), it "shifts' the code around in the time domain until it correlates or matches with that of the received code from the satellite. The amount of time by which the receiver had to 'slide' its code is the time taken for the signal to reach that point on earth.

Atomic Clock

In order to achieve a high level of timing accuracy, atomic clocks are mounted on board each satellite. Atomic clocks such as these achieve accuracies in the order of nanoseconds, and to ensure this level of accuracy is maintained at all times, each satellite has four such clocks on-board with three on stand-by acting as back-ups. The same cannot be said however, for the receivers. Such devices would make the prospect of cheap and portable receivers impossible. Atomic clocks in each off-the-shelf receiver would be impractical, so less accurate timing systems are employed.

This does in fact introduce a problem whereby an error in positioning can be introduced due to the difference in accuracy between the two timing systems. This error can be significant and in order to correct it, a fourth satellite measurement is required to finally fix the position. If three accurate measurements were used, a reasonable, but-less-than accurate positioning would result. However, if four less-than-perfect measurements are taken, the location can be determined with accuracy as you will see later on in the article.

Timing Errors

To illustrate the effect of accuracy, the velocity of electromagnetic radiation is 3E 8 Ms^{-1} If the accuracy of the clocks differs by as much as 1000th of a second, then a ranging error of 3E 5 meters or 300 km would result! This calls for the obvious need for accurate timing in the receiver. Figure 3. illustrates the effect timing errors have on ranging measurements in two dimensions. The thick bands offer a multitude of possible positions due to the possible ranges.

There is another possibility associated with timing errors — if a gross error occurred where the timing was off by an appreciable amount, all (imaginary) spheres would not intersect at the same point. There would be an impossible solution derived from the algorithms where there is no point of intersection that satisfies all three satellites. With a fourth measurement, the algorithms can start determining if these imaginary points of intersection are in fact feasible. If, after calculating the distances, no intersection point results from all satellites, the algorithms starts adding or subtracting plausible amounts off the timings from all satellites until a point is reached, where all timings intersect. The end result, being the location of the receiver. This is a point worth remembering, you can't obtain a reliable reading unless you have "visibility" to at least 4 satellites.

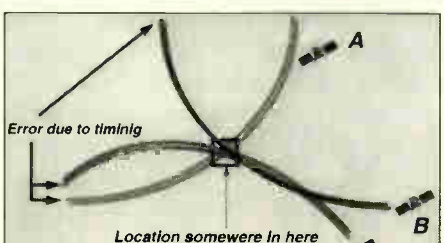


FIGURE 3

Positioning error due to variable timing.

More on Pseudo Random Codes

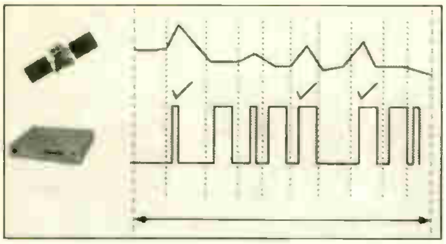
Users of GPS equipment may have pondered over the size of the antenna, and wondered how such a small device could receive anything at all, let alone intelligable signals from a satellite. Well, the reality of it all is the antenna itself is only capable of receiving noise: the noise present in the atmosphere, with the GPS signal literally buried in it somewhere. This is where pseudo random codes come into it as an important feature.

Noise is random and to a lesser extent, so are the GPS satellite signals. Although buried in the noise, and the code looks like noise, they are in fact an intelligible signal with a repeateable cycle. The means by which the signal is extracted is rather a complex one, but can be simplified somewhat by way of explanation.

The key to it is the fact that though the GPS pseudo random code appears like the random background noise, it isn't, and more to the point, the sequence of the pseudo random noise is known whereas the background noise isn't. The received signal or perhaps noise shall we say is divided up into time periods or chips as they are known. If the receiver output "noise" is compared to the generated output, there will be little comparison to be made right away; the peaks of noise would in all probability equal the nulls of noise giving an average of zero.

However, if the receiver generated code is shifted in time appropriately, after several time periods it will be seen that there is an increase in the number of matches of noise peaks coinciding with the generated noise peaks. At the optimum point, the receiver would have locked onto the signal that was previously buried in noise. This process has effectively amplified the signal as it has lifted itself out of the noises. This illustrates how the system allows not only the use of small receive antennas, but also low power amplifiers in the satellites themselves to transmit and receive low power signals, buried in noise.

Figures 4 and 5 illustrate the processes of extracting a signal from the noise. As a side note, this is the principle behind Code Division Multiple Access (CDMA) a system that will be chosen by some of the Personal Communications System (PCS) operators as their technology since it is claimed to offer a higher capacity and greater resilience to noise impairment. This technology is also not new, and has been in use by the military for considerable time. This modulation technique in its various forms provides protection



Low level of matches between pseudo generated signal with "noise" received by GPS receiver.

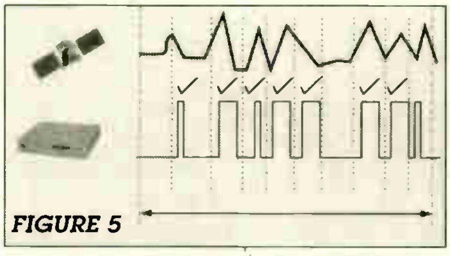


FIGURE 5

A high level of matches between pseudo generated signal with "noise" received by GPS receiver. Signal effectively amplified and recovered.

against jamming and eaves-dropping.

More Factors Affecting Accuracy

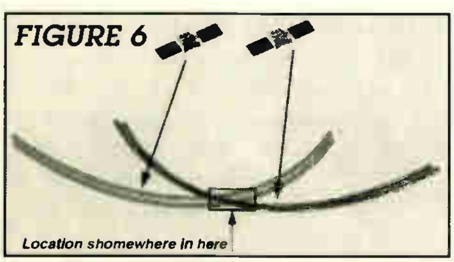
There are a number of factors that can affect the accuracy of the distance measurements that so far have not been discussed in the preceding text. These are namely :

Atmospheric and Ionosphere Delays
Multipath Error
Timing (Satellite)
Geometric Precision
Selective Availability

Atmospheric and Ionospheric Delays

The speed of electromagnetic radiation is constant in a vacuum, but will reduce when traveling through the various layers of the atmosphere. To this end, the delays measured by the GPS receiver will yield distance calculations, slightly off, because these delays would force the receiver to calculate a longer distance. The atmosphere varies in propagation conditions according to the weather, and is thus a forever changing value. However, the type of delays induced as a result of this is in the order of meters, and can be neglected.

The ionosphere, is a different situation. The GPS signal will be slowed down, and the simplest receivers incorporate an offset factor to compensate this. More sophisticated receivers apply a calculation based on the measured delay time received by an additional frequency. Another frequency band is applied here since there is a mathematical relationship between frequency and delay time. The relative delays are compared, and the appropriate measurement correction factors applied.



Positioning range error due to low angle between respective satellites.

Multipath Error

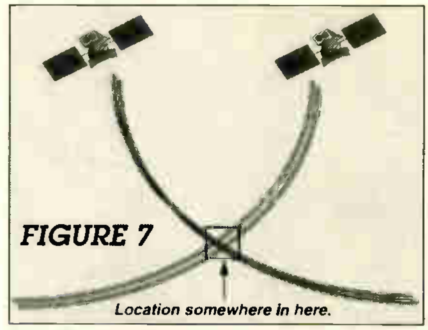
This unfortunate phenomena happens as a result of the direct signal path from one satellite or more reaching the receiver having bounced off natural or man-made obstacles reflecting the signal. This means that the signal has traveled longer than it should have, thus throwing uncertainty into the calculations. It is worth mentioning here, cellular radio systems in built up areas rely on multipath as the predominant propagation mechanism, sometimes with no direct path component in the signal. Since the satellites are higher than the base station antennas used in cellular systems, the chances of a direct signal path is very, very high compared to just a reflected signal. However from experience, I would not recommend trying to get a positional fix in the 'thick' of Manhattan Island.

Timing

We have already discussed timing inaccuracies at the receiver, but for errors in the atomic clocks onboard the satellite, other procedures are followed. DoD monitors the status of all satellites, including the errors in timing the atomic clocks may produce. These are corrected by the control stations that monitor the satellites on a 24 hour basis. Obvious large errors can occur due to a slight inaccuracy, and are easily detected. Smaller errors are not so easily detected, and induce a error in the order of meters in the measurements.

Geometric Precision

The situation could easily arise, where two satellites providing their ranging, have a low angle of separation, and thus, their intersection on the imaginary circle would form an elongated box. If the angular separation were higher, the intersection would allow greater precision as it would produce a smaller area of feasible locations. Figure 6 and 7 illustrates. Notice the thick lines produced by the satellites, these again represent the measurement uncertainty due to timing errors that exist. This problem is easily eliminated by good receivers, choosing which satellites to range. The receivers would know the satellites positions from information received, and select the four most suitable satellites.



Positioning range error due to higher angle between respective satellites.

Selective Availability

In the event of war, or other hostile conflicts, no matter where in the world, an enemy may well benefit from the use of GPS as would any military force. Since DoD has exclusive access to and the use of the GPS system, it can purposely degrade the accuracy by forcing timing errors in the satellite clock systems. As previously discussed, this would cause errors, and render the system unusable.

Military Use of GPS

In the event the above were to happen, the US military would still be able to use the system as they control the pseudo random code patterns, and use another frequency. In this situation, only the US military have use of the system since they will have access to the particular pseudo random codes the GPS satellite and receivers generate, as well as the frequency. The codes used for this purpose are extremely resilient against jamming and other forms of interference.

In the next issue of *Satellite Times* we will look at differential GPS, the method used for centimeter accurate posioning. In addition, some of the applications and users of GPS will be featured. ST

Steve Dye is a wireless system design consultant, based in Arlington VA. Starting in the next issue of ST, Steve will be a regular columnist covering Navigation Satellites.

GPS: *Putting it to Use*

By Haskell Moore

A major revolution is underway in the GPS consumer market, as receivers become affordable for almost anyone. The world's first hand-held GPS receiver for under US$200, the rugged Magellan GPS 2000 tracks your course and gives you position information at the push of a button. (Magellan photo)

Recognizing the need for a more precise method of electronic navigation, the U.S. Department of Defense (DoD) set out in 1973 to develop a new, worldwide system. Some twenty years and US$10 billion dollars later, the result of this effort was the Navigation Satellite Timing and Ranging Global Positioning System, or NAVSTAR GPS.

The DoD investment proved its worth many times over during Operation Desert Storm. On the featureless terrain of the desert, allied troops were able to navigate and communicate positions with precision and confidence using a wide variety of GPS systems. Even foot soldiers were able to take advantage of the system using Magellan NAV 1000M hand-held receivers.

Declared fully operational in July of 1995, the Global Positioning System is comprised of three components: the Space Segment, the Control Segment and the User Segment.

The Space Segment consists of a constellation of 24 satellites in asynchronous, circular orbit at approximately 20,180 km (10,900 nautical mile) above earth. The satellites circle the earth twice daily with four satellites in each of the six orbital planes. This arrangement is designed so there are a minimum of four or five satellites visible around the world at any given time. All satellites transmit a spread spectrum signal on 1227.6 MHz and 1575.42 MHz.

The Control Segment is made up of five monitoring stations worldwide and a Master Control Station, operated by the 2nd Space Operation Squadron of the 50th Space Wing at Falcon Air Force Base, located near Colorado Springs, Colorado. The monitoring stations transmit their data to the Master Control Station where is it processed to determine the exact location of each satellite. Since a GPS receiver depends on the satellite positional data (known as ephemeris data) as part of the method used to calculate its position, the Master Control Station corrects the ephemeris data transmitted by the satellites as required.

Finally, the User Segment is any receiver, military or civilian, which takes advantage of the GPS data being transmitted from the satellites.

The Author's "Hands-On" Experience

Perhaps the fastest-growing segment of the GPS market is the entry level systems, available to consumers starting at about US$200. Now hikers, boaters or practically anyone involved in outdoor activities can take advantage of this incredibly accurate navigation system for a fraction of the cost from only two years ago!

To get first-hand experience with a GPS receiver, I obtained one of the latest offerings from Magellan Systems, the GPS 3000. This unit, measuring a mere 16.76 cm x 5.84 cm x 3.3 cm (6.6x2.3x1.3 inches) is an example of the recent extraordinary leaps in technology.

After about twenty minutes with the manual, I was able to get the receiver configured to start my test. The first step was to initialize the receiver by taking it to a local park, where there is as much unobstructed sky visibility as possible. Then, I just turned the unit on and it to began acquiring data from the GPS satellites. A satellite tracking screen showed the relative location, along with the signal strength, of all satellites within range. In about fifteen minutes, the receiver had figured out where in the world it was and was ready to go to work; all in less than an hour from the time I opened the box.

I began by driving around to various locations in the neighborhood, obtaining a fix, and setting up waypoints (the GPS 3000 will hold 200 waypoints in memory). I then cycled through the six different graphical navigation screens to gain a better understanding of how each worked. There was a graphical display for almost any method of navigating one could imagine.

One of the screens I found most useful was the "pointer" display, which shows the direction of travel, along with an arrow that points continuously to the selected destination. Another display, which I found beneficial as a pilot, was a screen that simultaneously indicated bearing and distance to destination, as well as present bearing and speed. On the same screen is a Course Deviation Indicator (CDI) that displays in selectable increments how far off course you are. A word of warning to pilots: some GPS Course Deviation Indicators work opposite of the VOR CDI, and will take you from "off course" to "very disoriented" (we pilots don't get "lost", we get "disoriented") very quickly.

Perhaps one of the most beneficial screens, a moving map, scaleable from

Two more Magellan offerings: the sophisticated GPS-4000 (above) and the popular Trailblazer. Many outdoor adventurers consider the latter an essential piece of gear for hiking, hunting snowmobiling, fishing, etc.— guiding them where they want to go, and back again. (Magellan photo)

GeoExplorer system (left) is the newest handheld member of the Pathfinder family of GPS products. It is designed for the first-time buyer of GPS for mapping GIS data. The ScoutMaster GPS is designed for the land user. Its IO port lets you upload and download location data. Its mapping software helps you plot locations to scale and output them into transparencies, which can be placed over any topographical map. (Trimble photos) one-tenth to fifty miles, allowed me to track my course with extraordinary accuracy. I could see my present course as compared to the computed course to the selected waypoint.

Waypoints can be established by either keying in the coordinates ahead of time, or by storing a present position and assigning it a waypoint name. Numerous waypoints can then be strung together to create a "route". On the GPS 3000, up to five routes may be stored. After you reach your destination , the GPS 3000 can then automatically reverse the route to guide you back to the starting point.

One very annoying problem with this and some other GPS receivers I have used, was the tendency to give false readings when the unit was stationary. This is due primarily to the inaccuracies induced by Selective Availability. Since the perceived position of the receiver is constantly being altered by up to 100 meters (330 feet), the SA induced deviations can mislead the unit into sensing it is moving when it is actually stationary. This phenomena may be manifested by the various display screens pointing the wrong direction to waypoints, latitude and longitude varying slightly, and the odometer indicating inaccuracies. However, at even a walking pace, these errors usually diminish, or disappear altogether.

GPS - Nav Aid for the Outdoorsman

Hikers, hunters and fishermen are among the many outdoor enthusiasts who will benefit from the use of a GPS receiver. And though this tool may give the user a new-found sense of confidence, they are strongly advised not to rely entirely on a GPS receiver in the wilderness. While most of the units available are rugged and reliable (the GPS 3000 is even waterproof), GPS receivers are not immune to failure. Also, a heavy forest canopy or obstructions such as hills can absorb or block the satellite signals, rendering the receiver is unusable. Finally, extensive continuous use, especially with the backlight activated, may consume batteries far more quickly than anticipated. Anyone venturing into deep wilderness would be wise to carry a compass and appropriate topographical maps. Several sets of extra batteries would also be highly recommended. As your travel, use the coordinates from the GPS receiver to mark waypoints on your map. Then, if your electronic navigational wizard goes belly-up, you should still be able to find your way home.

People with a critical need to know their location may appreciate the new GPS technology—and pricing—the most. (Magellan photo)

Amateur Radio and GPS

Amateur (Ham) radio operators have found a number of innovative uses for GPS receivers. One of the more interesting variations of the hobby is attaching transmitters and repeaters to weather balloons and launching them high (100,000+ feet) into the atmosphere. From this altitude, amateurs can communicate through the repeaters for hundreds of miles!

To track the position of the payload during the ascent and parachute ride down, GPS receivers may be coupled to "packet" data transmitters. The precise latitude, longitude and elevation, along with other telemetry, are sent via radio signal to ground monitoring stations. The coordinates of the balloon are then relayed to the intercept team at the anticipated touchdown area.

In some instances, members of the intercept team, with the use of a laptop computer running Automatic Packet Reporting System (APRS) software, and a minimal amount of equipment to receive and interpret the data, can view a graphical depiction of the balloon superimposed on an area map, right from their own car. With thousands of dollars of electronic equipment floating with the wind, it's nice to know within a few yards of where the payload came to rest.

Getting the Right GPS Receiver

New GPS receivers are hitting the market at an astonishing rate. Receivers specifically designed for the aviation, marine or outdoor enthusiast offer a bewildering variety of options. And prices range from a low of about two hundred dollars up into the thousands.

The type of application for which you need a GPS receiver will usually be the primary deciding factor. GPS receivers are available with an assortment of pre-loaded databases, depending upon the application.

For pilots, receivers customized for aviation offer a database of airports, fixes, and airspace boundaries. Displays designed specifically for the pilot's needs show not only the current position, but ground speed, altitude, tracking information and estimated times for each leg of the trip. In the event of an emergency, a few keystrokes will get the pilot the names and directions to the nearest airports.

Boaters will appreciate the customized GPS receivers designed for this specialized audience. Again, along with current position data, coastlines, buoys, hazards and other navigational data are available on moving map displays. Handheld units are specially designed to handle the challenges of a marine environment, including several which are designed to float. Many marine models have a "man overboard" feature, which allows you to mark the position of a person who has fallen into the water, and then will automatically plot a course back to that location.

For hikers, handheld units are getting smaller and more affordable every day. Clear, concise graphical display point the way to the desired destination. A handy feature of the Magellan GPS 3000 is the capability to plot your way back home using fixes it has automatically logged during the course of your journey. Rugged, waterproof models, designed for the rigors of outdoors, make hiking into unfamiliar territory much safer and more enjoyable.

Future Applications

The ability to "mark" a particularly good fishing location is no small accomplishment to fishermen. (Magellan photo)

Advances in Global Positioning System technology will soon begin to touch our lives in ways we probably could have never envisioned. Already GPS receivers can connect to portable computers, and coupled with mapping software, indicate your current location and the most direct route to the desired destination. Soon these "moving maps", shown on built-in displays, will be available as a low-cost option on many new cars.

One of the most practicable applications of GPS technology is in the field of aviation. For years, commercial aircraft have had to fly indirect routes to their destinations via highways in the sky known as "airways", wasting immeasurable time and fuel in the process. Now that aircraft have the ability to transmit their precise position at all times without the help of radar, a concept known "free flight" is all but a foregone conclusion. Aircraft will be able to proceed directly from airport to airport, coordinated by computer controlled navigation systems which will track all other aircraft in the vicinity. The results will be a substantial reduction in travel time and an increased margin of safety. Even for light aircraft operating under Visual Flight Rules, navigation will be far easier, safer and more reliable than ever before.

For emergency services, the possible applications for GPS technology are almost endless. For example, it is feasible to track the position of all police patrol cars in a given district. Then, in an emergency, the dispatcher can route the nearest car to the scene, saving precious seconds. Likewise, should an officer need immediate assistance, merely pressing a button on his radio will alert the dispatcher to his situation while transmitting his position. Backup units could be quickly sent without the officer ever having transmitted a spoken word.

Soon, advances in GPS technology will allow Emergency Locator Transmitters (used in aircraft) and Emergency Position Indicating Radio Beacons (used on boats), to transmit their precise position when activated. Currently, Search And Rescue (SAR) teams have to rely on a system of approximate location by satellite or mobile radio direction finding equipment. With the ability of these devices to automatically transmit coordinates, SAR teams will be able to receive exact location information and locate downed aircraft or sinking vessels in a fraction of time. The resultant savings of life and property should be the most wonderful benefit of this incredible, new technology.

For additional information about the Global Positioning System, the U.S. Coast Guard operates a computer bulletin board with numerous text files. The BBS can be reached at (703) 313-5910. You can also reach them via the internet at the following URL: **http://navcen.uscg.mil**

For information about the GPS 3000, or other Magellan GPS receivers, call Magellan Systems at (800) 707-5221.

Other GPS manufacturers include:

Garmin	(800) 427-6460
Lowrance Electronics	(800) 324-4774
Trimble Navigation	(800) 487-4662

ST

GPS in SPACE

By Philip Chien, Earth News

STS-72 onboard view. Backdropped against Australia's Shark Bay, this panoramic scene of the Space Shuttle Endeavor in Earth-orbit was recorded the mission's second extravehicular activity (EVA-2). The Japanese Space Flyer Unit (SFU) and the Office of Aeronautics and Space Technology (OAST) Flyer satellites are seen in their stowed positions in the aft cargo bay. (NASA photo)

One of the more obvious applications for GPS receivers is to place one onboard a spacecraft in orbit. As long as a spacecraft is traveling below the altitude of the GPS constellation it can receive the GPS navigation signals as well - if not better than — a receiver within the atmosphere. However there are some unusual limitations.

GPS receivers have a built-in limiting feature which cause them to cease to function if they're moving faster than a given velocity. This is a fairly obvious 'safety feature' to avoid a terrorist group from building a GPS equipped SCUD missile. The 'anti-spoofing' capabilities can be bypassed, but needs much more software development by the user.

One of GPS's most esoteric capabilities is the ability to determine attitude — what direction it's pointing. The ability has been tested on the ground using ships and movable platforms and has been used by a couple of spacecraft. To determine a spacecraft's attitude a group of GPS antennas — as widely spaced as practical — is mounted on the body. If the spacecraft is aimed directly towards a GPS spacecraft the signals will all arrive at the the same time. However if the spacecraft has any angle then the closer antennas will receive their signals nanoseconds earlier than the farther antennas. Extremely accurate clocks and precise calculations permit the attitude of the spacecraft to be determined with a high degree of accuracy.

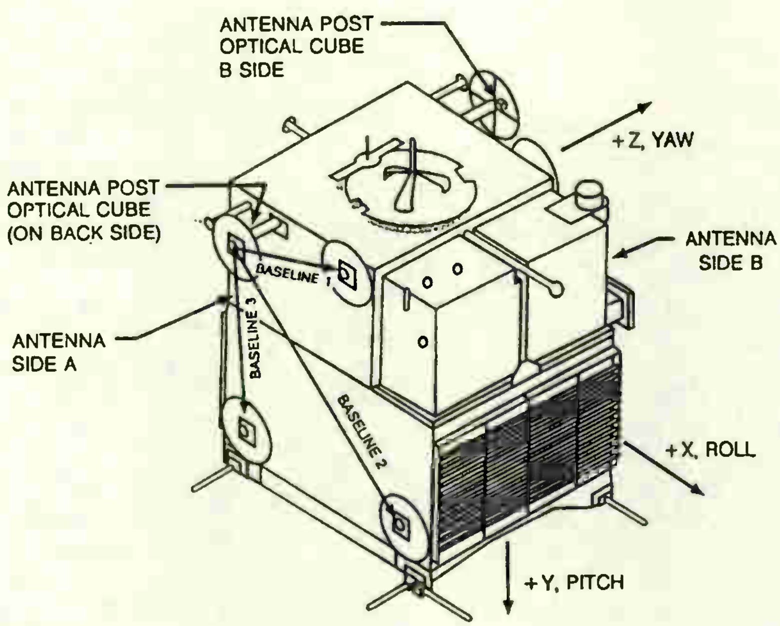
The key goal of spacecraft GPS teams is to develop an inexpensive space-qualified GPS unit for use aboard future satellites. To date every GPS receiver aboard a spacecraft has been one originally intended for

Data was compared postflight to determine how accurate the GPS systems were able to measure the locations relative distances of the shuttle and SPAS spacecraft. The STS-61 shuttle mission which refurbished the Hubble Space Telescope included a GPS receiver hooked directly into the shuttle's avionics as an evaluation. On the STS-66 shuttle mission in October 1994 the ASTRO-SPAS spacecraft included a Space Systems/Loral GPS receiver and for the first time, real-time attitude data was returned from a spacecraft in orbit. Four antennas mounted on the 15 foot (4 meters) wide spacecraft were used to collect data for the GPS experiment.

One of NASA's most interesting GPS experiments is GADACS - GPS Attitude Determination And Control System. It's flying aboard the OAST-Flyer, a Spartan spacecraft. Spartan was originally developed as an inexpensive platform for telescopes which were originally designed for sounding rockets. The whole principle of the Spartan program is to keep things simple and inexpensive.

The Spartan spacecraft is totally self-contained. Its power is supplied by batteries and data is stored on a tape recorder. Once it leaves the shuttle's cargo bay it performs a quick pirouette to verify that its attitude thrusters are working and is left to fly on its own for up to two days before the shuttle picks it up. The scientists have to be patient and wait until after the shuttle mission is completed before they can get the data off Spartan's tape recorder.

Six Spartan missions have been flown since the first flight in July 1985 and the only failure was the Spartan-Halley spacecraft lost during the Challenger accident. The OAST-Flyer on STS 72 in January, marked the first time that Spartan was used as a technology platform instead of

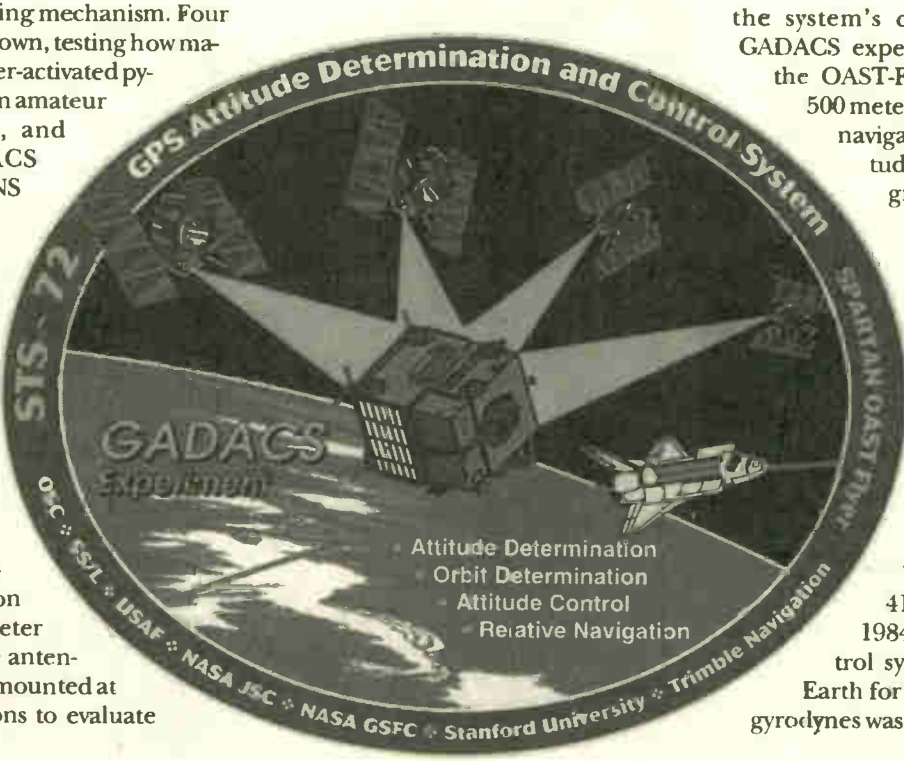


GADAC Antennas mounted on OAST-FLYER

STS-51 onboard view of Discovery's middeck as astronaut Carl E. Walz shows off the stowage locker for gear supporting the GPS on-orbit operations. (NASA photo)

as a telescope pointing mechanism. Four experiments were flown, testing how materials react, new laser-activated pyrotechnic devices, an amateur radio experiment, and GADACS. GADACS uses a Trimble TANS vector receivers.

For the first time Spartan included antennas — eight antennas for the GADACS experiment and two antennas for the ham radio experiment. The GPS antennas were microstrip antennas mounted on 30.48 cm (1 ft) diameter ground planes. The antennas were purposely mounted at non parallel locations to evaluate the system's capabilities. The goal of GADACS experiement was to determine the OAST-Flyer's position within 150-500 meters (495-1650 ft) accuracy for navigation purposes and its attitude to within .1 to .5 of a degree.



The OAST-Flyer also had a subcomponent with a long track record in space. When the Solar Max spacecraft was launched in 1980 its attitude control system included four gyrodynes to point the spacecraft. That box failed in orbit, and was replaced by astronauts Pinky Nelson and Ox Van Hoften aboard the STS 41-C shuttle mission in April 1984. The failed attitude control system box was returned to Earth for failure analysis. One of the gyrodynes was refurbished and flew a one week mission in space aboard the BroadBand Xray Telescope (BBXRT) mission in December 1990 as part of the Astro-1 astronomical mission. That same gyrodyne made its third flight as part of the GADACS experiment.

The GPS teams are analyzing the data collected from the OAST-Flyer with space shuttle Endeavour's GPS receiver to compare their performance and how well they tracked the positions of the two spacecraft during the two days when Spartan was flying separate from the shuttle.

AMSAT's Phase 3-D spacecraft, planned for launch later this year, is the largest spacecraft built specifically for amateur radio operators. It will set the altitude record for any spacecraft with a GPS receiver. The GPS experiment is being developed by AMSAT, with support from NASA's Goddard SpaceFlight Center. Dr. Thomas Clark, W3IWI, is the principal investigator.

It's anticipated that the GPS system will be able to backup some of Phase 3-D's critical functions. Like previous AMSAT spacecraft, Phase 3-D will use sun-earth sensors as its primary attitude sensors. The GPS experiment will independently determine the spacecraft's attitude. In addition, the GPS receiver will calculate the spacecraft's position, its orbital elements, and provide the exact time.

The Phase 3-D GPS system is a 24 channel GPS receiver with eight Plessey GP-1010 GPS downconverters and an AMD 292000 RISC controller. Any of the spacecraft's eight antennas can be electrically connected to any of the receiver channels. There will be more antennas and R-F cabling for the GPS subsystem than any other Phase 3-D frequency band. Four patch antennas are mounted on the bottom of the spacecraft, along with three bowl-shaped parabolic antennas and a patch antenna on the top surface. The parabolic 'helibowl' antennas are based on $1.69 metal salad bowls - the ultimate in inexpensive antenna construction techniques!

For most of each sixteen hour orbit, Phase 3-D will be above the GPS constellation's altitude. GPS measurements will be taken primarily while the spacecraft is at its lower altitudes, and the rest of the Phase 3-D spacecraft's orbit can be determined through fairly simple orbital dynamics calculations. However, the AMSAT GPS team hopes to be able to accomplish even more.

GPS signals are radiated towards the Earth by each of the 24 spacecraft, but some of the signal 'leaks' beyond the Earth. While Phase 3-D is at its highest altitudes it may be able to listen to GPS satellites — not the ones beneath it (which are facing the opposite direction) but the satellites on the opposite side of the world! The helibowl antennas will help concentrate weak signals from the distant satellites — over three times the distance of a typical ground-based GPS receiver!

GPS was originally designed as a system to guide ICBMs accurately towards their targets. In the ultimate case of other uses for military technologies GPS has become an extremely valuable tool for spacecraft designers. Many planned spacecraft will include GPS receivers as important parts of their design. The 50 kg. (110 lbs) South African microsat, Sunsat, will include a GPS receiver. On the high end of the scale — both in terms of mass and budget — the International Space Station will determine its position in orbit via GPS. ST

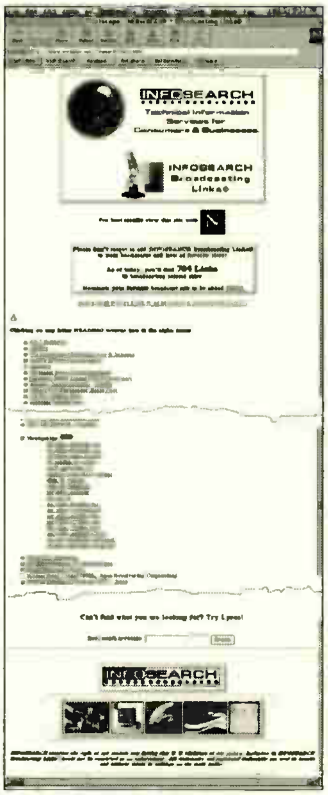
DOMESTIC

TVRO

By Doug Jessop

TVRO Wildfeeds

As I contemplated on what to write about for this issue of *Satellite Times*, I glanced around my office to see all the fun little trinkets and momentos from previous year's trade shows and conventions. A gold pan from the Outdoor Channel caught my eye and "Eureka," I hit paydirt (sorry for the pun). You see, I had met with the folks from the Outdoor Channel at what has to be one of the most interesting trade shows to attend, the National Association of Television Programming Executive or NATPE for short. NATPE is the place where all of the syndicators try to sell their TV shows to television executives.



INFOSEARCH Broadcasting Links© include web links to a variety of programming and satellite information.

The second part of the inspiration for this article is that one of the funniest parts of having a satellite dish can be compared to panning gold, by searching for "wild feeds." Wild feeds are basically the various satellite feeds done on an occasional basis for television stations to then broadcast locally. Syndication is at the heart of wild feeds.

How do you find wild feeds? That depends on how much patience you have and if you have access to the Internet. There really are only a handful of major players in the satellite transmission business (see table 1), with the majority of syndication being transmitted by Keystone Communications (Paramount and Buena Vista are two major clients) and Global Access (GATS). Some of the syndicators like Group W actually own their own transponders. With the growth of network programming (see table 2) being offered in syndication more feeds will be done of their satellites. While syndicators are reluctant to disclose exactly when and where their feeds are broadcast there are some ways to make things easier.

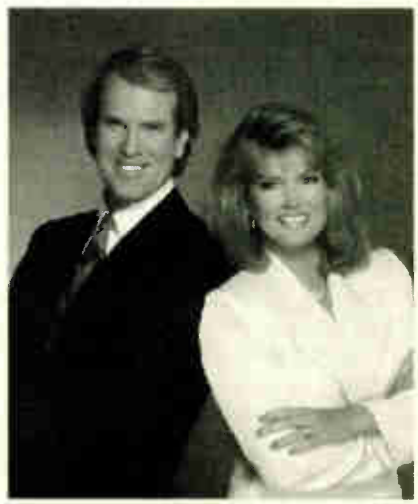
My suggestion, (hint, hint, wink, wink) would be to first look at the transponders listed in table 1. Most of these feeds are generally in the clear. Don't go asking the companies what shows are going to be on when, number one they don't have the time to answer all the questions and number 2 they generally are not supposed to release that information.

Another strong suggestion is to hop on the Internet and check out the latest release of *The Birdwatcher's Wildfeed List* by *Friday Night Live* host Gary Bourgois (BIRDWATCHER@genie.geis.COM). *(Editor's note: This is probably the single best source of wildfeed information available. Gary has produced several interesting articles that are available on the internet that are free of charge and are must reads for the TVRO entusiasts-Larry).* You can get a copy of the Wildfeed List through either the INFOSEARCH Broadcasting Links © page at: **http://www.xmission.com/~insearch/links.html** or point your web browser toward *Satellite Times* columnist Robert Smathers Satellite WWW page at: **http://www.nmia.com/~roberts/robert.html.**

To give you a little background on syndication via satellite you need to go back to the fall of 1981. All television programs were either done live or in the case of syndication sent on tape either en masse by courier or "bicycled" where it went to one station who aired the tape and then sent the tape on to the next station and on down the line. Obviously this wasn't all that efficient.

Paramount Domestic Television and the company that is now Keystone Communications came up with a radical new plan for the TV stations. It was proposed that a new "day and date" (be produced and aired on the same day) show be sent via satellite to each station that signed up. If the station signed up Paramount would pay for the satellite dish and Keystone would arrange to have the equipment installed. A pretty sweet deal for the stations when you consider that Paramount dished out more than a couple million of dollars in equipment.

Well, the stations signed up left and right, and now Paramount's reputation was on the line. The concept for the show was to send reporters out into the field and then send in the daily reports via satellite back to the studio where it would then be incorporated into a single news broadcasts with a male and female anchor. The kicker was getting the show produced on time every day for broadcast without fail. To give you an idea of how close things got, two runners would take the just completed show down from the Paramount studio and up 14 floors to the offices of what is now Keystone Communications to the satellite uplink in time for the 12:30 p.m. satellite feed window to 110 stations across the country. The only job that one of the runners had was to go first and hold the elevator...the timing was that close.



Entertainment Tonight was the first day & date syndicated show sent via satellite.

That same show took off like a rocket and is still around today. A microwave link between Para-

There are many more shows than there are hours available on your local stations. The neat thing for satellite dish owners is that you don't have to rely on if your local television stations bought the show, nearly all syndication is now sent via satellite.

mount and Keystone has replace the runners, but it is still not unheard of to be broadcasting the first half of the show while the second half is still being edited. If you haven't figured which show we are talking about yet here's a hint, yes...Mary Hart's legs are insured...the show that started syndication via satellite...*Entertainment Tonight.*

Going back to NATPE and why anyone with a satellite should give a darn.... What you end up seeing on television beginning this fall is dictated by what deals are cut at this show. There are many more shows than there are hours available on your local stations. The neat thing for satellite dish owners is that you don't have to rely on if your local television stations bought the show, nearly all syndication is now sent via satellite. So even if nobody in your market airs a show like *Weird TV* chances are with a little luck and some investigation and guess work you may pull a gold nugget off the bird.

If imitation in the sincerest form of flattery there should be some really proud folks in Hollywood. Imagine *Baywatch* meets *COPS* and you'll have the new show *Beach Patrol.* If you like *Hercules* and the spin off *Xena,* you should also go for *Tarzan: The Epic Adventure.* I saw a preview of the show and it scores high in the action area along with some great production value. Another show in the same genre is *Sinbad,* I did not personally check this one out, but associates say that it has a pretty decent chance at making it if they get enough stations to come aboard.

If you were one of those that was glued to the O.J. trial and you kind of miss Judge Wapner, you may want to check out *Final Justice.* Their flyer says

> "for the first time on television, be there: Eavesdrop on the sidebars. Observe the backroom dealmaking. Hear the please bargain negotiations. The drama, the people and the consequences are real; taped as it happens. No reenactments."

I don't know about you, but it sounds like this show is the *Reader's Digest* version of Court TV. Another new court type show for the Fall is *Hot Bench with Judge Judy Sheindlin* where Ms. Sheindlin, a New York judge, presides over real cases.

Another show in the "gosh that sounds familiar" category is called *America's Dumbest Criminals* which looks like the producers took *America's Most Wanted* and *America's Funniest Videos* and shook them both up in a big trash bag.

The dime-a-dozen talk shows seem to still be around. Rosie O'Donnel is the replacement show for the canceled Carnie Wilson show. The queen of the seven day makeup job, Tammy Faye is teaming up with Jim J. (he played the goofy guy on *Too Close for Comfort*) for a new talk show. MCA-TV introduced *He says, She says*—a single topic talk show that explores the different way that men and women look at different issues. *The Bradshaw Difference,* features relationship guru John Bradshaw trying to help people get along better. Other talk oriented shows coming to a satellite near you this fall include (I did not make up these names folks): *Donna Willis, MD., J & I, Later Today, Loveline, Maureen O'Boyle, Off the Hook, The Pat Bullard Show* and *Scoop with Sam and Dorothy.*

In other talk show news, Phil Donahue confirmed that he will quit his daily talk show following the end of the current season. *Donahue's* ratings had been suffering and the fate of the show seemed sealed last year when it was dropped by stations in New York City and San Francisco. In other talk show news — Dick Cavett announced that he will not renew his 6-year-old CNBC talk show for another year. Cavett's show will be replaced by *Straight Forward with Roger Ailes,* an interview program featuring Ailes, the president of CNBC (talk about "rank has its privilege!").

TABLE 1: Transponders owned/leased by Satellite Transmission Companies (excludes carriers GE Americom, Hughes and AT&T)

Company	Satellite	Transponder(s)
Autotote	Telstar 401-C	24
	Telstar 402R-C	6
Global Access (GATS)	Galaxy 4-C	5, 7, 9, 11
	Telstar 402R-C	20
	Galaxy 6	2
Group W	Telstar 402R-C	5
Keystone Communications	Galaxy 4-C	12
	Telstar 401-C	3, 5, 6, 18, 19
	Galaxy 6	1, 4, 7, 11, 16, 21, 22, 24
The Spaceconnection	GStar 1-K	13
	Galaxy 4-C	13
	Telstar 402R-C	4, 10, 11, 12, 18
Starnet	Telestar 401-C	1

Baywatch still lays claim to being the most watched show worldwide, while The Adventures of Hercules has revived the "fantasy" genre.

Geraldo is running ads in the broadcast trade journals about his new "higher standards." Tribune Entertainment Company and King World Productions Inc. recently announced the distribution of The Geraldo Rivera Show as well as a program development deal.

Geraldo is running ads in the broadcast trade journals about his new "higher standards." Tribune Entertainment Company and King World Productions Inc. recently announced the distribution of *The Geraldo Rivera Show* as well as a program development deal. "Our deal with King World works on a number of levels," Tribune executive vice president Dennis J. Fitzsimmons said. "This move adds financial strength to *The Geraldo Rivera Show* and the program development component provides additional funding for a future Tribune Entertainment first run program. Our station sales staff will continue to clear our other shows and concentrate on new programs."

Paramount Domestic TV announced that they have given the nod for another two years of *The Maury Povich Show*. Apparently the extension news came on the heels of a confirmation of a number of long-term station renewal deals. The new contract will take the five year old show through the 1998-99 season. During the most recent ratings sweeps in November, the Povich show earned an average 17-share beating fellow talkers *Sally Jessy Raphael, Ricki Lake,* and *Jerry Springer*.

Fox's cable network, *fX*, has acquired syndication rights to Fox's *X-Files*, for a cool $60 million. According to Daily Variety, the per-episode price ($600,000 each for 97 episodes) is the most ever paid by a cable network for an hour-long network drama. The previous record was held by the USA Network which paid $475,000 per-episode for CBS' *Murder She Wrote*. The *X-Files* will make its *fX* debut in fall, 1997 (see table 2)

On the Fox Network side, the hottest game shows of the 60's, *The Dating Game* and *The Newlywed Game*, are being revived thanks to one of the biggest deals in recent syndication history All twelve of the Fox-owned stations signed on with Columbia TriStar Television Distribution to create its new game show hour, *The Dating/Newlywed Hour*. Columbia TriStar Television president Barry Thurston said the Fox deal is proof that game shows will return as the hot genre in syndication. Does anyone remember *Studs*?

The UPN network will expand its Sunday morning kids lineup in September with four new animated series. Among them, a series based on the movie *Jumanji, The Mouse and the Monster, B.A.D. (Bureau of Alien Destroyers)*, and *The Incredible Hulk*. UPN recently dropped the previous Tuesday night line up of *Live Shot* and *Deadly Games* replacing the shows with *Moesha* and *Minor Adjustments*.

Before we depart the world of syndication, please indulge me and let me tell you my favorite schmooz story (OK Doug, but only one per issue-Larry). At last years NATPE show, Marilu Henner of *Taxi* and *Evening Shade* fame, was pitching her new talk show. As part of the hype, attendees to the show could get their picture taken with various stars and the lines can get pretty long. A co-worker of mine decided to brave the line and when it was finally his turn to get his picture taken with Marilu the camera ran out of film. While they were reloading the camera Marilu started up a conversation and said "I would really like to do what those girls do" referring to a pair of attractive women who had just had their picture taken. Marilu continued, "you know they work on a cooking show called *Spice*." Imagine how Marilu's face dropped when my friend explained that *Spice* was not a cooking show, but instead a heavy duty adult-only satellite TV channel...

TABLE 2: Future off-Network shows

Program	Distributor	Available Fall of:
Boy Meets World	Buena Vista	1997
Dave's World	CBS	1997
Dr. Quinn, Medicine Woman	MTM	1996
Ellen	Buena Vista	1998
Frasier	Paramount	1997
Friends	Warner Brothers	1997
Grace Under Fire	Carsey-Werner	1997
Hangin' with Mr. Cooper	Warner Brothers	1996
John Larroquette	Warner Brothers	1997
Living Single	Warner Brothers	1997
Mad About You	Columbia	1996
Martin	Warner Brothers	1996
The Nanny	Columbia	1997
NYPD Blue	20th Century/Fox	1997
The X-Files	20th Century/Fox	1997

The Duck is Back

Donald Duck has been returned to grace at Wal-Mart stores nationwide. Claiming that Donald Duck quacks an expletive in the cartoon *Clock Cleaners*, part of the Walt Disney Cartoon Classics series' video *Fun on the Job*, the Wal-Mart chain had pulled it from the shelves of one store while the tape was being reviewed. Meanwhile, Wal-Mart worked with Buena Vista Home Video to figure out exactly what the duck is uttering. Donald E. Wildmon, president of the conservative media watchdog group, the American Family Assn., said Donald quacks the F-word and has asked that Disney pull the video from circulation. Disney has declined comment. The video has now been returned to that store's shelves. Yes, I am a father myself and don't want to expose my children to garbage, but I wonder what Donald says when you play the tape backwards?

DBS War Heats Up

The Direct Broadcast Satellite (DBS) war has heated up with the latest round of FCC auctions for satellite channels. The bidding started with three parties — EchoStar, MCI and TCI. Echostar has recently launched its first DBS satellite — Echo 1. MCI had promised to start the bidding at $175 million. MCI apparently has a strategic alliance with media mogul, Rupert Murdoch's News Corp. The Fox network is part of News Corp. TCI, the country's largest cable company, is one of the Primestar partners.

After a day and half and 18 rounds of bidding, MCI came up the winner with a bid of $682.5 Million. In addition to television signals, MCI is expect to use the bandwidth to deliver audio/telephone service and data transmissions through their new asset.

In the next issue of *Satellite Times*, we'll take a closer look at the DBS market. Until then, get your big dish out and start panning for gold. ST

By George Wood

Trekking Across the Clarke Belt

Star Trek fans who have been able to get ahold of Sky Multichannels cards have been happily following the *Next Generation* and *Voyager* series on Sky One, with *TNG* repeats twice every weekday evening and new episodes of *Voyager* on Sundays. In January the original *Star Trek* series returned to Sky One as well, Sunday afternoons. The new European Sci-Fi Channel has carried several *Star Trek* movies among its infrequent offerings. What has been missing has been *Deep Space Nine*, which Sky removed from its schedule last Fall to make room for *Voyager*.

But in early January Sweden's TV1000 began broadcasting *Deep Space Nine* Wednesday evenings, with repeats the following Wednesday mornings. Legally only viewers in Scandinavian can subscribe to the channel, but there seem to be a lot of pirate D2-MAC cards out there, especially in Britain (apparently driven by consumer interest to watching the hardcore pornography on TV1000 and its arch-rival FilmNet). TV1000 is committed to broadcasting 46 episodes, which corresponds to the series' first two seasons.

Sweden's TV5 Nordic/Femman continues to broadcast the *Next Generation* Sundays at 1500 hours, and has added *Babylon 5* to its Saturday afternoon line-up. So British and Scandinavian science fiction fans have something to watch, in addition to the meager Astra offerings of the new Science Fiction Channel.

In the Star Trek universe Orion is the home of interstellar pirates, but back here in the Earth's Clarke Belt, Orion Network Systems operates satellites. Beginning February 1, Performance - The Arts has been digitally broadcast to cable operators in the UK via the Orion 1 satellite. The digital transmission also includes the Channel One news and entertainment channel.

Viacom is proposing launching versions of VH-1 for the Benelux and Scandinavian markets in 1996, either from the Swedish position at 5 degrees East, or the rival Norwegian constellation at 1 degree West. There is already an English version of VH-1 as part of the Multichannels package on Astra transponder 22, and a German verison is now part of the digital Viacom package on Hot Bird 1 at 11.283 GHz. Viacom has also started a German version of Nickelodeon, sharing the France-German cultural channel Arte's Astra transponder 49.

What Satellite TV reports that the satellite that changed European TVRO when it was launched in 1988, Astra 1A, will probably be used for satellite news gathering duties from 1998 onwards after its successor Astra 1H is in position. 1A will be placed in an inclined orbit, and moved to either 24.3, 26, or 28.2 degrees East. There have been reports of various bidders and buyers for all or part of Luxembourg's CLT, owner of the RTL television and radio channels around Europe, and part owners of Astra. The latest report is that a group made up of Germany's Bertelsmann, and France's Canal Plus and Havas wants to buy one third of CLT. Recently CLT was forced to deny rumors that Rupert Murdoch's BSkyB was to buy a 30 percent share in the company.

Eastern Europe is the new frontier of European broadcasting, as the first wave of relays of Western channels is replaced by new outmore domestic outlets supported by Western investments. CLT is to launch a Polish-language satellite channel this Spring. The channel will be called RTL-7, and will be the sixth satellite delivered Polish channel.

Also from Eastern Europe, Romanian Televison has launched a new international satellite channel, called TV Romania International, on Eutelsat II-F3 on 11.575 GHz (which it shares with the Arabic Muslim TV Ahmadiyya, NTV Russia, Albania's TV Shqiptar, and Telepace Vaticano). There's a daily program at 19:30-23:00 hrs UTC. By 1998, the channel hopes to broadcast to the United States.

Radio Daze

On December 8th, BBC World Service radio left NBC Super Channel's 7.38 MHz audio channel on Eutelsat II-F1 (it continues via BBC World and EBN on Eutelsat II-F1 as well on UK Gold's transponder on Astra). The frequency was taken over a few hours later by the World Radio Network for its WRN2 European service, relaying Vatican Radio. The previous WRN/Vatican relay on the MBC transponder on the same satellite ended on December 31.

Also on the WRN front, partners National Public Radio and Public Radio International launched their America One service, on Astra transponder 22, audio 7.74 MHz as scheduled right after midnight on New Years Day. NPR/PRI programming continues on the WRN1 channel two steps down, at 7.38 MHz. The 24 hour America One service gives NPR/PRI the chance to carry many programs beyond the basic *Morning Edition*, *Talk of the Nation*, *All Things Considered*, etc. shows relayed on WRN, such as the new PRI/BBC co-production *The World*.

Digital satellite radio is starting slow in Europe. *What Satellite TV* reports that reluctant merger talks between Astra's first subscription music broadcaster, Digital Music Express, and its chief competitor, Music Choice Europe, may lead to a deal. DMX has postponed the full launch of its British service until April (although the German service is up and running), due it says, to a shortage of the necessary microchips for digital receivers. But the financial losses have proved far greater than anticipated.

British Sky Broadcasting has finally unveiled its digital plans, in co- operation with the domestic British broadcaster Granada. This involves an eight-channel subscription television service to Britain from the new Astra 1E satellite.

Digital Dreams

More digital broadcasts are appearing on European satellites, in addition to those reported last time.

Swedish Television's 2 channels, renamed SVT1 and SVT2 at the beginning of the year, are now broadcasting in digital MPEG-2 on the Tele-X satellite, at 12.322 GHz. Danmarks Radio from Denmark is planning to send its terrestrial TV 1 channel via satellite from May this year, using MPEG-2 from 1 degree West (Intelsat 702, Thor or TV-Sat).

British Sky Broadcasting has finally unveiled its digital plans, in co- operation with the domestic British broadcaster Granada. This involves an eight-channel subscription television service to Britain from the new Astra 1E satellite. The joint venture, Granada Sky Broadcasting, will supply the new channels. The centerpiece will be the *Granada Gold Plus* channel which will show repeats of popular British shows such as *Coronation Street.* Other channels will focus on lifestyle themes, with such names as *Health and Beauty, Food and Wine,* and *Granada Men and Motoring.*

Germany's two public service broadcasters, ARD and ZDF, will also begin digital transmissions from Astra 1E this year. The broadcasts will be in parallel with the two stations' existing analog programming on Astra 1B and 1C.

MTV Europe announced on December 13 that it is widening and fine- tuning its pan-European advertising reach by using new digital satellite feeds. Digital compression allows a programmer to squeeze several channels or feeds onto one satellite transponder. MTV will be providing the same programming on several regional feeds, allowing each to carry separate targeted advertising. There is now some local advertising in Germany and Central Europe, MTV is just starting local ads to Italy, and will be the same in the Benelux and Scandinavia. Some of this programming will probably be on Viacom's digital transponder on the Eutelsat Hot Bird satellite at 13 degrees East, and currently carries VH-1 Germany and the 24 hour cable-only Science Fiction Channel Europe (as opposed to the much reduced Sci-Fi Channel service on Astra). MTV also broadcasts to Scandinavia in the half-digital D2-MAC format on Norway's Thor satellite at 1 degree East, 12.092 GHz.

Home Box Office and FilmNet Nethold are reported to be negotiating to bring in major investors from Hollywood studios, for new digital channels to Central Europe. MCA and Sony Pictures are among the companies pursuing the deals most aggressively. HBO hopes to have about 1.3 million Central European cable subscribers by 2004, and FilmNet expects to have a total of 1.2 million cable and direct-to-home subscribers by then.

The Kirsch Group says it will join the alliance for a digital TV decoder standard in Germany, removing a major obstacle to broadband television in Europe. Kirsch is joining the Multi Media Beteiligungs Gesellschaft (MMBG), which also includes Bertelsmann and France's Canal Plus. However, British Sky Broadcasting may still introduce a rival technology.

France is farther behind in the move towards digital satellite television. At the beginning of the year, Telecommunications and Information Technology Minister Francois Fillon says he favors a wide alliance of private and public companies to launch digital satellite television. Fillion was speaking at the presentation of a report into satellite television by a committee chaired by George Vanderchmitt. Vanderchmitt said public broadcasters like France Television or Arte should not try to become digital satellite broadcasters on their own because of the enormous investments needed and the large risks attached. State-owned France Telecom should also abandon ambitions to continue trying to offer television satellite services on its own, and needs to co-operate with Astra instead, he said. He also urged France to stop "ignoring" Astra.

This may mean the phase-out of France's Telecom satellites. December 7 saw the Ariane launch of Telecom 2C, which is replacing Telecom 1C at 3 degrees East (as well as India's Insat 2C — see below). Telecom 2C carries 10 C-band transponders, 11 Ku-band transponders, and 5 X-band transponders.

Ariane is hoping to launch 13 rockets this year, including the first two new generation Ariane-5 launchers. This is up from 11 launches in 1995, placing 13 satellites successfully in orbit. The first Ariane-5 launch is scheduled for May. The new rocket has been designed to carry single satellite payloads of 6.8 tons and double payloads with a total weight of 5.9 tons.

Eutelsat has signed a contract with Arianespace for the launch of three new television and telecommunications satellites. The digital TV satellite Hot Bird 4 will be placed alongside Eutelsat II-F1 and Hot Bird 1 and the upcoming 2 and 3 at 13 degrees East. The other two satellites, for telecommunications, are known as W24, and will replace two existing Eutelsat II satellites at other orbital positions. They will be launched from French Guiana, beginning in mid-1997.

Nordic News

All of the Scandinavian D2-MAC channels from the Kinnevik media empire on Sirius have now encrypted. Here is the channel plan:

TV3 11.785 Ghz TV6 12.015 GHz ZTV 11.862 GHz ??? 12.092 GHz

Kinnevik's second TV1000 channel, TV1000 Cinema, has begun broadcasts on TV-Sat 2 on 11.900 GHz. This satellite has been leased by the Norwegians and placed alongside Thor and Intelsat 702 at 1 degree West. But the German cast-off experienced problems on November 6, when the aging satellite lost two of its

Hughes Space and Communications International has contracted with McDonnell Douglas to launch Norway's Thor 2A satellite. It will launch aboard a Delta II rocket from Cape Canaveral in early 1997. Thor 2A will be a high-power version of Hughes's HS 376 satellite.

transponders. The Danish version of Kinnevik's TV6 vanished, along with the private Norwegian station TV Plus. They've since been relocated. TV Plus is now on the hithertoo unused 12.054 GHz on TV-Sat, while TV6 Denmark has replaced SVT 1 on Intelsat 702 at the same location, on 11.679 GHz.

Kinnevik will be starting its new Sports Channel on March 1st, from Intelsat 702. While the intention is that cable companies will include the channel in their basic tier, it will be encoded on the satellite, to keep viewers from outside the Nordic region from watching.

Kinnevik's rival FilmNet has renamed its two film channels. Instead of the cumbersome FilmNet Plus and FilmNet: The Complete Movie Channel, they are now simply known as FilmNet 1 and FilmNet 2.

Hughes Space and Communications International has contracted with McDonnell Douglas to launch Norway's Thor 2A satellite. It will launch aboard a Delta II rocket from Cape Canaveral in early 1997. Thor 2A will be a high-power version of Hughes's HS 376 satellite, delivering direct-to-home television to the Nordic countries via fifteen 40 watt transponders in the Ku-band. Like Sweden's rival Sirius 2 satellite, Thor 2 will be launched in 1997.

Budget cutbacks at Swedish Television, the country's public service broadcaster, have resulted in a re-organization, including the revival of old plans for a pay-TV cable channel. The channel is to be called Dacapo, and programming would be classics from Swedish Television's extensive archives. Dacapo would begin operation in September, on the 40th anniversary of the first regular TV broadcasts in Sweden.

The head of Swedish Television, Sam Nilsson, has also revealed that they have been talking with the private TV 4, about a joint satellite project, to better compete with the international media empires.

Into Africa

Digital Music Express has launched a service to South Africa on December 1 called DMX(R). Multichoice, owners of Europe's FilmNet and Nethold, which recently introduced the DStv MPEG-2 digital direct-to-home TV service to southern Africa, is offering subscribers 40 channels of DMX as part of its basic package. DStv and DMX are reaching subscribers in southern Africa via the PAS-4 satellite. Multichoice has also reached aggreements to distribute CNN International, ESPN Africa, VH-1, TNT/Cartoon Network, and the Discovery Channel to southern Africa.

BET International will launch BET On Jazz: The Cable Jazz Channel as part of the Multichoice package through-out southern Africa starting April 1, 1996, via the satellite PAS-4. The channel launches in the US on January 15, 1996.

Egypt has signed an agreement with a French consortium led by Matra Marconi Espace to build and launch Egypt's first satellite. NileSat will begin operating in mid-1997, and is supposed to cover the Arab world, the Americas, and Asia. That seems a bit exaggerated, as there's hardly a single position in the Clarke Belt that permits that kind of coverage.

The new satellite will offer 16 channels of sports, movies, children's and cultural programs.

Egypt currently has two channels on Eutelsat II-F3 at 16 degrees East. The all-Arabic language Egyptian Space Channel puts a powerful signal into northern Europe where there are unlikely to be many viewers, while Nile TV, which carries programs about Egypt in English and French, uses a weak half transponder, and is barely visible.

Digital Broadcasting Arrives in Asia

While Rupert Murdoch has been slow getting into digital television in Europe, his Star-TV is getting ready to take the digital plunge to Asia, following the successful launch of Asiasat-2 on November 30. The first test signals from Asiasat-2 were sighted by Kim Slyns — who reported his discovery to the Internet TVROSAT mailing list — on December 18, with the text: "Welcome to Asiasat 2 Merry Christmas and Happy New Year". The position was some degrees West of Asiasat-1, with a very strong signal on 3860 MHz.

The new satellite carries 24 C-band transponders and 9 Ku-band band transponders, and will be Asia's first digital broadcast satellite. The launch was delayed nine months, following China's failure to launch the Apstar-2 satellite in January, 1995.

According to Murdoch himself, Star's new offerings via Asiasat-2 include movie channels in Mandarin, Hindi, English, Indonesian, Tagalog, Cantonese and Japanese. Besides movies, Murdoch wants Star to dominate the markets for sports, general entertainment, music and youth programming.

Addressing the News Corp annual meeting, in Adelaide, Australia, Rupert Murdoch said Star-TV would experience "great growth" during the next 12 months, noting that the Hong Kong-based broadcaster would launch a package of 15 movie channels into Indonesia in six months, while working on its first venture into Japan. The Japanese venture is expected to start in April, and comes after Japan's Post and Telecommunications Ministry decided to allow international broadcasting via satellite.

Other broadcasters booked on Asiasat-2 include the Associated Press's APTV, Reuters Financial Television, Worldwide Television News, Hong Kong Telecom, Portugal's Marconi Global Communications, Malaysia's Time Telecommunications, and Germany's Deutsche Welle.

Included in the Deutsche Welle package is the World Radio Network, which will be offering a digtal version of its WRN Network 1 package of English language broadcasters to Asia. When I asked WRN's Karl Miosga if the choice of digital transmission (forced upon by Deutsche Welle's choice for digital) rather than analog might not cost them listeners his reply was "MPEG-2 will be the new satellite standard to Asia, and we expect digital receivers to become common there soon."

Besides Telecom, the December 7 Ariane launch also carried India's Insat 2C satellite into orbit. It is co-located with Insat 2B at 93.5 degrees East. Insat 2C is equipped with 17 C-band transponders, as well as 6 wide C-band, 3 Ku-band, and one in the S-band.

PanAmSat has added Bloomberg Information Television to the line-up on the PAS-2 Pacific Ocean Region satellite. Bloomberg's service consists of one digital channel on PAS-2's Pacific Rim

Viewers in the United States will soon be able to watch India's state-owned television network Doordarshan, via Panamsat. Doordarshan's signals will be relayed via the PAS-4 Indian Ocean satellite to a British Telecom station near London, and then transmitted via PAS-1 to the United States.

Beam. In early January a new station called Channel KTV also joined PAS-2. This is a Singapore- based service, offering sing-a-long programs for Karaoke enthusiasts. It's billed as the world's first station offering voice-optional music videos, and also features two separate language feeds, in Mandarin and Cantonese.

Besides Bloomberg and KTV, other broadcasters on PAS-2 now include ABS-CBN, Asia Business News, China Central Television, Disney, Discovery, ESPN, Liberty, NBC, NHK, Television Corporation of Singapore, Turner Broadcasting, TVBI, and Viacom. PAS-2 now transmits more than 40 analog and digital TV channels through-out the Asian-Pacific region.

The Gals 2 satellite was successfully launched from Kazakhstan on November 17th. Russian built and Chinese-owned, Gals 2 will be leased for $9 million a year to the Global DBS Company, which includes the Loral Corp., General Instruments, and TCI from the United States, and Britain's General Telecommunciations Ltd/ Asian TV Network. Gals carries 3 high-powered transponders. Gals 1 is located at 71 degrees East. Gals 2 could be located at any of the 17 slots reserved for Gals at the International Telecommunications Union (ITU).

Asia Comes to the West

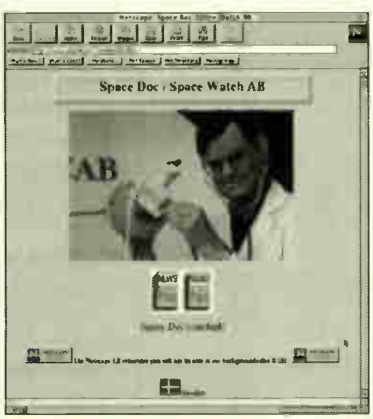
There's a new Indian broadcaster seeking to establish a global presence. Apna-TV is actually based in London, but it broadcasts Hindi-language films for South Asians around the world. The European service is using Russia's Statsionar 11 satellite at 11 degrees West, on its Ku-band transponder on 11.525 GHz, as well as the nearby Ekspress 2 satellite at 14 degrees West, on C-band 3.825 GHz. The channel's test pattern also says it is relayed over the Russian Ekran satellite at 90 degrees East to South Asia, using the L-band.

Viewers in the United States will soon be able to watch India's state-owned television network Doordarshan, via Panamsat. Doordarshan's signals will be relayed via the PAS-4 Indian Ocean satellite to a British Telecom station near London, and then transmitted via PAS-1 to the United States.

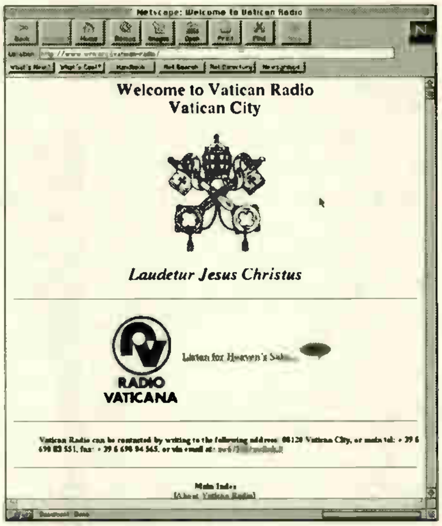
Thai TV is reported to be beginning broadcasts to Europe from Eutelsat 2F3 at 11.163 GHz.

CyberSatellite News

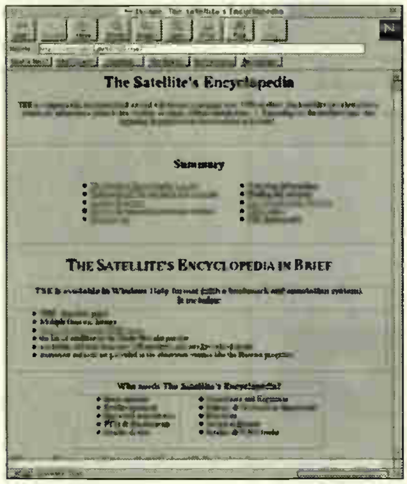
Sweden's "Space Doctor", Bertil Sundberg, has stopped writing his excellent column of satellite news for the magazine *Paa TV*, finding it hard to get along with the top-down management style of Kinnevik's Jan Stenbeck, who wants to be Scandinavia's answer to Rupert Murdoch. Fortunately Bertil has now opened his own World Wide Website, at: **http://www.algonet.se/~rymdis/EW.htm**



Satco DX, in co-operation with *TeleSatellit*, has started an interactive frequency chart, "covering all satellite channels worldwide" (except that it currently lists only European satellites): **http://www.sat-city.com**



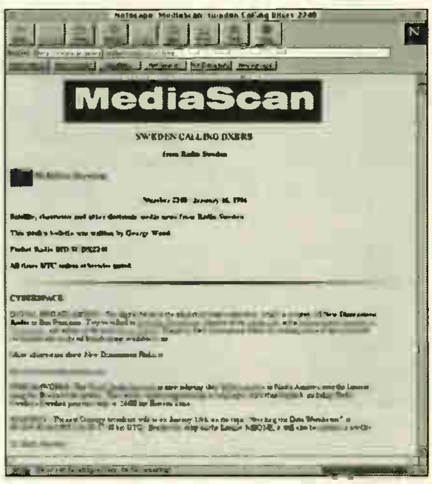
Now that WRN is relaying Vatican Radio, it's put together a WWW site for Vatican Radio at: **http://www.wrn.org/vatican-radio/**



A new version Jean-Philippe Donnio's *The Satellite's Encyclopedia* is available as shareware, and can be downloaded from: **http://www.tele-satellit.com/tse/**

That's it for this time. Thanks especially to Curt Swinehart, James Robinson, Nils Sundstrom and Frank Ostergren from the Stockholm newspaper *Aftonbladet*, and the good people at *Tele-satellit* and *What Satellite TV* for contributions. If you'd like to send an update (or a correction) my e-mail address is: **wood@rs.sr.se**

The latest MediaScan news is on the Radio Sweden Worldwide Web site at: **http://www.sr.se/rs/english/media/scdx.htm** ST



By *Steve Handler*

Buy The Numbers!

Lassie had Jeff. Rin Tin Tin had Rusty. Basil has money that could be yours.

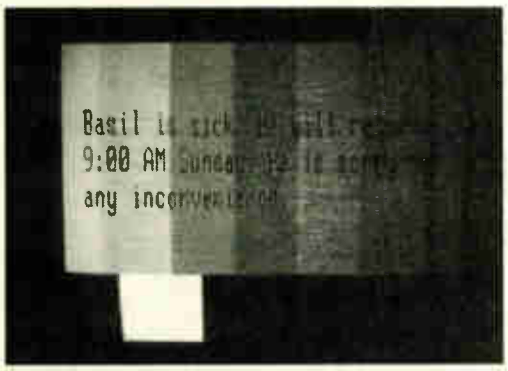
Basil is his name, and Bingo is his game. Airing 24 hours a day on SpaceNet 4, transponder 7, the Basil Basset Bingo ‡ Channel brings the C-band viewer the opportunity to play bingo in your own home for cash prizes.

Basil Basset, courtesy of 3B TV, Inc..

Tune in and you will be greeted by a computer generated animated dog named Basil. Using electronic puppeteering, Basil hosts over 280 Bingo games per day. The bingo balls are also created by computer generated graphics. Every ten seconds during the bingo game a colored ring appears on screen. It catches a numbered bingo ball which is followed by Basil's voice announcement of each bingo ball's number, giving the broadcast the flavor of a bingo hall. If the pattern of matching numbers on your bingo card matches the red pattern that is displayed in the upper left portion of the TV screen, you call a special number (800) 474-1027. The first person to reach them, who has the correct numbered pattern on their activated bingo card, wins that games prize.

Launched last September, Basil is one of the first ventures into a new form of computer animation. The animation is created by 3B TV, Inc., a subsidiary of American Satellite Network (the parent company of Prime Time 24), Mr Film Studios Inc., and Spelsinne of Sweden, a computer software programming company.

Mr. Film Studios, Inc.— a computer graphics studio specializing in real time animation, utilizes state of the art motion capture technology to create the animated Basil in real time. Two actors are used in the production of Basil. The voice actor wears a special headset with four infrared cameras that read the facial muscle movements and expressions of the voice actor. The computer then translates his movement into the realtime animation of Basil's facial expressions. The movement of the physical actor in a magnetic body suit is used by the computer to create Basil's body movement. Nothing less than cutting edge animation technology is used to create Basil for the TV screen.



Sometimes Basil is Sick, and after a short rest he should be back. After all, a little maintenance never hurts. (Photo by Steve Handler)

No purchase is necessary to play, but you can purchase bingo cards from the outset. By sending a self-addressed stamped #10 envelope, and a paper with your name, address, telephone number and age, a free official bingo card for one day's play will be sent to the viewer. Your self-addressed envelope will bring you a numbered Bingo card along with a letter indicating what day the bingo card will be valid.

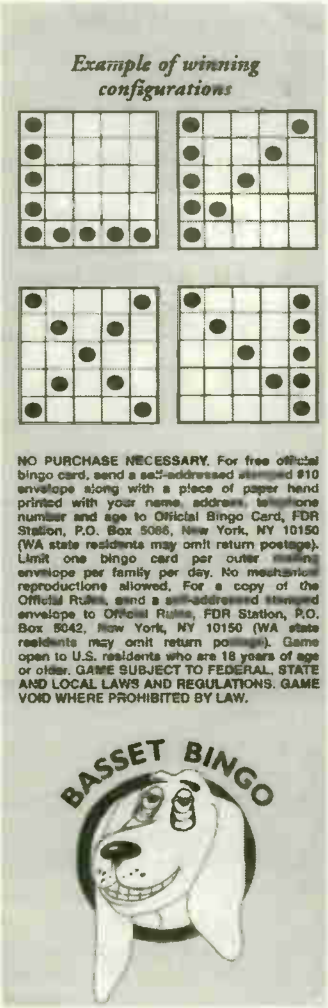
That's the catch, your card will be valid for only one day, and only that specific day assigned to you by 3B TV, Inc. They also offer another option once you have your free Bingo card. After your free day has expired, you can call their "EZ" Activation 800 phone number and for a processing fee, reactivate your bingo card. The amount I was quoted was $2 for one day, $10 for a week, and $25 for a month. However, rather than paying a fee, you can still send for more free Bingo cards. Their rules noted that there is a limit of one bingo card per outer mailing envelope. per family. per day. To get a copy of their current rules as well as the address to mail your request for a free card, contact 3B TV, Inc. at (800) 474-1043.

Where are they headed with all this technology? With over 250,000 bingo cards sent out, there appears to be an audience interested in playing bingo in their home via television. One might speculate that the C-band broadcasts are a shakedown cruise for the technology. Perhaps DBS and cable might be in Basil's future. If so, the C-band market of 3 million plus viewers could be a gateway to the cable and DBS markets with viewers a dozen times larger.

For those of you who enjoy lotteries, satellite TV also provides a smorgasbord of viewing. State lotteries use satellite to get the broadcast of the lottery drawing from their studio to television stations throughout the state. Participating stations typically receive a broadcast schedule from the state lottery of the times of these satellite broadcasts. They can schedule the broadcast to be included live within their programming or taped for use on their news programs.

POWERBALL ® is one of the largest U.S. lotteries, and is regularly aired via satellite. Run by the Multi-State Lottery Associa-

To dissuade anyone from even thinking of tampering with the ball sets, they are randomly sent to the Iowa Department of Transportation's weights and measures lab to make sure that each ball is within the weight and size parameter of its original manufacture and design.



Basel Basset Bingo Card, coutesy of 3B TV, Inc.

tion, *POWERBALL* tickets can be purchased in 20 states as well as the District of Columbia. Several smaller states got together in 1988 and started a lottery game called *Lotto America.* The states, each of which does not have a large population base, wanted to be able to offer their residents a chance at a bigger jackpot. In April of 1992, *Lotto America* became *POWERBALL.* As time has gone on, forty percent of all of the U.S. states have joined in *POWERBALL.*

The program is produced at the studios of the Iowa Teleproduction Center, a multimillion dollar film and video production facility located in West Des Moines, Iowa. *POWERBALL* is broadcast live at 10:59 p.m. each Wednesday and Saturday night and is repeated from digital storage disks at 11:00 p.m. and 11:01 p.m. Wednesday night's broadcast is via Galaxy 4, channel 12 and Saturday night's broadcast is aired via AT&T Telstar T-401 channel 3.

The game consists of two machines. In the first machine are 45 solid white rubber balls numbered 1 through 45. In the second machine are 45 solid red rubber balls numbered 1 through 45. When activated, the first machine selects five white balls and the second machine (the *POWERBALL* machine) selects one red ball. Any person who has purchased a ticket with the number chosen by the *POWERBALL* machine wins a prize. There are nine levels of winning and ticket purchasers that match the *POWERBALL* and all five white balls win the grand prize of at least $5,000,000 (paid out over 20 years).

What's the most you can win? The record goes to a Wisconsin couple (he's a teacher and she's a nurse) won $111,000,000 paid out over 20 years.

POWERBALL leaves nothing to chance. Redundancy and security are the hallmarks of the TV production. The solid rubber balls are manufactured especially for lotteries. Each *POWERBALL* production is attended by Sue E. Dooley the drawing manager for the Multi-State Lottery Association, a representative of their CPA auditing firm (currently Ernst and Young), and a senior security official. Other security precautions are taken,

Powerball Lottery in Progress (Photo courtesy Multi-State Lottery Association)

including guards and other security officials attending the drawing.

Two studios are available at the production facility, so that if one has a problem the other can be used. The signal is sent from the studio to the uplink facility by fiber optic line, with a microwave backup. Four lotto machines are available, of which two are randomly chosen by coin flip before each broadcast. Four ball sets are available in each color, of which one set of each color is randomly chosen for each broadcast. In addition, when not in use for a broadcast, the lotto equipment, balls, and drawing machines are kept in a sealed vault that requires two keys in the possession of two different people. A sophisticated alarm system keeps a vigilant watch on the vault and its contents.

To dissuade anyone from even thinking of tampering with the ball sets, they are randomly sent to the Iowa Department of Transportation's weights and measures lab to make sure that each ball is within the weight and size parameter of its original manufacture and design. Before being put back in use, security officials have each ball X-rayed at a medical lab to make sure that no foreign object has been inserted into the ball.

The Iowa Teleproduction Center is connected to the Iowa Communications Network, a modern fiber optic system. This system links the production facility studios with WOI, an ABC television affiliate in Ames, Iowa. At WOI, the *POWERBALL* broadcast is uplinked by C-band satellite. C-band is used rather than Ku-band so as to avoid possible signal problems due to rain fade. The C-band uplink facility is fully redundant, like all other aspects of *POWERBALL.*

POWER BALL

The satellites and channels used to broadcast the lotteries are subject to change and you may have to search around to find your favorite lottery. In the past, AT&T Telstar T302 has seen a substantial amount of use for lottery broadcasts.

Uplink sight for the Texas Lottery, the Texas Gateway Teleport at Cedar Hill, Texas (Photo courtesy Southwest MicroNet, Inc.)

TABLE 1: Lotteries on the Air

Lotto Game	Day of Week	Time (EST)	Satellite, Transpon.
California Big Spin	Wed./Sat.	1:55 a.m.	G4, 9 or 11
California Super Lotto	Wed./Sat.	10:56 p.m.	G4, 9
Colorado Lottery	Daily	11:59 p.m.	SBS 6 Ku, 12
Florida Cash 3	Daily	7:55 p.m.	T302, 3 or 8
Florida	Saturday	11:00 p.m.	T302, 4
Georgia Cash 3	Daily	6:58 p.m.	T302,. 23
Georgia Lottery	Tues./Fri./Sat.	10:55 p.m.	T302, 3,11, or 23
Hoosier Millionaire (Ind.)	Saturday	10:56 p.m.	T302, 8
Indiana Daily Game	Daily	10:58 p.m.	T302 and G6
Iowa Lotto	Daily (Except Sun.)	7:27 p.m.	T401, 3 or 6
Kansas Cash Lotto	Wed./Sat.	7:58 p.m.	T302, 13
Louisiana Lotto	Daily	10:59 p.m.	T302, 24
Minnesota Daily 3	Daily	7:50 p.m.	G4, 18
Missouri Pick 3	Daily (Except Sun.)	7:55 p.m.	T401,.3 or 5
New Hampshire Lotto	Friday	9:58 p.m.	SBS 5 Ku, 13
New York State Lotto	Daily		S3 Ku, 22
Ohio Lottery	Daily (Except Sun.)	6:59 p.m.	T302, 13
Oregon Lotto			S3 Ku, 23
POWERBALL	Wednesday	10:59 p.m.	G4, 3
POWERBALL	Saturday	10:59 p.m.	T401, 3
Texas Lotto	Daily (Except Sun.)	10:50 p.m.	G4, 7 and G4 Ku, 1
Tri-State Lottery			SBS 5 Ku, 12
Washington Lotto	Wed./Sat.	9:59 p.m.	T303, 23

TABLE 2: POWERBALL Participating States

Arizona	Minnesota
Connecticut	Missouri
District of Columbia	Montana
Delaware	Nebraska
Georgia	New Hampshire
Idaho	Oregon
Indiana	Rhode Island
Iowa	South Dakota
KansasKentucky	Wisconsin
Louisiana	West Virginia

Several times a year the *POWERBALL* broadcast goes on the road, originating from one of the participating jurisdictions' facilities. In 1995 live remotes of drawings took place in Atlanta, Louisville and Phoenix.

Over a dozen other state lotteries use satellite to distribute their drawing broadcasts to local TV stations within their states. A list is included within this column.

The satellites and channels used to broadcast the lotteries are subject to change and you may have to search around to find your favorite lottery. In the past, AT&T Telstar T302 has seen a substantial amount of use for lottery broadcasts. As T302 continues in its inclined orbit, many of the lotteries may decide to shift their broadcasts to other satellites. This would avoid the necessity of receiving stations having to use tracking software to receive high quality T302 broadcasts. Perhaps AT&T's Telstar T402R may pick up some of these broadcasts along with T401 and Galaxy 4.

What does the future hold for Basil? Will he expand to DBS, to Cable? Will kids watching their parents playing bingo find Basil irresistible and will he become a new hit doll, perhaps as popular as the Cabbage Patch kids? Will *POWERBALL* continue to expand and add states? If they run out of states will they expand to foreign countries or will congress come to their aid by adding more states? If *POWERBALL* expands to foreign countries will they have to change their name to the *International Lottery Association*?

Who knows what the future holds? It takes more than luck to find out what's *On The Air*.

All times in this column are eastern standard time (EST). The inclusion of information regarding legalized gambling is not and should not be considered an endorsement of gambling by the author, Grove Enterprises, or *Satellite Times* magazine. ST

HOOSIER LOTTERY®

LISTENING POST

By Keith Stein

us011192@pop3.interramp.com

Listening to the Amateurs

A good friend of mine here in the Washington D.C. area is in a career probably a lot of us hobbyist would love to hold. He's an a aerospace engineer who builds and launches satellites. With a 4-year bachelors degree in aerospace, electric, or mechanical engineering you could also move into the same career pattern. But are all these college degrees and educational courses really needed to work in this field? Of course it helps, but it is not required for one volunteer organization also based in the Washington D.C area.

If you really want a good start in aerospace engineering, volunteering to work with the Amateur Radio Satellite Corporation (AMSAT), who has built and operates several satellites in earth orbit. Let's take a closer look at their satellites that operate in the VHF spectrum.

As we continue our tour through the satellite frequency spectrum, we now exam the 145.8-146.0 MHz band, known as the 2-meter amateur satellite band. Sure this portion of the spectrum has been covered over and over again by various other space publications, but you'd be surprised how many times I see Internet messages and e-mail from individuals who are looking for the basic information on the birds that inhabit this region of the VHF spectrum.

AMSAT consists of a group of amateur radio operators who share an active interest in building, launching and then communicating with each other through non-commercial, amateur radio or ham satellites. Since its founding, nearly 25 years ago, AMSAT's volunteer labor force has designed, constructed and successfully launched, almost 30 amateur radio communications satellites into Earth orbit. AMSAT satellites carry the name OSCAR qhich stands for Orbiting Satellite Carrying Amateur Radio. These satellites are built, quite literally, in people's garages and basements.

Of course there is always more to research and learn about these amateur space birds. I'm only going to touch on the amateur satellites that are easy to hear and decode activity from. For more details and additional frequencies for other amateur satellites, be sure to check-out *ST's Satellite Services Guide*— Amateur Satellite Frequency Guide section, and John Magliacane's (KD2BD) Amateur Radio Satellite column.

UoSat 2

Built in less than six months by students at England's University of Surrey, this amateur satellite is similar mechanically and in appearance to UoSat 1, the first satellite in the series. Its primary mission is to store-and-forward digital communications. With a low altitude orbit, both ground stations and the satellite transmitter can use low power.

This 59.4 kg (132-lbs) spacecraft was launched in March 1984 from California as a secondary payload aboard the Landsat 5 mission. Here are the downlink frequencies:

Downlink frequencies: 145.826, 435.025, and 2401.5 MHz

Digital Orbiting Voice Encoder (DOVE)

In 1990, AMSAT and Surrey turned their attention to some foreign spacecrafts. The two organizations built six small amateur radio satellites for a free ride to space aboard a European booster called Ariane. One of the six satellites was called Dove-OSCAR-17 (or DO-17), also called known as Peacetalker — a microsat for Brazil.

Weighing under 11.25 kg (25-lbs). each, all six satellites were launched from the Guiana Space Center in Kourou, French Guiana, South America. With the ability to be heard from anywhere on earth, along with its other five partners, Dove has had the largest listening audience among radio hobbyists . Out of all the amateur satellites currently in orbit, it's 2-meter signal is the easiest to monitor.

With a voice synthesizer attached to its transmitter, Dove was the first amateur satellite to talk from Earth orbit. The system transmits voice for 2.5 minutes, then waits 30 seconds for commands from ground stations.

Downlink frequencies: 145.825 and 2401.220 MHz

Russian MIR Space Station

The former Soviet Union was the first country to put a satellite in space, launch a man in space, launch a women in space, conduct the first manned walk in space, and launch the first space station.

But they haven't been first in everything. They were the second country to launch amateur radio satellites into space.

On the MIR space station it all started in 1988 when Vladimir Titov made several contacts with amateurs on the ground using the callsign U1MIR. This practice has continued since then, and it can lead to some of the most interesting voice transmissions from space to monitor, but patience is the name of the game.

Most of the time a packet radio terminal node controller (TNC) and a lap top computer are running in unattended mode on the stations amateur radio downlink. This is during the times when the crew is busy working on experiments. You can still connect with this robot and leave personnel electronic messages to the crew.

I still remember the days when my brother and I would go outside our house with a hand-held scanner waiting to possibly pick up on some voice from Mir as we watch it in the night sky. But we never did and you know why? Hey, these guys have to sleep sometime. A normal day aboard the MIR begins around midnight eastern time (0500 UTC) and ends at 3:00 p.m. eastern time (2000 UTC). Thats why we've never heard them in the early evening, but the packet signal is there all the time.

Plug in these frequencies and give it a try. And oh yes, they do speak pretty good English so you should have no trouble understanding them during North America passes:

Downlink frequencies: 145.550 and 145.800 MHz

U.S. Space Shuttle

Our U.S. astronauts began their amateur radio operations in 1983 on mission STS-9 when Dr. Owen Garriot, W5LFL operated from the Columbia. This first ham in space mission made 250 contacts with amateurs in their homes, cars, and children in schools.

One disadvantage of amateur operations onboard the shuttle is the antenna is taped to one of the flight deck windows and is not permanently fixed. The Russians mounted an external antenna on the side of their station during a past spacewalk.

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With the outstanding success of Owen Garriot's flight, NASA saw these operation as a great public affairs event, so things have changed since that first flight. The majority of contacts are now scheduled with school classrooms, astronaut families or with the crew aboard Mir. The days of random contacts are almost gone.

The next time there is a shuttle amateur radio experiment (SAREX) on board the shuttle, it would be well worth the effort to tune into the following frequencies: 145.550 and 145.840 MHz

Spartan Packet Radio Experiment (SPRE)

The Spartan Packet Radio Experiment (SPRE) was an amateur radio communications experiment on board NASA's Office of Aeronautics and Space Technology (OAST) satellite. The OAST satellite conducted carried four experiments designed to enable or extend space flight technology including SPRE. Developed and built by the University of Maryland Amateur Radio Association (UMARA), SPRE's mission was to test satellite tracking using amateur packet radio and the Global Positioning System (GPS).

The spacecraft was launch on January 11, 1996 onboard the space shuttle Endeavour as part of mission STS-72. A few days after launch the OAST/Spartan vehicle was deployed by the shuttle's robot arm for 48 hours and then retrieved back into the cargo payload.

SPRE was designed to relay ground station positions and transmit telemetry containing the GPS location of the spacecraft and housekeeping data. Data was transmitted on a downlink frequency of 145.55 MHz. The data format consisted of ASCII characters and was fully compatible with amateur packet radio equipment in common use today.

David Breadsley of Lutz, Florida copied the following data from SPRE on January 15, 1996 between 0636 and 0645 UTC:

SER TIME	L-Temp deg C	BoxTemp deg C	H-Temp deg C	X-Temp deg C	12v-PS Volts
16:26:27	8.78999	23.145	23.14	31.56	12.13
16:26:57	8.78999	23.145	23.14	32.05	12.13
16:27:27	8.78999	23.145	23.14	31.06	12.13
16:28:27	8.78999	23.145	23.14	31.56	12.13
16:28:57	8.78999	23.145	23.14	31.56	12.13
16:29:27	8.78999	23.145	23.14	33.04	12.13

Mir VHF News

According to documents obtained from NASA's Goddard Space Flight Center, future visits by U.S. astronauts aboard the Russian Mir space station will operate with voice and data downlink transmissions on 143.625 MHz, and 139.208 MHz over North America.

New voice modulation units installed at NASA's Wallops Flight Facility in Virginia and the Dryden Flight Research Center in California will support two-way communications with the Mir complex on an as-needed basis, Monday through Friday, when the crew is awake.

Radio hobbyist in North America have not heard much on these frequencies since 1991 when Russia decommissioned all their tracking ships that also used the VHF high band spectrum.

Satellite Listening Post Intercepts

Abbreviations used in this column:
ARIA—Advanced Range Instrumentation Aircraft; CNN—Cable News Network; G—Gigahertz; K—Kilohertz; SOHO—Solar Heliospheric Observatory; USB—Upper Side Band; UTC—Coordinated Universal Time; W—West

All times in UTC. All voice transmissions in English unless otherwise noted.

K6889 Aria Control, Abnormal20, and Tel4 working Aria1 and Aria2 during tracking support toward the SOHO satellite launch on 12/02/95 at 0702, USB. SOHO was successfully launch at 0808. Also heard on 5145.5, and 5837 First time I've heard these guys, great stuff.(Keith Stein-Woodbridge, VA)

K10780 Cape Radio-Cape Canaveral, FL, working ARIA2 for Galaxy III-R launch on the ETR, weak. Ascension Radio began working ARIA 1 and had both aircraft loud and clear. Also heard Aria Control at 0211 (Tim Dobbins-FL)

K11175 NASA931 was heard conducted a radio check with MacDill AFB, USB, at 2027. MacDill reported weak but readable (Mike Fink-Florida) All NASA callsigns starting with a 9 are usually a T-38 flown by an astronaut-Keith

K11414 Aria Control, Tel4 and Cape Radio working Aria1 and Aria2 during tracking support toward the Galaxy III-R satellite launch on 12/14/95 at 2340, USB. Launch occurred at 0023, 12/15/95. They started out on K10780 but switched to this freq to conduct operations (Stein-VA)

K15560 Ascension Radio working ARIA1 at 0821, USB, for tracking support toward the Koreasat 2 satellite launch on 01/14/96. They started out on 10780, but switched to 14432, 14819, and then lost them here. Launched occurred at 1110. (Stein-VA)

K29408 Russian navigation/amateur radio satellite Cosmos 2123 was transmitting CW and voice at 0144, USB mode. Frequencies being used were K29408;CW, K29450;Voice, and K29454 CW First time I've ever heard voice on this one. (Stein-VA)

M126.650 NASA944 (Gulfstream G-1159) was heard at 0345, AM mode, reporting on weather conditions for space shuttle mission STS-72 landing at Kennedy Space Center, FL (David Breadlsey-Lutz, FL)

M137.620 U.S. weather satellite NOAA 14 heard at 0605, NFM (Stein-VA)

M145.550 Amateur radio operator Phil Chien (KC4YER) made a voice contact with Russian flight engineer Sergei Avdeev aboard the Mir space station at 0845, NFM. (Phil Chien-FL)

M145.800 A special Christmas message was transmitted to earth by the three man crew aboard the Russian space station Mir at 0234, NFM. Here is a transcript portion of that message;German Cosmonaut Thomas Reiter "All on earth, we are celebrating Christmas Eve today here in earth orbit and we wish you all a Merry Christmas, peaceful and Happy New Year. I will handover now to Yuri who will also direct some words to you." Yuri spoke in Russian but here is a english translation "Dear people of the Earth, the crew of the MIR orbital station greets you and sends you the best Christmas wishes. Let the teachings of Christ be always present in our life. Our best wishes of health, love and happiness to you. Peace to you and your families." Thomas Reiter added "All the best to you once again, Merry Christmas, 73 and bye bye." (Stein-VA)

M146.835 Washington D.C. Area Amsat Information Net was heard at 0200 in NFM with WD8LAQ (Pat) as Net Control (Stein-VA)

M149.940 Russian military navigation satellite Cosmos 2279 heard at 2210, NFM. Also transmits on M399.840 (Stein-VA).

M150.000 Russian civilian navigation satellite Tsikada was heard at 0656, NFM (Stein-VA)

M150.030 Russian military navigation satellite Cosmos 2233 was heard at 0826, NFM. Also transmits dead carrier on M400.075 This is the unidentified satellite reported in the Nov/Dec issue of *ST*. (Stein-VA).

G3.860 The first test signals from Asiasat 2 were observed with a test pattern reading "Welcome to Asiasat 2, Merry Christmas and Happy New Year". Disappeared the next morning at 01:15 (Kim Slyns-Western Australia) Nice job Kim, only 20 days after its launch-Keith.

G4.000 Anik E2 (107.3 deg W) transponder 15 provides BBC World TV audio broadcast from 1400-1430, part of BBC World "News Hour" (Ken Reitz KC4GQA-Virginia).

G3.980 The Eagle Radio Network is now a 24 hour a day service on Galaxy 6, (74.1 deg. W) transponder 14. In addition to their evening and early morning talk shows, they are now running a very nice music service during the day. There are no commercials, and the music is from the 60's to the 90's. The music service ends around 2200. (Gary Bourgois, WB8EOH-Michigan)

G11.8850 Very weak signal was viewed on Orion 1 (37.8 deg. W) at 0000. Could not make out what the subject was (Keith Knipschild-New York)

G11.9630 A "live" CNN news feed from Bosnia was viewed on Orion 1 (37.8 deg. W) at the top of each hour and half hour. (Knipschild-NY)

G12.1670 CNN International was found on Telstar 401 (97 deg W), transponder 16, H, at 2000 (Knipschild-NY)

G12.6640 Chinese Channel KDBS TV was broadcasting feeds in the clear on Orion 1 (37.8 deg. w), transponder 3, vertical polarity. Mostly news programming ending at 1955. Following this was mixed graphic/color bar test card for KDBS Frankfurt prior to transponder going down (John Hockenhull-UK).

Are you receiving the Satellite Listening Post e-mail bulletins? Send a request to Keith Stein and be added to the distribution list: us011192@pop3.interramp.com ST

INTRODUCTION

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

How to Use the Satellite Service Guide

The various sections of the SSG include:

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

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

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

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

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

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

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

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

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

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

Satellite Radio Guide

By Robert Smathers and Larry Van Horn

AUDIO SUBCARRIERS

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

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

Classical Music

Classical music	E2, 22	6.30
KUCV-FM (90.9) Lincoln, Neb. (Nebraska Public Radio)	S3, 2/4	5.76/5.94 (DS)
SuperAudio — Classical Collections	G5, 21	6.30/6.48 (DS)
WFMT-FM (98.7) Chicago, Ill.	G5, 7	6.30/6.48 (DS)
WQXR-FM (96.3) New York, N.Y., ID-*96.3 FM*	C4, 15	6.30/6.48 (DS)

Satellite Computer Services

Planet Connect, Planet Systems, Inc 19.2 kbps srvc.	G4, 6	7.398
Planet Connect, Planet Systems, Inc 100 kbps srvc.	G1, 9	7.80
Skylink, Planet Systems, Inc	G1, 9	7.265
	G1, 14	7.265
	G4, 6	7.264
Storyvision	G5, 3	7.30
Superguide	G5, 7	5.48

Contemporary Music

Safeway In-Store Radio — contemporary	S3, 18	5.78, 5.96, 6.48
SuperAudio — *Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
WVTY-FM (96.1) Pittsburgh, Pa.	C1,18	7.28
	G7,20	7.28

Country Music

CINC-FM (96.3) Thompson, Manitoba	E1, 2	6.40
Safeway In-Store Radio — country	S3, 18	6.12
SuperAudio — *American Country Favorites*	G5, 21	5.04/7.74 (DS)
Transtar III radio network	S3, 9	5.76/5.94 (DS)
WOKI-FM (100.3) Oak Ridge-Knoxville, Tenn., ID-*The Hit Kicker*	E2, 18	6.20
WSM-AM (650) Nashville, Tenn.	G5, 18	7.38, 7.56
WSM-FM (95.5) Nashville, Tenn.	C4, 24	7.38, 7.56

Easy Listening Music

Easy listening music, unidentified station	G4, 6	7.69
Safeway In-Store Radio — easy listening	S3, 18	6.32, 7.22, 7.40
SuperAudio — *Soft Sounds*	G5, 21	5.58/5.76 (DS)
United Video — easy listening	C4, 8	5.895 (N)

Foreign Language Programming

CBC Radio-East (French)	E1, 20	5.38/5.58 (DS)
	E1, 20	7.36
CHIN-AM/FM (1540/100.7) Toronto, Ontario Canada, ID-*CHIN* — multilingual	E1, 2	7.89
CITE-FM (107.3) Montreal, Quebec Canada (French) — soft adult contemporary	E1, 21(Ku-band)	6.12, 6.20
CKAC-AM (730) Montreal, Quebec Canada (French) — adult contemporary	E1, 21(Ku-band)	6.43, 6.55
Cosmos FM, Hellenic Public Radio, New York, N.Y. (Greek)	S2, 11	8.30
DZMM-Radyo Patrol (from Philippines)	G4, 24 (Ku-band)	6.80
French language audio service	E1, 15	6.12
India ethnic radio	E1, 2	7.61
Indian Sangeet Sager	E1, 16(Ku-band)	6.12
Irish music (Sat 1430-0000 UTC)	S3, 3	6.20
Northern Native Radio (Ethnic)	E2, 26 (Ku-band)	6.43/6.53 (DS)
RAI Satelradio (Italian)	C1, 15	7.38
Radio Canada (French)	E1, 15	5.40/5.58 (DS), 5.76
Radio Dubai (Arabic)	G7, 10	7.48
Radio Energie	E2, 10(Ku-band)	6.12/6.30 (DS)
	E2,21 (Ku-band)	6.12/6.30 (DS)
Radio Maria (Italian-Religious programming)	G7, 10	5.80
Radio Sedeye Iran (Farsi)	S3, 15	6.20 (N)
Radio Tropical (Haitian Creole)	S2, 11	7.60
Religious music (unid language)	G7, 10	8.03
RTE-Italian Radio	T402R,18	5.80
Russian-American radio network	SBS5, 14 (Ku-band)	6.20
The Clanny Channel (Spanish) — Anti-Castro Cuban clandestine programming-occasional audio	S2, 4	5.80
The Weather Network-Canada (French)	E1, 9	5.94
Trinity Broadcasting radio service (Spanish) SAP — religious	G5, 3	5.96
WCMQ-FM (92.3) Hialeah, Fla. (Spanish), ID-*Mega 92* — contemporary hit radio	S2, 4	7.74, 7.92
WCRP-FM 88.1, Guyama, P.R. (Spanish) — religious	G4, 6	6.53
WLIR-AM (1300) Spring Valley, N.Y. (Ethnic)	S2, 1	7.60
WNTL-AM (1030) Indian Head, Md./Arab Network of America radio network (Arabic)	G6, 10	5.80
WNWK-FM (105.9) Newark, N.J.(Ethnic)	S2, 11	8.30
XEW-AM (900) Mexico City, Mexico (Spanish), ID-*LV de la America Latina*	M2, 8	6.80
XEW-FM (96.9) Mexico City, Mexico (Spanish), ID-*W-FM 96.9*	SD1, 7	7.38
XEWA-AM (540) Monterrey, Mexico (Spanish), ID-*Super Estelar* — contemporary music	M2, 8	7.38
XEX-AM (730) Mexico City, Mexico (Spanish), ID-*Frecuencia Libre*	M2, 14	6.80

Jazz Music

KLON-FM (88.1) Long Beach, Calif., ID-*Jazz-88*	G5, 2	5.58/5.76 (DS)
Superaudio — *New Age of Jazz*	G5, 21	7.38/7.56 (DS)
WQCD-FM (101.9) New York City, N.Y., ID-*CD 101.9, Cool FM*	C4, 6	6.20

News and Information Programming

Arkansas Radio Network	G4, 6	6.20
Business Radio Network	C4, 10	8.06 (N)
Cable Radio Network	C3, 23	7.24 (N)
CNN Headline News	G5, 22	7.58
CNN Radio News	S3, 9	5.62
	G5, 5	7.58
USA Radio Network — news, talk and information	S3, 13	5.01 (Ch 1), 5.20 (Ch 2)
WCBS-AM (880) New York, N.Y. — news	G7, 19	7.38
WCCO-AM (830) Minneapolis, Minn.	G6, 15	6.20
WGN-AM (720) Chicago, Ill./Interstate Radio Network (overnight) — talk	E1, 2	5.22

Religious Programming

Ambassasor Inspirational Radio	S3, 15	5.96, 6.48 (DS)
American Spirit Network/KYND-AM (1520) Houston, Tex. — Religious/variety (weekends)	S3, 24	7.40
Brother Staire Radio	G5, 6	6.48
CBN Radio Network/Standard News	G5, 11	6.12
	C3, 1	6.20
Heaven Radio Network	G1, 17	7.92
KILA-FM (90.5) Las Vegas, Nev.—SOS radio network	C4, 8	7.38/7.56 (DS)
Salem Radio Network	S3, 17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
WCIE-FM (91.1) Lakeland, Fla.	S2, 21	6.20,7.60
WHME-FM (103.1) South Bend, Ind, ID-*Harvest FM*	G4, 15	5.58/5.78
WROL-AM (950) Boston, Mass. (occasional Spanish)	S3, 3	6.20
Z-music — Christian rock	G1, 6	7.38/7.56

Rock Music

CHOZ-FM (94.7) St. John's, Newfoundland Canada, ID-*Oz FM*	E2, 20	5.76/5.96 (DS)
CILQ-FM (107.1) Toronto, Ontario Canada, ID-*Q-107*	E1, 2	5.76/5.94 (DS)
Safeway In-Store — oldies	S3, 18	5.20, 5.40, 7.58
Seltech Radio Syndicated service — classic rock	E1, 2	5.40/5.58 (DS)
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) — Oldies	G$,22	5.80

Satellite Radio Guide

Speciality Formats

Aries In Touch Reading Service	C5, 24	6.48
	C4,10	7.87
Colorado Talking Book Network	C1, 2	5.58
C-SPAN I ASAP (program schedule)	C3, 7	5.58
C-SPAN II ASAP (program schedule)	C4, 19	5.58
Georgia Radio Reading Service	T401, 14 (Ku)	5.76
Nebraska Talking Book Network	S3, 4	6.48
Starsound Gold Radio Network	S3, 24	5.80
SuperAudio — Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
The Weather Channel-USA — occasional audio	C3, 13	6.80
The Weather Channel-USA — classical music	C3, 13	7.78
Voice Print Reading Service	E1, 16	7.44 (N)
Yesterday USA — nostalgia radio	G5, 7	6.80
	T402R, 11	5.80

Talk Programming

Business Radio Network	E1,2	7.43
Eagle Radio Network	G6,14	7.56
For the People radio network — (Chuck Harder) talk and information	C1, 2	7.50
KTRT-AM (1270) Claremore, OK	T2, 2	5.60
Marinet Broadcasting	G6, 23	8.10
One on One Sports radio network — sports talk	E1, 2	7.51
Practical Radio Communications (audio distribution circuit)	T2, 2	7.90
Prime Sports Radio — sports talk and information	C1, 10	7.20
	S3, 24	7.78
Sun Radio Network — talk programs (backhauls)	C1, 15	7.58
Talk America — talk programs	S3, 9	6.80
Talk Radio Network — talk programs	C1, 5	5.80
Tech Talk Network	E2, 18	5.80
USA Patriot Radio Network	G6, 14	5.80
WWTN-FM (99.7) Manchester, TN — news and talk	G15,18	7.38,7.56

Variety Programming

American Urban Radio — news/features/sports	S3, 9	6.30/6.48 (DS)
CBC Radio (English)	E1, 16	5.40/7.58, 5.58
CBC Radio (occasional audio)	E1, 20	5.78
CBC-FM Atlantic (English)	E1, 16	6.12/6.30 (DS)
CBC-FM Eastern (English)	E1, 16	5.76/5.94 (DS)
CBM-AM (940) Montreal, Quebec Canada — variety/fine arts	E1, 20	6.12
CFR-FM	E2, 19 (Ku-band)	6.12/6.30
CJRT-FM (91.1) Toronto, Ontario Canada — fine arts/jazz-nights	E2, 26 (Ku-band)	5.76/5.94 (DS)
KBVA-FM (106.5) Bella Vista, Ark., ID-*Variety 106.5*	G4, 6	5.58/5.76 (DS)
KSKA-FM (91.1) Anchorage, Alaska — variety/fine arts	C5, 24	
7.38/7.56 (DS)		
KSL-AM (1160) Salt Lake City, Utah — news/talk/country-overnight	C1, 6	
5.58		
Peach State Public Radio (Georgia PBS)	T401, 14 (Ku)	5.40/5.58 (DS)
WUSF-FM (89.7) Tampa-St. Petersburg, Fl. (Public Radio), ID-*Concert 90*	C4, 10	8.26 (N)

FM SQUARED (FM²) AUDIO SERVICES

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

Satcom K2 Transponder 12

Background music services: Some of these are Muzak™ carriers and others are retail in-store network background music: .270, .390, .510, .630, .750, .870, .990, 1.110, 1.230, 1.350, 1.470, 1.590, 1.710, 1.830, 1.950, 2.190, 2.310, 3.330, and 4.255 MHz
Blank Audio carriers: .150, 2.945, and 2.990 MHz
Data Transmissions: 3.050, 3.110, 3.155, 4.115, 4.130, and 4.160 MHz
Generic News: 3.510 MHz
In-store networks: 2.070, 2.730, 3.240, 3.420, 3.600, 3.690, 3.780, and 3.860 MHz

Spacenet 3 Transponder 1

Associated Press 1: 1.595 MHz
Associated Press 2: 2.105 MHz
Associated Press 3: 3.705 MHz

Spacenet 3 Transponder 13

Ambassador Inspirational Radio: 1.420, 4.470, and 4.650 MHz
Background Music: .640 MHz
Blank Audio carrier: 2.500 and 3.390 MHz
International Broadcasting Network: 4.830 MHz
Radio AAHS — children's radio: 1.590 Mhz
Religious Backhauls (various): 1.235 MHz
Satellite Music Network — *Country Coast-to-Coast*: 3.570 and 3.750 MHz
Satellite Music Network — *Good Time Rock and Roll Oldies*: 2.670 MHz
Satellite Music Network — *Pure Gold*: 2.860 and 3.030 MHz
Satellite Music Network — *Stardust*: 2.130 and 2.310 MHz
Satellite Music Network — *Starstation*: 3.930 and 4.110 MHz
Satellite Music Network — *The Heat*: 1.050 MHz
USA Radio Network: .330 MHz
VCY America: .540 and .780 MHz
WJSO-FM (90.1) Pikeville, KY (Moody Broadcasting Network): 1.770 and 4.290 MHz

Spacenet 3 Transponder 17

Childrens Sunshine Network: 1.275 MHz
Data Transmission: .840 and 1.225 MHz
In-Touch — religious: 4.470 MHz
Salem Satellite Network: 4.650 and 5.010 Mhz
Satellite Music Network — *Traditional Country*: 3.570 and 3.750 MHz
Skylight — religious: 1.770 and 4.260 MHz
UPI Radio Network: .330 MHz

Spacenet 3 Transponder 18

Data Transmissions: 4.800 MHz

Galaxy 4 Transponder 3 (Ku-band)

Blank Audio Carriers: 1.065, 1.155, 1.245, 2.070, 2.430, 2.550, 2.670, 2.790, 2.950, 3.040, 3.160, 3.960, and 4.080 MHz
Data Transmissions: 3.090 MHz
Generic News: 3.510 MHz (occasional audio)
In-Store audio network ads: .710, .795, .880, 3.420, 3.600, 3.690, 3.780, and 3.860 MHz
MuZAK™ Services: .275, .390, .510, .975, 1.355, 1.470, 1.590, 1.710, 1.830, 1.945, 2.190, 2.310, and 3.330 MHz
MUZAK™ Voice Mirrors: .150 MHz

Galaxy 4 Transponder 4 (Ku-band)

Blank Audio Carriers: .180, .350, and 1.250 MHz
Data Transmissions: .110, .255, .300, .350, .470, .575, .675, .710, .740, .765, .845, .890, .930, 1.180, and 1.225 MHz
Russian-American Network: 1.350 MHz

Galaxy 4 Transponder 16 (Ku-band)

Blank Audio Carriers: 1.230, 1.470, 1.965, 2.070, 2.280, 2.730, and 3.280 MHz
Data Transmissions: .645, 2.140, 2.350, 2.470, 2.820, 2.870, 2.970, 3.000, 3.060, 3.115, 3.205, 3.245, 3.265, 3.345, 3.620, 3.735, 4.145, and 4.150 MHz
In-Store audio networks: .150, .270, .390, .755, .870, .990, 1.110, 1.350, 1.590, 1.710, and 1.800 MHz

Anik E1 Transponder 7 (Ku-band)

Nova Network FM Squared Services

FM CUBED (FM³) AUDIO SERVICES

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

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

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

Spacenet 2 Transponder 12-Vertical (C-band)

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

Galaxy 6 Transponder 3-Horizontal (C-band)

1405.60 (54.4) KIRO-AM (710) Seattle, Wash — news, talk, and sports talk radio
1405.40 (54.6) Sports Byline USA/Sports Byline Weekend
1404.60 (55.4) Talk America Radio Network
1403.80 (56.2) Occasional audio/Free Enterprise Radio Network
1403.20 (56.8) Motor Racing Network (MRN)
1400.80 (59.2) WBAL-AM (1090) Baltimore, Md — news/talk
1397.20 (62.8) WTMJ-AM (620) Milwaukee, Wis — talk radio/Univ. of Wisconsin college sports/Milwaukee Bucks NBA radio network
1393.40 (66.6) WGN-AM (720) Chicago, Ill — talk radio/Interstate Radio Network (IRN)
1393.20 (66.8) Wisconsin Radio Network/Illinois Radio Network/Tribune Radio Networks
1392.70 (67.3) WGN-AM (720) Chicago, Ill — talk radio/Interstate Radio Network
1391.60 (68.4) XEPRS-AM (1090) Tijuana, Mexico — Spanish language programming, ID - *Radio Express*
1389.70 (70.3) Occasional audio/data transmissions (burst)
1389.50 (70.5) Data transmissions (burst)
1388.90 (71.1) Occasional audio
1387.10 (72.9) Michigan News Network (MNN)/Univ. of Michigan college sports/Detroit Red Wings NHL radio network
1386.70 (73.3) Michigan News Network (MNN)/Detroit Pistons NBA radio network
1386.50 (73.5) WJR-AM (760) Detroit, Mich — talk radio
1386.30 (73.7) Illinois News Network/Chicago Blackhawks NHL radio network
1385.80 (74.2) WMAQ-AM (670) Chicago, Ill — news/Chicago Bulls NBA radio network
1385.10 (74.9) For the People Radio Network
1384.20 (75.8) Occasional audio
1383.80 (76.2) KJR-AM (950) Seattle, Wash — sports talk radio/Washington State college sports/Seattle Supersonics NBA radio network
1377.90 (82.1) Los Angeles Lakers NBA radio network/Kings NHL radio network
1375.40 (84.6) USA Radio Network
1374.10 (85.9) Northwest Direct — news and talk/Oregon State college sports/Portland Trailblazers NBA radio network

Satcom K2 Transponder 2-Vertical (Ku-band)

1010.60 Foreign language audio service identifying as *Radio Tejan*

Satcom K1 Transponder 12-Vertical (Ku-band)

1313.10 Customized IGA spots

Spacenet 3 Transponder-Horizontal 13 (C-band)

1207.90 (52.1) Wisconsin Voice of Christian Youth (VCY) America Radio Network — religious
1207.20 (52.8) Good News Radio Network — christian radio
1207.00 (53.0) Good News Radio Network — christian radio
1206.70 (53.3) Data Transmission
1206.55 (53.45) ABC Satellite Music Network — adult contemporary *Starstation*
1206.30 (53.7) ABC Satellite Music Network — adult contemporary *Starstation*
1206.00 (54.0) ABC Satellite Music Network — modern country *Country Coast-to-Coast*
1205.85 (54.15) ABC Satellite Music Network — modern country *Country Coast-to-Coast*
1205.65 (54.35) ABC Satellite Music Network — traditional music format *Stardust*
1205.40 (54.6) ABC Satellite Music Network — traditional music format, *Stardust*
1204.45 (55.55) KJAV-FM (104.9) Alamo, Tex — spanish language religious, Nuevo Radio Christiana Network
1204.25 (55.75) Wisconsin Voice of Christian Youth (VCY) America Radio Network — religious
1202.25 (57.75) ABC Satellite Music Network — golden oldies format *Pure Gold*
1202.10 (57.9) ABC Satellite Music Network — golden oldies format *Pure Gold*
1201.90 (58.1) Occasional audio
1201.70 (58.3) ABC Satellite Music Network — modern rock *The Heat*
1201.50 (58.5) Wisconsin Voice of Christian Youth (VCY) America Radio Network — religious
1201.30 (58.7) Wisconsin Voice of Christian Youth (VCY) America Radio Network — religious

Spacenet 3 Transponder 17-Horizontal (C-band)

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

Galaxy 4 Transponder 1-Horizontal (C-band)

1445.00 (55.0) WPGC-FM (95.5) Morningside, Md. — R&B format
1444.45 (55.55) Data transmissions
1443.80 (56.2) Voice of Free China (ISWBC) Taipei, Taiwan
1443.60 (56.4) WYFR (ISWBC) Oakland, Calif. — religious programming and talk, ID - *Family Radio Network*
1443.40 (56.6) Voice of Free China (ISWBC) Taipei, Taiwan
1438.30 (61.7) WWRV-AM (1330) New York, N.Y. — Spanish religious programming and music, ID - *Radio Vision Christiana de Internacional*
1436.50 (63.5) Radio Labio, Los Angeles, Calif — spanish talk radio
1436.30 (63.7) KOJY-AM (540) Costa Mesa, Calif/KJQI-AM (1260) Beverly Hills, Calif — all news
1436.00 (64.0) KUSC-FM (91.5) Los Angeles, Calif — fine arts, National Public Radio (NPR) affiliate
1435.70 (64.3) KUSC-FM (91.5) Los Angeles, Calif — fine arts, National Public Radio (NPR) affiliate
1429.00 (71.0) Occasional audio

Galaxy 4 Transponder 2-Vertical (C-band)

1402.60 (77.4) WVAQ-FM (101.9) Morgantown, W Va — West Virginia Metro News
1402.00 (78.0) WVAQ-FM (101.9) Morgantown, W Va — West Virginia Metro News/West Virginia college sports
1399.00 (81.0) Oklahoma News Network/Texas A&M college sports/Univ. of Oklahoma college sports/San Antonio Spurs NBA radio network
1398.80 (81.2) Progressive Farmers Network
1398.00 (82.0) Oklahoma News Network
1397.20 (82.8) Oklahoma News Network/Univ. of Oklahoma college sports/San Antonio Spurs NBA radio network

Galaxy 4 Transponder 3-Horizontal (C-band)

1405.00 (55.0) Mutual Broadcasting System (MBS)/Georgia Southern college sports
1404.80 (55.2) KOA-AM (850)/KTLK-AM (760) Denver, Colo — news and talk/Univ. of Colorado college sports
1404.40 (55.6) Tennessee Radio Network (TRN)/Univ. of Tennessee college sports
1404.00 (56.0) South Carolina Radio Network/South Carolina State college sports
1403.50 (56.5) International Broadcasting Network (IBN) — Lutheran religious programming/Home Front program (Sat 10a-2p Eastern Time)
1403.00 (57.0) Minnesota Public Radio Network
1402.40 (57.6) KNOW-FM (95.3) St. Paul, Minn — fine arts, Minnesota Public Radio (occasional audio)
1402.10 (57.9) KNOW-FM (95.3) St. Paul, Minn — fine arts, Minnesota Public Radio
1401.80 (58.2) BBC World Service (ISWBC)
1398.50 (61.5) Colorado Avalanche NHL radio network
1398.30 (61.7) WSB-AM (750) Atlanta, GA — news/talk/Atlanta Hawks NBA radio network/Univ. of Georgia college sports
1397.80 (62.2) Colorado Avalanche NHL radio network
1397.50 (62.5) Minnesota Talking Book network
1397.30 (62.7) WSB-AM (750) Atlanta, GA — news/talk/Atlanta Hawks NBA radio network/Univ. of Georgia college sports
1396.90 (63.1) KRLD-AM (1080) Dallas/Ft Worth, TX - talk/Texas State Network flagship
1396.40 (63.4) Georgia Network News (GNN)
1396.20 (63.8) WCNN-AM (680) Atlanta, GA — all sports talk radio/Georgia Tech college sports
1396.00 (64.0) WHO-AM (1040) Des Moines, Iowa — talk/Iowa News Network/Iowa college sports
1395.80 (64.2) Kentucky News Network/Univ. of Kentucky college sports
1395.50 (64.5) American Public Radio (APR) - Monitor Radio programming
1395.10 (64.9) Occasional audio
1394.70 (65.3) WHAS-AM (840) Louisville, Ky — adult contemporary music/Univ of Louisville college sports
1394.40 (65.6) Minnesota Public Radio
1394.00 (66.0) Minnesota Public Radio
1392.90 (67.1) Minnesota News Network
1388.90 (71.1) Data transmissions (burst)
1387.80 (72.2) Data transmissions (constant)
1384.40 (75.6) KOA-AM (850)/KTLK-AM (760) Denver, Colo — news and talk/Univ. of Colorado college sports
1384.20 (75.8) WSB-AM (750) Atlanta, Ga. — news and talk/Univ. of Georgia college sports/Atlanta Hawks NBA radio network
1383.70 (76.3) Minnesota Network News (MNN)/Midwest Radio Sports
1383.10 (76.9) VSA Radio Network — Ag news/Texas A&M college sports
1382.90 (77.1) Minnesota News Network (MNN)/Minnesota Timberwolves NBA radio network
1382.60 (77.4) Soldiers Radio Satellite (SRS) network — U.S. Army information and entertainment/Army college sports
1382.30 (77.7) Motor Racing Network (occasional audio)
1382.00 (78.0) WFAE-FM (90.7) Charlotte, N.C. — NPR affiliate/Univ. of South Carolina college sports
1381.80 (78.2) WHO-AM (1040) Des Moines, Iowa — talk radio/Iowa News Network/Iowa college sports
1381.60 (78.4) Alabama Radio Network/Univ of Alabama-Birmingham college sports

Single Channel Per Carrier (SCPC) Services Guide

1381.40 (78.6)	Various talk shows (No network ID)
1377.40 (82.6)	Data transmission (packet burst/tones)
1377.10 (82.9)	In-Touch — reading service for blind
1376.00 (84.0)	Kansas Audio Reader Network

Galaxy 4 Transponder 4-Vertical (C-band)

1387.50 (52.5)	Dakota Sports network/Dakota News network
1381.80 (58.2)	Data transmissions
1379.00 (61.0)	Louisiana Network/Louisiana Ag Network
1378.80 (61.2)	WLAC-AM (1510) Nashville, Tenn. — news and talk/Road Gang truck driver radio network (overnight)/Louisiana State Univ. college sports
1377.50 (62.5)	Mid-America News Network/Mid-America Ag Network
1377.30 (62.7)	WLAC-AM (1510) Nashville, Tenn. — news and talk/Road Gang truck driver radio network (overnight)/Univ. of Tennessee college sports
1376.00 (64.0)	Data transmissions
1375.60 (64.4)	KISN-AM (570) Salt Lake City, Utah — sports talk/Utah Jazz NBA radio network

Galaxy 4 Transponder 6-Vertical (C-band)

1346.90 (53.1)	WCRP-FM (88.1) Guayama, P.R. — religous/educational (Spanish)

Galaxy 4 Transponder 1-Horizontal (Ku-band)

959.20	ABC Satellite Music Network — country and western *Real Country*
959.00	ABC Satellite Music Network — country and western *Real Country*
957.50	Russian-American Radio Network — Russian language audio service

Anik E2 Transponder 19-Horizontal (C-band)

1086.00 (54.0)	Blank audio carrier

Anik E1 Transponder 11-Horizontal (C-band)

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

Anik E1 Transponder 13-Horizontal (C-band)

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

Anik E1 Transponder 15-Horizontal (C-band)

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

Anik E1 Transponder 17-Horizontal (C-band)

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

Anik E1 Transponder 19-Horizontal (C-band)

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

Anik E1 Transponder 21-Horizontal (C-band)

1024.30 (75.7)	Canadian weather conditions and warnings

SBS5 Transponder 2-Horizontal (Ku-band)

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

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2)	RFD Radio Service
1404.60 (55.4)	WGN-AM (720) Chicago, Ill — news/talk
1400.60 (59.4)	Indiana Radio Network
1400.40 (59.6)	Missouri Net
1400.20 (59.8)	Occasional audio
1400.00 (60.0)	Indiana Radio Network/Purdue college sports
1396.60 (63.4)	Kansas Information Network/Kansas Agnet/Kansas State college sports
1396.40 (63.6)	Nebraska Ag Network/Univ of Nebraska college sports/S.W. Missouri State college sports
1396.20 (63.8)	Missouri Network/Univ. of Illinois college sports
1396.00 (64.0)	Occasional audio
1395.70 (64.3)	Missouri Net/WIBW-AM (580) Topeka, Kan — news and talk
1387.50 (72.5)	Capitol Sports Network
1387.30 (72.7)	WPTF-AM (680) Raleigh, N.C. — news and talk/North Carolina News Network
1386.40 (73.6)	ABC Direction Network/Brownfield Network/Occasional audio/Univ. of Kansas college sports
1386.20 (73.8)	Radio Iowa
1385.00 (74.0)	People's Radio Network
1384.60 (75.4)	North Carolina News Network/Capitol Sports Network
1384.40 (75.6)	Capitol Sports Network/Univ of Duke college sports/Charlotte Hornets NBA radio network
1384.20 (75.8)	Capitol Sports Network/East Carolina college sports
1384.00 (76.0)	Occasional audio/ABC Direction Network
1383.80 (76.2)	Occasional audio
1383.60 (76.4)	Occasional audio
1382.90 (77.1)	Missouri Network/Univ. of Missouri college sports
1382.60 (77.4)	North Carolina News Network
1382.30 (77.7)	Virginia News Network/Univ. of Virginia college sports
1382.10 (77.9)	Missouri Net
1378.70 (81.3)	Radio Pennsylvania Network
1378.50 (81.5)	Radio Pennsylvania Network
1378.30 (81.7)	Radio Pennsylvania Network
1378.10 (81.9)	Radio Pennsylvania Network

RCA C5 Transponder 21-Vertical (C-band)

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

International Shortwave Broadcasters via Satellite

By Larry Van Horn and Robert Smathers

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

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

ARMED FORCES RADIO & TELEVISION SERVICE (AFRTS)
AFTRS-BC, 10888 La Tuna Canyon Road, Sun Valley, CA 91352-2098. AFRTS radio service carries a variety of radio network news and sports programming for servicemen overseas aboard Navy ships. Satellites carrying AFTRS transmissions include: Spacenet 2 (69.0 west) Tr 20 (4100 MHz V) 7.41 MHz audio and Intelsat 703 (177.0 east) Tr 38 (4177 MHz LHCP) 7.41 MHz audio

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

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

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

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

DEUTSCHE WELLE (DW)
P.O.Box 100 444, 50968 Cologne, Germany. Telephone: +49 221 389 4563 (voice), +49 221 389 3000 (fax)
Deutsche Welle services are available on the following satellites: Satcom C4/F4 (135 west) Tr 5 (3800 MHz V) 7.38/7.56 MHz audio, Astra 1A (19.2 east) on Tr 2 (11229 MHz V) 7.38/7.56 MHz audio, Eutelsat (13.0 east) Tr 27 (11163 MHz V) 7.02/7.20 MHz. audio, Intelsat K (21.5 west) Tr H7 (11605 MHz H), 7.38/7.56 MHz audio, and Intelsat 702 (1.0 west) Tr 23B (3.911 MHz RHCP) digital MPEG-2 subcarrier.

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

ISRAEL RADIO
P.O. Box 1082, Jerusalem 91010, Israel. Intelsat 702 (1.0 west) Tr 73 (11178 MHz V) 7.20 MHz audio.

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

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

RADIO AUSTRALIA
GPO Box 428G, Melbourne, Vic. 3001, Australia. Telephone: +61 3 616 1800 (voice), +61 3 626 1899 (fax)
Palapa B2P (133.0 east) Tr 9 (3880 MHz H) 7.20 MHz audio

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

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

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

RADIO EXTERIOR DE ESPANA (REE)
Apartado 156202, Madrid 28080, Spain. Telephone +34 13461083/1080/1079/1121 (voice); 34 13461097 (fax).
Eutelsat II F6 (Hot Bird 1 at 13.0 east) (11220 MHz H) 7.56 MHz audio and Hispasat 1A/B (31.0 west) Tr 6 (12149 MHz RHCP) 7.92 MHz audio.

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

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

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

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

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

RADIOTELEVISIONE ITALIANA (RAI)
Viale Mazzini 14, 00195 Roma, Italy. Telephone: +39 6 5919076. Selected programs of RAI's external service are carried on Eutelsat II F6 (Hot Bird 1 @ 13.0 east) (11446 MHz V) 7.56 MHz audio. This is a feed to the BBC Atlantic relay station on Ascension Island. Satcom C1 (137.0 west) Tr 15 (4000 MHz V) 7.38 MHz audio.

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

RDP INTERNATIONAL
Av. 5 de Outubro 197, 1000 Lisbon, Portugal. Telephone: +351 1 535151 (voice), +351 1 793 1809 (fax).
RDP International uses the following satellites for various broadcast to the indicate coverage areas: Asiasat 2 (service due to start on this satellite in September 1995), Eutelsat II F2 (10.0 east) Tr 39 (11658 MHz V) 7.02/7.20 MHz audio to Europe. Express 2 - Russian Statsionar 4 (14.0 west) on 4025 MHz (RHCP) 7.0 MHz audio to South America, Africa, the US east coast and southern Europe, Gorizont 22 - Russian Statsionar 12 (40 east) Tr 11 (3925 MHz RHCP) 7.02 MHz audio to Africa, southern Europe, and the Indian Ocean region, Telstar 302 (85 west) Tr 5 (3880 MHz V) 8.00 MHz audio to North America.

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

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

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

VATICAN RADIO
I-00120, Vatican City State, Italy. Telephone: +396 6988 3551 (voice), +396 6988 3237 (fax)
Eutelsat II F1 (13.0 east) Tr 32 (11554 MHz H) 7.74 MHz audio. Reports at presstime indicate that Vatican Radio will be downlinking on two Intelsat C-band birds (34.5 wesr and 66 east) by the fourth quarter of 1995.

International Shortwave Broadcasters via Satellite

VOICE OF AMERICA (United States Information Agency)

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

Eutelsat II F1	13.0 east	Tr 27	11163 MHz.	PAL system
Intelsat 510	66.0 east	Tr 38	4177.5 MHz.	PAL system
Intelsat 601	27.5 west	Tr 14	3995 MHz.	PAL system
Intelsat 601	27.5 west	Tr 81	3742 MHz.	PAL system
Spacenet 2	69.0 west	Tr 2H	3760 MHz.	NTSC system
Intelsat 511	180.0 west	Tr 14	3974 MHz.	PAL system

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

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

VOICE OF THE ARABS

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

VOICE OF SAHEL

Niger Radio and Television Service. Transmissions of the domestic radio shortwave service have been reported on Intelsat 702 at 1.0 west. No other details are available at this time.

VOICE OF THE IRAQI PEOPLE (CLANDESTINE)

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

WORLD HARVEST INTERNATIONAL RADIO, WHRI-South Bend, Indiana

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

WORLD RADIO NETWORK

BCM, London, WC1N 3XX, England, Telephone: +44 171 896 9000 (voice), +44 171 896 9007 (fax). In North America, call at local rates on (202) 414-3185. E-mail via Internet: *online@wrn.org*. WRN can also be heard live on the World Wide Web to users with high speed connections at: http//town.hall.org/radio/wrn.html. WRN schedules are subject to change.

North American Service Schedule

WRN1 — Galaxy 5 (125.0 west) Tr 6 (3820 MHz V) 6.80 MHz audio.

UTC/EST/PST	SERVICE/PROGRAM
0000/1900/1600	Radio Netherlands - Hilversum
0200/2100/1800	YLE Radio Finland - Helsinki*+
0230/2130/1830	Radio Sweden - Stockholm
0300/2200/1900	Radio Prague (Slovakia)
0330/2230/1930	Radio Austria International - Vienna
0400/2300/2000	Polish Radio - Warsaw
0430/2330/2030	Radio Budapest (Hungary)
0500/0000/2100	Radio Sweden - Stockholm
0530/0030/2130	BBC Europe Today (Mon-Sat) BBC International Call (Sun)
0600/0100/2200	Deutsche Welle - Cologne (Germany)
0700/0200/2300	Swiss Radio International - Berne
0730/0230/2330	Radio Canada International - Montreal
0800/0300/0000	ABC Radio Australia - Melbourne*+
0900/0400/0100	KBS Radio Korea International - Seoul*+
1000/0500/0200	Voice of Russia - Moscow*
1030/0530/0230	Radio Netherlands - Hilversum
1130/0630/0330	Channel Africa - Johannesburg, South Africa (Mon-Fri) BBC International Call (Sat) BBC Intl Money Prog & Health Watch (Sun)
1200/0700/0400	Radio Australia - Melbourne*+
1300/0800/0500	Radio Telefis Eireann (RTE) - Dublin, Ireland+
1400/0900/0600	KBS Radio Korea International - Seoul*
1500/1000/0700	YLE Radio Finland - Helsinki*
1530/1030/0730	Radio Vlaanderen International - Brussels Calling*
1600/1100/0800	Radio France International - Paris*
1700/1200/0900	Voice of Russia - Moscow*
1830/1230/0930	Radio Netherlands - Hilversum*
1830/1330/1030	Radio Telefis Eireann (RTE) - Dublin, Ireland*
1900/1400/1100	ABC Radio Australia - Melbourne*
2000/1500/1200	Blue Danube Radio - Vienna (Mon-Fri) Glen Hauser's World of Radio (Sat) BBC Intl Money Prog & Sports Zone (Sun)
2030/1530/1230	Radio Vlaanderen International - Brussels Calling
2100/1600/1300	BBC Europe Today (Sun-Fri) BBC International Call (Sat)
2130/1630/1330	Polish Radio - Warsaw
2200/1700/1400	Radio Telefis Eireann (RTE) - Dublin, Ireland/News and Both Sides Now

WRN2 — Galaxy 5 (125.0 west) Tr 6 (3820 MHz V) 6.20 MHz audio. New 24 hour multi-lingual channel for North America designed for the re-broadcasting of programs in a variety of languages for domestic FM/AM relays and cable distribution. This is a provisional schedule and subject to change.

0000/1900/1600	YLE Radio Finland - Helsiniki (News in Swedish)
0030/1930/1630	YLE Radio Finland - Helsiniki (News in English)
0100/2000/1700	YLE Radio Finland - Helsiniki (Light music in Finnish)
0200/2100/1800	YLE Radio Finland - Helsiniki (Documentaries in Finnish) Mon-Fri YLE Radio Finland - Helsiniki (Church belle & concert in Finnish) Sat YLE Radio Finland - Helsiniki (New classical releases in Finnish) Sun
0230/2130/1830	YLE Radio Finland - Helsiniki (Light music in Finnish) Fri only
0300/2200/1900	YLE Radio Finland - Helsiniki (News in English)
0330/2230/1930	YLE Radio Finland - Helsiniki (News in Finnish)
0400/2300/2000	YLE Radio Finland - Helsiniki (News in Finnish)
0410/2310/2010	YLE Radio Finland - Helsiniki (Religious programs in Finnish) Sun-Fri
0420/2320/2020	YLE Radio Finland - Helsiniki (News in Swedish)
0423/2323/2023	YLE Radio Finland - Helsiniki (Program preview in Finnish)
0430/2330/2030	WRN announcements**
0530/0030/2130	Radio Netherlands - Hilversum (Dutch)**
0625/0125/2225	WRN announcements**
1100/0600/0300	YLE Radio Finland - Helsiniki (News in Finnish)
1125/0625/0325	YLE Radio Finland - Helsiniki (News in Swedish)
1130/0630/0330	YLE Radio Finland - Helsiniki (News in English)**
1200/0700/0400	WRN announcements**
1300/0800/0500	Radio Telefis Eireann (RTE) - Dublin, Ireland (News in Irish)
1400/0900/0600	WRN announcements**
1500/1000/0700	YLE Radio Finland - Helsiniki (Regional broadcasts in Finnish)
1530/1030/0730	YLE Radio Finland - Helsiniki (News in Finnish)
1600/1100/0800	YLE Radio Finland - Helsiniki (Features in Finnish)
1620/1120/0820	YLE Radio Finland - Helsiniki (Slow speed Finnish)
1630/1130/0830	YLE Radio Finland - Helsiniki (News in English)
1700/1200/0900	WRN announcements**
1900/1400/1100	Radio Sweden - Stockholm (News in Swedish)**
1930/1430/1130	WRN announcements**
2030/1530/1230	Radio Netherlands - Hilversum (Dutch)**
2125/1625/1325	WRN announcements**
2300/1800/1500	Radio Vlaanderen International - Brussels Calling (Flemish)**
2330/1830/1530	YLE Radio Finland - Helsiniki (Rock music & talk in Finnish) Mon-Fri YLE Radio Finland - Helsiniki (Phone-in for children in Finnish) Sat & Sun

All broadcasts are daily unless otherwise indicated. WRN program information can be heard daily on North American WRN1 service at 1025 and 1725 UTC. * indicates program also carried by C-SPAN 1 audio service Monday-Friday. + indicates program also carried by C-SPAN 1 audio service Saturday-Sunday. ** indicates subject to pre-emption without notice.

European Service Schedule

Astra 1B (19.2 east) Tr 22 (11538 MHz V) 7.38 MHz audio. All broadcasts are in English and daily unless otherwise indicated. Program information is available on Astra 1B VH-1 text page 222/ MTV text 535. WRN network information can be heard on the European service daily at 0525, 1225 and 1925 CET.

YLE RADIO FINLAND

Box 10, SF-00241 Helsinki, Finland. Telephone: +358 0 1480 4320 (voice), +358 0 1481 169 (fax) E-mail: *rfinland@yle,mailnet.fi* Most of YLE's broadcasts to Europe are available on Eutelsat II F1 (13.0 east) Tr 27 (11163 MHz V) 8.10 MHz. audio, and Asiasat 2 (100.5 east) Tr 10B (4000 MHz H) early this year.

Direct Broadcase Satellite (DBS) Systems

By Larry Van Horn

Alphastar (United States)

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

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

DirecTV and USSB (United States)

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

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

100	Direct Ticket Previews (DTV)	Previews
101-199	Direct Ticket Pay Per View (DTV)	PPV
120/121	Unknown service (LTBX)	
140-142	Unknown service (LC)	
200	Direct Ticket Previews (DTV)	Previews
201	DirecTV Information Updates (DTV)	Promo
202	Cable Network News (CNN)	News
203	Court TV (CRT)	Speciality
204	CNN Headline News (HLN)	News
205	DirecTV Special Events Calendar (DTV)	Promo
206	ESPN 1 (ESPN)	Sports
207	ESPN Alternate (ESNA)	Sports
208	ESPN 2 (ESN2)	Sports
210	DirecTV Sports Schedule (DTV)	Promo
212	Turner Network Television (TNT)	TV programming
213	Home Shopping Network (HSN)	Home Shopping
214	Home and Garden TV (HGTV)	Home Improvement
215	E! Entertainment TV (E!)	Speciality
216	MuchMusic (MUCH)	Music Videos
217	Black Entertainment TV (BET)	Entertainment
219	American Movie Classics (AMC)	Movies
220	Turner Classic Movies (TCM)	Movies
221	Arts and Entertainment (A&E)	TV
222	The History Channel (HIST)	History
223	The Disney Channel East (DIS1)	Movies/Kids
224	The Disney Channel West (DIS2)	Movies/Kids
225	The Discovery Channel (DISC)	Science/TV documentary
226	The Learning Channel (TLC)	Science/TV documentary
227	Cartoon Network (TOON)	Cartoons
229	USA Network (USA)	TV
230	Trio (TRIO)	TV
232	The Family Channel (FAM)	TV
233	WTBS-Ind Atlanta, Ga.(TBS)	Superstation
235	The Nashville Network (TNN)	Country/Outdoors
236	Country Music TV (CMT)	Country Music Videos
240	The Sci-Fi Channel (SCFI)	Science Fiction
242	C-SPAN 1 (CSP1)	Congress-House of Representatives
243	C-SPAN 2 (CSP2)	Congress-U.S. Senate
245	Bloomberg Information Television (BIT)	News
246	CNBC (CNBC)	Financial/Talk
247	America's Talking (AT)	Talk
248	The Weather Channel (TWC)	Weather
250	Newsworld International (NWI)	News
252	CNN International (CNNI)/CNN fN	News/Financial
254	The Travel Channel (TRAV)	Travel Shows
258	Bravo (BRAV)	Arts
268	Direct Ticket Previews (DTV)	Previews
269	STARZ! - West (STZW)	Movies
270	STARZ! (STZE)	Movies
271	Encore (ENCR)	Movies
273	Encore-Westerns (WSTN)	Movies
274	Encore-Mystery (MYST)	Movies
275	Encore-Action (ACTN)	Movies
276	Encore-True Stories (TRUE)	Movies
277	Encore-WAM! (WAM!)	Movies
278	Encore (ENC)	Movies
282	WRAL-CBS Raleigh, N.C. (CBS)	Network TV
284	WNBC-NBC New York, N.Y. (NBC)	Network TV
286	KRMA-PBS Denver, Colo. (PBS)	Network TV
287	WABC-ABC, New York, N.Y. (ABC)	Network TV
289	FoxNet. (FOX)	Network TV
298	TV Asia (TVA)	Ethnic Programming
299	In-store dealer info channel (DTV)	Retailers only
300-399	Regional and PPV Sports	Sports
300	DirecTV Sports Offers (DTV)	Promo
301	Sports Special Events Calendar (DTV)	Promo
302	Sunday Ticket 95 Promo/World League of American Football	Sports
303	Newsport (NWSP)	Sports
304	The Golf Channel (GOLF)	Sports
305	Classic Sports Network (CSN)	Sports
306	Speedvision (SV)	Sports
307	Outdoor Life Channel (OL)	Sports
309	SportsChannel New England (SCNE)	Sports
310	Madison Square Garden (MSG)	Sports
311	New England Sports Network (NESN)	Sports
312	SportsChannel New York (SCNY)	Sports
313	Empire Network (EMP)	Sports
314	SportsChannel Philadelphia (SCPH)	Sports
315	Prime Sports KBL (PKBL)	Sports
316	Home Team Sports (HTS)	Sports
317	SportsSouth (SPTS)	Sports
318	Sunshine (SUN)	Sports
320	Pro AM Sports (PASS)	Sports
321	SportsChannel Ohio (SCOH)	Sports
322	SportsChannel Cincinnati (SCCN)	Sports
323	SportsChannel Chicago (SCCH)	Sports
324	Midwest SportsChannel (MSC)	Sports
325	Prime Sports Southwest (PSSW)	Sports
326	Prime Sports Midwest/Upper Midwest/ Rocky Mountain/Intermountain West (PS)	Sports
331	Prime Sports West (PSW)	Sports
332	SportsChannel Pacific (SCP)	Sports
330-348	NFL Sunday Ticket	Sports
335	DirecTV Sports Schedule (DTV)	Promo
350	NFL Sunday Ticket/NBA League Pass	Sports
356	NFL Sunday Ticket/NBA League Pass	Sports
380	DirecTV Sports Schedule (DTV)	Promo
402	Playboy (PBTV)	Adult
501	Music Choice — Hit List (MC1)	Audio
502	Music Choice — Dance (MC2)	Audio
503	Music Choice — Hip Hop (MC3)	Audio
504	Music Choice — Urban Beat (MC4)	Audio
505	Music Choice — Reggae (MC5)	Audio
506	Music Choice — Blues (MC6)	Audio
507	Music Choice — Jazz (MC7)	Audio
508	Music Choice — Singers and Standards (MC8)	Audio
509	Music Choice — Contemporary Jazz (MC9)	Audio
510	Music Choice — New Age (MC10)	Audio
511	Music Choice — Electric Rock (MC11)	Audio
512	Music Choice — Modern Rock (MC12)	Audio
513	Music Choice — Classic Rock (MC13)	Audio
514	Music Choice — 80's Retro (MC14)	Audio
515	Music Choice — Metal (MC15)	Audio
516	Music Choice — Solid Gold Oldies (MC16)	Audio
517	Music Choice — Soft Rock (MC17)	Audio
518	Music Choice — Love Songs (MC18)	Audio
519	Music Choice — Progressive Country (MC19)	Audio
520	Music Choice — Contemporary Country (MC20)	Audio
521	Music Choice — Country Gold/ Classic Country (MC21)	Audio
522	Music Choice — Big Bands Nostalgia (MC22)	Audio
523	Music Choice — Easy Listening (MC23)	Audio
524	Music Choice — Classic Favorites (MC24)	Audio
525	Music Choice — Classics in Concerts (MC25)	Audio
526	Music Choice — Contemporary Christian (MC26)	Audio
527	Music Choice — Gospel (MC27)	Audio
528	Music Choice — Big Kids Music (MC28)	Audio
529	Music Choice — Sounds of the Seasons (MC29)	Audio
599	For private use only (NRTC)	
790	Real Estate Channel (REAL)	

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

899	USSB Programming Higlights	Promo
963	All New Channel (ANC)	News
965	Video Hits One (VH1)	Rock Music Videos
967	Lifetime (LIFE)	TV
968	Nickelodeon (NICK)	TV/Kids
970	Flix (FLIX)	Movies
973	Cinemax East (MAX)	Movies
974	Cinemax 2 (MAX2)	Movies
975	Cinemax West (MAXW)	Movies

DBS/Primestar Channel Guide

977	The Movie Channel East (TMC)	Movies
978	The Movie Channel West (TMCW)	Movies
980	HBO East (HBO)	Movies
981	HBO 2 East (HBO2)	Movies
982	HBO 3 (HBO3)	Movies
983	HBO West (HBOW)	Movies
984	HBO 2 West (HB2W)	Movies
985	Showtime East (SHO)	Movies
986	Showtime 2 (SHO2)	Movies
987	Showtime West (SHOW)	Movies
989	MusicTV (MTV)	Rock Music Videos
990	Comedy Central (COM)	Comedy
999	USSB Programming Highlights	Promo

EchoStar (United States)

The new Echostar 1 high power DBS (Ku-band 12.2-12.7 GHz) satellite has been launched and is currently undergoing testing at 119º West. Echostar's service is called "TheDISH (Digital Satellite Network) Television Network. Channel assignments and programming where not available at presstime.

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

ExpressVu (Canada)

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

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

Galaxy Latin America (Mexico, Central and South America)

Ft. Lauderdale, FL
Web site: **http://www.sattv.com**
New Latin American DBS service carried on Galaxy 3R at 95º West (Ku-band, 11.7-12.2GHz). Medium power Direct-to-Home service for Mexico, Central and South America. Galaxy Latin America will have 144 channels of video (72 channels in Spanish/72 channels in Portuguese). 60-CD quality channels of music as well as pay-per-view movies and events will also be provided. A .6-1.1 meter dish will be needed to utilize the service. Channel assignments and programming where not available at presstime.

Primestar (United States)

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

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

1	HBO (East)	Movies
2	HBO 2 (East)	Movies
3	HBO 3	Movies
7	Cinemax (East)	Movies
8	Cinemax 2	Movies
13	TV Japan (English)	Not included in $50 a month package
14	TV Japan (Japanese)	Not included in $50 a month package
15	Future service	
17	Future service	
19	Future service	
27	Starz!	Movies
30	Encore 2-Love Stories	Movies
31	Encore 3-Westerns	Movies
32	Encore 4-Mystery	Movies
33	Encore	Movies
34	The Disney Channel (East)	Movies/Kids
35	The Disney Channel (West)	Movies/Kids
40	The Golf Channel	Sports
47	C-SPAN	Congress
48	CNBC — occasional service	Financial/Talk
49	The Weather Channel (TWC)	Weather
50	CNN International (CNNI)/CNN fN	News/Financial
51	Cable Network News (CNN)	News
52	CNN Headline News	News
	Ingenius News Service	Data Wire Services
55	PreVue Channel	Program Guide
56	Future service	
58	Turner Network Television (TNT)	TV
59	Turner Classic Movies (TCM)	Movies
63	WTBS-Ind Atlanta, Ga. (TBS)	Superstation
65	The Discovery Channel (TDC)	Science/TV documentary
66	The Learning Channel (TLC)	Science/TV documentary
68	Arts & Entertainment (A&E)	TV
70	USA Network	TV
71	The Sci-Fi Channel	Science Fiction
72	The Family Channel	TV
73	The Cartoon Channel	Cartoons
74	Future service	
77	The Nashville Network (TNN)	Country/Outdoors
78	Country Music TV (CMT)	Country music videos
80	Future Service	
84	QVC — occasional service	Home Shopping
111	WHDH-NBC Boston, Mass.	Network TV
114	WPLG-ABC Miami, Fla	Network TV
117	WUSA-CBS Washington, D.C.	Network TV
120	KTVU-FOX Oakland/San Francisco, Calif	Network TV
124	WHYY-PBS Philadelphia, Penn.	Network TV
131	ESPN	Sports
132	Future service	
138	Mega+1	Sports
141	New England Sports Network (NESN)	Sports
142	Madison Square Garden Network (MSG)	Sports
143	Empire Sports Network	Sports
144	Prime Sports KBL	Sports
145	Home Team Sports (HTS)	Sports
146	SportSouth	Sports
147	Sunshine	Sports
148	Pro American Sports (PASS)	Sports
149	Future service	
152	Prime Sports Midwest	Sports
153	Prime Sports Rocky Mountain	Sports
154	Prime Sports Southwest	Sports
155	Prime Sports Inter-Mountain West	Sports
156	Prime Sports Northwest	Sports
157	Future service	
158	Prime Sports West	Sports
159	Midwest SportsChannel	Sports
190	Univision	Spanish language
201	Viewer's Choice	PPV
202	Request 1	PPV
203	Request 5	PPV
204	Hot Choice	PPV
205	Continuous Hits 1	PPV
206	Continuous Hits 2 — occasional service	PPV
207	Continuous Hits 3	PPV
208	Request 2	PPV
209	Request 3	PPV
210	Request 4	PPV
221	Playboy — occasional service	Adult
301	Superadio — Classical Hits	Audio
302	Superadio — America's Country Favorites	Audio
303	Superadio — Lite 'n' Lively Rock	Audio
304	Superadio — Soft Sounds	Audio
305	Superadio — Classic Collections	Audio
306	Superadio — New Age of Jazz	Audio
527	Testing Channel	Tests

New services reported on since October: 1995:
Cinemax Selecciones; Classic Sports Network; DMX audio:
Lite Jazz, Classic Rock, 70's Oldies, Adult Contemporary, Hottest Hits, Modern Country, Traditional Blues, and Salsa; E! Entertainment TV; ESPN2; Faith and Values Network; HBO 1 en Espanol; HBO 2 en Espanol; HBO 3 en Espanol; Lifetime; MTV; and Nickelodeon/Nick at Nite.

Ku-band Satellite Transponder Services Guide

By Robert Smathers

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

Spacenet 2 (S2) 69º West

19	11740-H	Data transmissions
20	11820-H	Occ video
21	11900-H	TV ASAHI [Leitch]
22	11980-H	Empire Sports Network [video compression]
24	12140-H	Occ video

SBS 6 (SBS6) 74º West

1	11717-H	Occ video
2	11749.5-V	Occ Video/IBM TV [B-MAC]
4	11798.5-V	Occ video
5	11823-H	Occ video
6	11847.5-V	Occ video
7	11872-H	Occ video
8	11896.5-V	Occ video
9	11921-H	Occ video
10	11945.5-V	Occ video
11	11963-H	CONUS Communications (half transponders)
12	11994.5-V	CONUS Communications (half-transponders)
13	12019-H	CONUS Communications (half transponders)
14	12043.5-V	Occ video
15	12075-H	Occ video
16	12092.5-V	Occ video
17	12110-H	Occ video
18	12141.5-V	Occ video
19	12174-H	Occ video

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

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

Satcom K2 (K2) 81º West

1	11729-H	NBC-East
2	11758.5-V	Pagesat computer service/Data transmissions
3	11788-H	NBC-Pacific (West spot beam)
4	11817.5-V	Cyclesat/occ video
5	11847-H	NBC contract channel
6	11876.5-V	Occ video
7	11906-H	NBC contract channel (network feeds)
8	11935.5-V	North American Chinese TV Network [Oak]
9	11965-H	NBC-Mountain
10	11994.5-V	[Compressed video]
11	12024-H	NBC contract channel (network feeds)
12	12053.5-V	FM² services
13	12083-H	NBC NewsChannel
14	12112.5-V	Occ video
15	12142-H	Data transmissions
16	12171.5-V	[Compressed video]

Satcom K1 (K1) 85º West

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

Transponders 2-13 and 15-16 consists of Primestar programming encrypted and compressed using the Digicipher system. GE K1 uses the same frequency plan as GE K2. A complete Primestar channel guide is presented in the DBS section of *Satellites Times* Satellite Service Guide.

Spacenet 3R (S3) 87º West

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

Telstar 402R (T402) 89ºWest

7	11910-V	Occ video
9	11956-V	AT&T Tridom dish aiming slate

14 transponders belong to the Alphastar DBS service. Infomation on this DBS service will be presented in the *Satellite Times* DBS section of the Satellite Services Guide as information becomes available. AT&T Tridom also has leased some transponders.

Galaxy 7 (K7) 91º West

1	11720-V	Occ video
2	11750-H	Data transmissions
3	11750-V	Indiana Higher Education [Compressed video]
4	11780-V	Occ video
5	11810-H	Occ video
8	11870-H	Data transmissions
9	11870-V	Data transmissions
10	11900-V	Occ video
11U	11945-H	[Compressed video]
12	11930-V	Occ video
13	11960-V	Occ video
14	11990-H	Occ video
15	11990-V	Occ video
16	12020-V	Occ video/Real Estate TV Network (occasional)/The People's Network (TPN)
17	12050-H	Westcott Communications ASTN [B-MAC]/ANTN (Half-transponders)/National Weather Networks (occasional)
19	12080-V	The Asia Network/Occ video
20	12110-H	Data transmissions
21	12110-V	TCI Promo Channel [B-MAC]
22	12140-V	Classic Sports Network
23	12170-H	Data transmissions

GSTAR-3 (GST3) 93º West (Inclined Orbit)

1	11730-H	Data transmissions
2	11791-H	Data transmissions
3	11852-H	Occ video/NBC Newsfeeds
4	11913-H	Occ video/NBC Newsfeeds
5	11974-H	Occ video/NBC Newsfeeds
6	12035-H	Occ video/NBC Newsfeeds
7	12096-H	Occ video/NBC Newsfeeds
8	12157-H	Occ video
9	11744-V	Occ video
11	11866-V	Occ video
12	11927-V	Occ video/Mayo Clinic teleconference [B-MAC]
13	11988-V	Occ video/Mayo Clinic teleconference [B-MAC]
14	12049-V	Occ video/Mayo Clinic teleconference [B-MAC]
15	12110-V	Gstar 3 ID Channel
16	12171-V	Occ video

Galaxy 3R (G3R) 95º West

Ku-band side of this satellite is used entirely for the Galaxy Latin American DBS System. Infomation on this DBS service will be presented in the *Satellite Times* DBS section of the Satellite Services Guide as information becomes available.

Telstar 401 (T401) 97º West

1	11730-V	SCPC transmissions
2	11743-H	AT&T Skynet TV [compressed video]
3	11790-V	South Carolina Educational TV State Network [Digicipher]
4	11798-H	National Tech University [compressed video]
5	11845-V	PBS [Digicipher]
6	11855-H	SERC/PBS regionals/stations (half-transponders)
7	11902-V	PBS educational services (half-transponders)
8	11915-H	PBS stations/regionals and backhauls
9	11957.5-V	PBS digital video [Digicipher]/ VSAT traffic
10	11962.5-H	Louisiana Public TV State Network [Digicipher]
11	12040-V	Occ video
12	12046-H	Occ video/Data transmissions (half-transponders)
13	12095-V	Spectradyne Hotel Hotel in-room movies [compressed video]
14L	12093-H	Peachstar Educational Network (Distance Learning)
14U	12123-H	Georgia Public TV State Network (GPTV)
15	12147-V	ABC network and affiliate feeds (half-transponders)
16	12167-H	ABC network and affiliate feeds (half-transponders)

Galaxy 4 (K4) 99º West

1	11720-H	SCPC services/Data transmissions
2	11750-V	Data transmissions
3	11750-H	FM² services/MUZAK/Data transmissions
4	11780-H	FM² services/Planet Connect computer service (19.2 kbps)/ Data transmissions
5	11810-V	Data transmissions
6	11810-H	Occ video
7	11840-H	*Jong Ten* - Chinese/Taiwan all-news service
8	11870-V	Occ video
9	11870-H	Occ video
10	11900-H	CNN Airport Network [SA MPEG]
11	11930-V	Occ video (half-transponders common)
12	11930-H	Occ video/Channel One (occ video)
13	11960-H	Occ video
14	11990-V	Occ video (half-transponders common)
15	11990-H	Occ video
16	12020-H	FM² services/Data transmissions
17	12050-V	CBS Newsnet and affiliate feeds (half-transponders)
18	12050-H	Honk Kong TVB Jade Channel (Chinese) [scrambled unknown system]
19	12080-H	Data transmissions
20	12110-V	Occ video (half-transponders common)
21	12110-H	Asian-American TV Network
22	12140-H	Family Net [Digicipher]
23	12170-V	CBS Newsnet and affiliate feeds (half-transponders)
24	12170-H	The Filipino Channel [Oak]

Spacenet 4 (S4) 101º West

20	11820-H	Occ video
22	11980-H	Occ video
24	12140-H	E.M.G. courses [digicipher]

DBS-1 101.2º W/DBS-2 & DBS-3 100.8º W

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

GSTAR-1 (GST1) 103º West

1	11730-H	Data transmissions
2	11791-H	Data transmissions
3	11852-H	Fed-X - occ video [B-MAC] /Occ video
4	11913-H	Data transmissions
5	11974-H	CourtTV feeds (half transponders)
6	12035-H	Data transmissions
7	12096-H	Healthcare Satellite [video compression]
8	12157-H	Data transmissions
9	11744-V	Data transmissions
10	11805-V	Data transmissions
11	11866-V	Data transmissions
12	11927-V	Data transmissions
13	11988-V	Occ video
14	12049-V	Data transmissions
15	12110-V	Data transmissions
16	12171-V	Data transmissions

GSTAR-4 (GST4) 105º West

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

Anik E2 (A1) 107.3º West

1	11717-V	Data transmissions
2	11743-V	Data transmissions
3	11778-V	Data transmissions
4	11804-V	Occ video
5	11839-V	Canadian Parliamentary Access Channel [video compression]
6	11865-V	Moviepix!; The Movie Network [video compression]
7	11900-V	Rogers Network [video compression]
8	11926-V	Rogers Network [video compression]
9	11961-V	Data transmissions/DirecPC Canada
10	11987-V	Musique Plus
11	12022-V	Showcase TV (West)
12	12048-V	Saskarchewan CommunicaNetwork
13	12083-V	Data transmissions
14	12109-V	Data transmissions
15	12144-V	Telesat Canada stationkeeping (GLACS)
16	12170-V	Knowledge Network
17	11730-H	Discovery Channel Canada [Oak]
18	11756-H	Occ video
19	11791-H	Bravo! Canada
20	11817-H	Life Network
21	11852-H	Musique Plus
22	11878-H	Meteo Media
23	11913-H	Showcase TV (East)
24	11939-H	Ontario Legislature
25	11974-H	La Chaine (TV Ontario's French lanaguage service)
26	12000-H	TV Ontario (English)
27	12035-H	Data transmissions/DirecPC Canada
28	12061-H	Canal D — French arts channel
29	12096-H	RaiUno
30	12122-H	Telesat Canada stationkeeping (GLACS)
31	12157-H	Super Ecran [V2+]
32	12183-H	Le Canal Famile [V2+]

Solidaridad 1 SD1 109.2º West

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

Anik E1 (A2) 111º West

1	11717-V	Data transmissions
2	11743-V	Data transmissions
3	11778-V	Data transmissions
4	11804-V	Data transmissions
5	11839-V	MuchMusic
6	11865-V	NovaNet FM² Services
7	11900-V	Rogers Network — CHSC, Youth TV, Vision [video compression]
8	11926-V	Expressvu DBS
9	11961-V	Expressvu DBS
10	11987-V	Expressvu DBS
11	12022-V	Expressvu DBS
12	12048-V	Expressvu DBS
13	12083-V	CBC Newsworld feeds/Occ video
14	12109-V	RDI feeds/Occ video
15	12144-V	Expressvu DBS
16	12170-V	Occ video
17	11730-H	Woman's Television Network East and West [video compression]
18	11756-H	Data transmissions
19	11791-H	Data transmissions
20	11817-H	SCPC/Data transmissions/Shaw [video compression]
21	11852-H	Radio Ouebec
22	11878-H	Family Channel — East and West, MovieMax!, SuperChannel feeds [video compression]
23	11913-H	Expressvu DBS
24	11939-H	Expressvu DBS
25	11974-H	Expressvu DBS
26	12000-H	Expressvu DBS
27	12035-H	Expressvu DBS
28	12061-H	Expressvu DBS
29	12096-H	Reseau des Sports [V2+]
30	12122-H	Expressvu DBS
31	12157-H	Expressvu DBS
32	12183-H	Atlantic Satellite Network

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

(This satellite rarely has video transmissions)

Morelos 2 (M2) 116.8º West

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

EchoStar 1 119ºWest

Satellite is still testing at presstime. A complete channel guide for TheDISH Televison Network will presented in the DBS section of *Satellites Times* Satellite Service Guide as information becomes available. This satellite operates in the 12.2-12.7 GHz range.

SBS 5 (SBS5) 123º West

1	11725-H	Comsat Video in-room programming [B-MAC] (half transponders) — Satellite Cinema 1/3
2	11780-H	SCPC services
4	11872-H	Comsat Video in-room programming [B-MAC] (half transponders) — Satellite Cinema 4/2
5	11921-H	Data transmissions
6	11970-H	Data transmissions
7	12019-H	Data transmissions
8	12068-H	Comsat Video in-room programming [B-MAC] (half transponders) — ESPN/ Showtime
9	12117-H	Comsat Video in-room programming [B-MAC] (half transponders) — CNN Headline News/WTBS
10	12166-H	ID Channel/WalMart [V2+]/Occ video
11	11748-V	Data transmissions
12	11898-V	Occ video
13	11994-V	Occ video
14	12141-V	WMNB Russian-American TV [inverted video]

GSTAR-2 (GST2) 125º West

9	11744-V	Data transmissions
11	11866-V	GSTAR-2 ID slate/Occ video

NAVSTAR Orbital Information

We are aware of 34 NAVSTAR satellites in orbit and only 25 are reportedly operating. The NAVSTAR satellites are often referred to as GPS satellites, and the Pseudo Random Noise (PRN) code number for the satellite is shown after the slash mark.

PRN Pseudo Random Noise number is the identity of the satellite as determined by a receiver. Since all GPS satellites transmit on the same frequency, they are distinguished by their pseudo random noise code. Some receivers list the satellites as "SVN", but this is really the PRN.

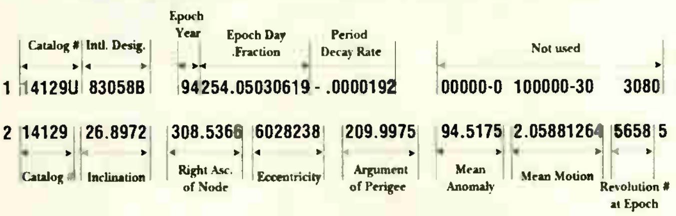
SVN Satellite Vehicle NAVSTAR, also known as NAVSTAR number.

In the first line of the element set we have also included the satellite's launch name, block/satellite number, launch date, and orbital slot designator.

The following is a list of the reportedly operational satellites as of February, 1, 1996. Information used to prepare this section of the *Satellite Times* SSG was provided by the Orbital Information Group at Goddard, the U.S. Coast Guard Navigation Center, and the University of New Brunswick (Dr. Richard Langely).

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.

NAVSTAR 10/12 (USA 5 Block I-10) Launched 9/8/84 Slot A1
1 15271U 84097A 96030.37811540 .00000045 00000-0 10000-3 0 1075
2 15271 62.0601 258.8172 0159138 357.0738 2.9155 2.00609026 82485
NAVSTAR 14/14 (USA 35 Block II-1) Launched 2/14/89 Slot E1
1 19802U 89013A 96022.56495707 -.00000009 00000-0 10000-3 0 1775
2 19802 55.3088 116.4859 0029802 164.4567 195.6201 2.00557954 50779
NAVSTAR 13/2 (USA 38 Block II-2) Launched 6/10/89 Slot B3
1 20061U 89044A 96025.89426545 -.00000065 +00000-0 +10000-3 0 01863
2 20061 054.2866 292.3144 0148842 217.1294 141.8843 02.00562952048585
NAVSTAR 16/16 (USA 42 Block II-3) Launch 8/17/89 Slot E3
1 20185U 89064A 96025.23413323 -.00000025 +00000-0 +10000-3 0 01912
2 20185 055.0760 116.8835 0020600 309.3332 050.5063 02.00556498047148
NAVSTAR 19/19 (USA 47 Block II-4) Launched 10/21/89 Slot A4
1 20302U 89085A 96029.75938220 .00000064 00000-0 10000-3 0 1861
2 20302 53.2920 232.0463 0017665 132.9833 227.1246 2.00562054 46035
NAVSTAR 17/17 (USA 49 Block II-5) Launched 12/11/89 Slot D3
1 20361U 89097A 96030.26920891 -.00000040 00000-0 10000-3 0 282
2 20361 55.9103 58.7751 0085380 131.4489 229.3552 2.00563395 35520
NAVSTAR 18/18 (USA 50 Block II-6) Launched 1/24/90 Slot F3
1 20452U 90008A 96025.68043752 +.00000043 +00000-0 +10000-3 0 01226
2 20452 054.0341 172.6077 0060527 086.0009 274.6573 02.00558827043935
NAVSTAR 20/20 (USA 54 Block II-7) Launched 3/25/90 Slot B2
1 20533U 90025A 96029.07083438 -.00000063 00000-0 10000-3 0 1646
2 20533 54.6597 292.8617 0050637 75.9809 284.6371 2.00577131 42772
NAVSTAR 21/21 (USA 63 Block II-8) Launched 8/2/90 Slot E2
1 20724U 90068A 96029.39724267 -.00000063 00000-0 00000+0 0 9960
2 20724 54.9161 114.2822 0130879 178.5756 181.4914 2.00564757 38645
NAVSTAR 15/15 (USA 64 Block II-9) Launched 10/1/90 Slot D2
1 20830U 90088A 96030.44684654 -.00000039 00000-0 10000-3 0 9994
2 20830 55.8469 56.7302 0064355 98.5216 262.2766 2.00560346 39301
NAVSTAR 23/23 (USA 66 Block IIA-10) Launched 11/26/90 Slot E4
1 20959U 90103A 96029.35086213 -.00000062 00000-0 10000-3 0 9647
2 20959 55.1131 116.3270 0101329 235.6946 123.3975 2.00564904 37879
NAVSTAR 24/24 (USA 71 Block IIA-11) Launched 7/3/91 Slot D1
1 21552U 91047A 96029.12824987 -.00000048 00000-0 10000-6 0 9353
2 21552 56.1420 54.5465 0069486 246.8791 112.4421 2.00572757 33460
NAVSTAR 25/25 (USA 79 Block IIA-12) Launched 2/23/92 Slot A2
1 21890U 92009A 96029.58480824 .00000064 00000-0 10000-3 0 7559
2 21890 53.8294 232.4056 0058103 188.5026 171.4429 2.00560370 28845
NAVSTAR 28/28 (USA 80 Block IIA-13) Launched 4/10/92 Slot C2
1 21930U 92019A 96029.29553188 -.00000087 00000-0 10000-3 0 7294
2 21930 55.7172 354.2190 0030160 180.4031 179.5965 2.00561798 27767
NAVSTAR 26/26 (USA 83 Block IIA-14) Launched 7/7/92 Slot F2
1 22014U 92039A 96025.34562036 .00000046 00000-0 00000+0 0 6517
2 22014 54.8398 174.3138 0123492 321.6776 37.4043 2.00559855 19525
NAVSTAR 27/27 (USA 84 Block IIA-15) Launched 9/9/92 Slot A3
1 22108U 92058A 96025.80868691 +.00000034 +00000-0 +10000-3 0 06847
2 22108 054.0725 233.3821 0116650 155.5751 205.0206 02.00556253024715
NAVSTAR 32/1 (USA 85 Block IIA-16) Launched 11/22/92 Slot F1
1 22231U 92079A 96026.49104233 .00000048 00000-0 10000-4 0 6563
2 22231 54.6824 175.4471 0025724 281.2626 78.4195 2.00554208 23305
NAVSTAR 29/29 (USA 87 Block IIA-17) Launched 12/18/92 Slot F4
1 22275U 92089A 96029.62415721 .00000020 00000-0 10000-3 0 6881
2 22275 54.6266 172.8205 0050921 246.9537 112.4746 2.00573662 22771
NAVSTAR 22/22 (USA 88 Block IIA-18) Launched 2/3/93 Slot B1
1 22446U 93007A 96025.70655174 -.00000065 00000-0 10000-3 0 6571
2 22446 54.3007 293.1732 0087155 358.6260 1.3899 2.00565455 21681
NAVSTAR 31/31 (USA 90 Block IIA-19) Launched 3/30/93 Slot C3
1 22581U 93017A 96025.35100235 -.00000083 00000-0 10000-3 0 5003
2 22581 55.2160 353.8291 0061047 35.5979 324.8013 2.00565172 20737
NAVSTAR 37/7 (USA 91 Block IIA-20) Launched 5/13/93 Slot C4
1 22657U 93032A 96025.99029936 -.00000083 00000-0 10000-3 0 5978
2 22657 55.2466 353.6693 0074805 222.3932 137.0223 2.00555534 16075
NAVSTAR 39/9 (USA 92 Block IIA-21) Launched 6/26/93 Slot A1
1 22700U 93042A 96025.44920127 +.00000030 +00000-0 +10000-3 0 05050
2 22700 054.2425 234.2018 0043716 353.2673 006.7131 02.00571316018861
NAVSTAR 35/5 (USA 94 Block IIA-22) Launched 8/30/93 Slot B4
1 22779U 93054A 96025.04626229 -.00000061 +00000-0 +10000-3 0 05708
2 22779 054.4500 293.2200 0017167 262.6775 097.1797 02.00561061017618
NAVSTAR 34/4 (USA 96 Block IIA-23) Launched 10/26/93 Slot D4
1 22877U 93068A 96025.09209500 -.00000062 +00000-0 +10000-3 0 03851
2 22877 055.5725 054.8982 0040486 297.5717 062.0659 02.00562082016508
NAVSTAR 36/6 (USA 100 Block IIA-24) Launched 3/10/94 Slot C1
1 23027U 94016A 96025.17309396 -.00000082 +00000-0 +10000-3 0 03106
2 23027 055.0783 355.6945 0064638 203.8167 155.8812 02.00570864013810

The following satellites are reportedly not operating or have been turned off by the owner:
10684 1978 020A NAVSTAR 1/4 (Block I-1) Launched 2/22/78 Clock failure
10893 1978 047A NAVSTAR 2/7 (Block I-2) Launched 5/13/78 Clock failure
11054 1978 093A NAVSTAR 3/6 (Block I-3) Launched 10/6/78 Clock failure
11141 1978 112A NAVSTAR 4/8 (Block I-4) Launched 12/11/78 Clock failure
11690 1980 011A NAVSTAR 5/5 (Block I-5) Launched 2/9/80 Wheel failure
11783 1980 032A NAVSTAR 6/9 (Block I-6) Launched 4/26/80 Wheel failure
------- NAVSTAR 7/-- (Block I-7) Launched 12/18/81 Booster failure
14189 1983 072A NAVSTAR 8/11 (Block I-8) Launched 7/14/83 EPS degrade
15039 1984 059A NAVSTAR 9/13 (Block I-9) Launched 6/13/84 Clock failure
16129 1985-093A NAVSTAR 11/3 (Block I-11) Launched 10/9/85 TT&C failure
The satellite that would have been known as NAVSTAR 7 failed to achieve orbit due to a booster failure. The satellite that will be known as NAVSTAR 12 will be used as an experimental platform and is not part of the GPS constellation.

The Goddard Space Flight Center (GSFC), Mission Operations and Systems Development Division (Code 510), Mission Operations Branch (Code 513), Operations Management and Support Section (Code 513.1), Orbital Information Group (OIG) Bulletin Board System (BBS) provides access to satellite orbital Two Line Element (TLE) data, in addition to other satellite related orbital information. This data is compiled, stored, grouped, and made available in descrete files, downloadable from a user-friendly menu driven system. Data files are in standard TLE format or text files. The BBS User's Guide is also a downloadable file.

NASA/GSFC Code 513 implemented a BBS to provide a user friendly access to Two Line Element (TLE) data and other satellite orbital information. The BBS is free, convenient, user friendly, menu driven, fast, and is accessible around-the-clock from anywhere in the World, either by telephone modem or by Internet media. The routine BBS data is updated Monday through Friday, usually around 14:00 GMT. All data on the BBS is provided to the OIG around- the-clock, and is as accurate as the source. You may send the SysOp an e-mail message to **sysop@oig1.gsfc.nasa.gov**or you may call the SysOp in the United States at (301)-805-3917. Alternatively, you may send a facsimile message to the SysOp in the United States at (301) 805-3916. The mail address for the SysOp is: NASA/Goddard Space Flight Center, Operations Management and Support Section, Code 513.1, Attn: Orbital Information Group (OIG), Greenbelt, MD 20771 USA

Satellite Transponder Guide

By Robert Smathers

	Spacenet 2 (S2) 69°	Galaxy 6 (G6) 74°	Telstar 302 (T2) 85°	Spacenet 3 (S3) 87°	Telstar 402R (T4) 89°	Galaxy 7 (G7) 91°	Galaxy 3R (G3R) 95°	Telstar 401 (T1) 97°	Galaxy 4 (G4) 99°	Spacenet 4 (S4) 101°
1	SC New York [V2+]	Tokyo BS New York feeds	XXXplore (adult) [V2+]	(none)	The Babe Channel/o/v	Sega Channel [digital]	TVN Theatre 1 [V2+]	Exxxtasy (Adult) Promo/VTC	SCPC services	Data Transmissions
2	GEMS TV (Spanish) [V2+]	Data Transmissions	A.I.N.	Nebraska Educational TV	TVN Promo Channel	CBS West	TVN Theatre 2 [V2+]	Data Transmissions	SCPC services	Home Dish Market Channel
3	USIA Worldnet TV	SCPC services	(none)	WSBK-Ind Boston [V2+]	o/v	Action PPV [V2+]	TVN Theatre 3 [V2+]	Parmount Syndication feeds/o/v	SCPC services	Data Transmissions
4	H.TV (Spanish)	o/v	(none)	Nebraska Educational TV (NETV)	The Shopping Channel (TSC)	fX East	TVN Theatre 4 [V2+]	Fox feeds	SCPC services	Encore-Westerns [V2+]
5	NASA Contract Channel-o/v [Leitch]	NHK New York feeds	(none)	Univision [V2+]	o/v	fX West	TVN Theatre 5 [V2+]	4MC Syndicated feeds/o/v	o/v	Data Transmissions
6	Data Transmissions	NHK (TV Japan) feeds	(none)	(none)	o/v	Game Show Network [V2+]	TVN Theatre 6 [V2+]	Buena Vista TV feeds	Sheperd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]
7	o/v	National Empowerment TV	(none)	Data Transmissions	Cable Video Store [V2+]	The Golf Channel [V2+]	TVN Theatre 7 [V2+]	Fox feeds-East	o/v	Basil Bassett Bingo
8	Data Transmissions	Data Transmissions	o/v	Data Transmissions	o/v	(none)	TVN Theatre 8 [V2+]	PBS X	Telemundo [SA MPEG]	KOMO-ABC Seattle (PT24W) [V2+]
9	NASA TV	MuchMusic U.S. [V2+]	(none)	WPIX-Ind New York [V2+]	Data Transmissions	MCI (Andover) contract ch/RAI/o/v	Adultvision (adult) [V2+]	Fox feeds East	o/v	Data Transmissions
10	Data Transmissions	Arab Network of America (ANA)	ABC West [Leitch]	Data Transmissions	XXXtreme (adult) Promo [V2+]	United Arab Emirates TV Dubai	Showtime East 2 [V2+]	Fox feeds West	WABC-ABC New York (PT24E) [V2+]	FOXNet (PT24E) [V2+]
11	SC Philadelphia [V2+]	FOX News Feeds/o/v	XXXpose (adult) [V2+]	Prime [V2+]	The Outdoor Channel	Estacion Montellano (Spanish Rel)/o/v	o/v [Leitch]]	ABC feeds	o/v	STARZ! East [V2+]
12	Data Transmissions	TV Asia [digicipher]	XXXpose (adult) Promo	Data Transmissions	XXXotica (adult) [V2+]	International Channel [V2+]	o/v	ABC NewsOne feeds	o/v	H.TV
13	Data Transmissions	None	(none)	SCPC/FM2 services	BBC Breakfast News/o/v	CSN/Kaleidoscope/PS-S [Digicipher]	Space Connection	Fox East	o/v	Data Transmissions
14	Data Transmissions	Cornerstone TV WPCB-TV (Rel)	XXXotica (adult) Promo	CNN [BMAC]	o/v	Independent Film Channel [V2+]	o/v	Fox West	WRAL-CBS Raleigh (PT24E) [V2+]	Data Transmissions
15	HERO Teleport [Digicipher]	Midwest Sports Channel [V2+]	XXXtreme (adult) Promo	KTLA-Ind Los Angeles [V2+]	Spice (adult) [V2+]	TV! [V2+]	o/v	Exxxtasy 2 (adult) [V2+]	World Harvest TV (Rel)	Data Transmissions
16	Data Transmissions	Data Transmissions	(none)	CNN International [BMAC]	Adam and Eve (adult) [V2+]	Data Transmissions	HBO 2 East [V2+]	UPN/o/v	CBS West	NPS Promo Channel
17	Data Transmissions	Keystone Comm Contract Ch/MSG II-o/v	(none)	FM2/SCPC services	o/v	Via TV (Home Shopping)	Cinemax 2 East [V2+]	National Home Net/o/v	CBS East/o/v	Data Transmissions
18	(none)	Merchandise and Entertainment TV (MET)/o/v	(none)	Shop-at-Home/ In-store audio	Radiotelevisao Portuguesa Internacional (RTPi)	Teleport Minnesota/CBS feeds/o/v	(none)	o/v	CBS feeds/o/v	STARZ! West [V2+]
19	Data Transmissions	University Network/Dr. Gene Scott (Rel)	(none)	SSN Sportsouth [V2+]/ American Collectables Network	Channel America	CBS East [VC1]	HBO 3 [V2+]	United Paramount Network/Keystone/o/v	CBS East/o/v	Data Transmissions
20	Armed Forces Radio & Television Service [B-MAC]	CNN Headline News Clean Feed [V2+]	ABC East (contingency channel) [Leitch]	o/v	o/v	Prime Sports Showcase	HBO 2 West [V2+]	ABC East [Leitch]	CBS East	Data Transmissions
21	SC New England [V2+]	o/v	Data Transmissions	SSN Pro Am Sports (Pass) [V2+]	(none)	BET on Jazz	(none)	ABC East [Leitch]	WB Syndication-Network/CBS feeds/o/v	Data Transmissions
22	SC New York Plus [V2+]	o/v	Data Transmissions	Data Transmissions	ABC feeds - LA Bureau	NewsTalk Television	(none)	ABC West [Leitch]	WNBC-NBC New York (PT24E) [V2+]	Data Transmissions
23	NHK TV Japan secondary feeds	Worship TV (Rel)	Data Transmissions	SSN Home Teams Sports (HTS) [V2+]	La Cadena de Milagro (Spanish Rel)	fX Movies [V2+]	3 Angels Broadcasting (Rel)	ABC East [Leitch]	SCOLA [Wegener]/Blue&White Network	Data Transmissions
24	Data Transmissions	Data Transmissions	o/v	America One	PandaAmerica (Home Shopping)	(o/v)	FLIX [V2+]	Exxxtasy Premier (adult) [V2+]	CBS Newspath feeds	KPIX-CBS San Francisco (PT24W) [V2+]

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Satellite Transponder Guide

By Robert Smathers

Anik E2 (A1) 107.3º	Solidaridad 1 (SD1) 109.2º	Telesat E1 (A2) 111º	Morelos 2 (M2) 116.8º	Telstar 303 (T3) 123º	Galaxy 5 (G5) 125º	Satcom C3 (F3) 131º	Galaxy 1R (G1) 133º	Satcom C4 (F4) 135º	Satcom C1 (F1) 137º	
Data Transmissions	(none)	Data Transmissions	Data Transmissions	TVN Theatre 1 [V2+]	Disney East [V2+]	Family Channel West [V2+]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	NewSport [V2+]	1
(none)	(none)	The Sports Network [Dak]	Data Transmissions	TVN Theatre 2 [V2+]	Playboy (Adult) [V2+]	The Learning Channel	Spanish language networks [SA MPEG]	Request TV PPV [GI Digicipher]	KMGH-ABC Denver [V2+]	2
Telesat Digital Video Compression	SCPC services	Data Transmissions	Data Transmissions	TVN Theatre 3 [V2+]	Trinity Broadcasting (Rel)	Viewer's Choice PPV [V2+]	Encore [V2+]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2+]	3
(none)	(none)	Data Transmissions	Data Transmissions	TVN Theatre 4 [V2+]	Sci-Fi [V2+]	Lifetime West [V2+]	TV Food Network [GI Digicipher]	Lifetime East [V2+]	SC Pacific [V2+]	4
Telesat Digital Video Compression	o/v	Data Transmissions	Data Transmissions	TVN Theatre 5 [V2+]	CNN [V2+]	Faith and Values Channel/ACTS (Rel)	Classic Arts Showcase	Deutsche Welle TV (German)	KDVR-Fox Denver [V2+]	5
(none)	(none)	Cancom [SA MPEG]	Data Transmissions	TVN Theatre 6 [V2+]	WTBS-Ind Atlanta [V2+]	Court TV [Digicipher]	Z-Music	Madison Square Garden [V2+]	KCNC-CBS Denver [V2+]	6
(none)	XEQ-TV canal 9	Data Transmissions	Data Transmissions	TVN Theatre 7 [V2+]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN Prime Sports West [V2+]	7
Global TV [Leitch]/Global feeds	(none)	Cancom (CHCH City TV WUHF CFCM) [SA MPEG]	XHGC canal 5/Q-CVC	TVN Theatre 8 [V2+]	HBO West [V2+]	QVC-2 Fashion Channel	Cartoon Network [V2+]	Prevue Guide	NBC-East	8
o/v	(none)	Data Transmissions	(none)	TVN Theatre 9/CVS [V2+]	ESPN [V2+]	Music Choice [digital]	ESPN2 Blackout [V2+] SAH	QVC Network	Syndicated Entertainment TV (SET)	9
(none)	Mexican Parliament	Cancom [SA MPEG]	SEP	XXXpose-XXXplore (adult) Promo/o/v	MOR Music	Home Shopping Club Spree	America's Talking [V2+]	Home Shopping Network (HSN)	SSN Prime Sports SW [V2+]	10
Canadian Horse Racing/o/v	(none)	CBC-North Pacific feed	XEIPN canal 11	(none)	Family Channel East [V2+]	Prime Network [V2+]	Eternal Word TV Network (Rel)	The Box [analog/digital]	Network One N1 [V2+]	11
CTV (Blue) Canadian Horse Racing/o/v	Data Transmissions	Cancom [SA MPEG]	Data Transmissions	Data Transmissions	Discovery West [V2+]	History Channel [V2+]	Valuevision	Nustar (Promo Channel)	Data Transmissions	12
Canadian Horse Racing/o/v	(none)	CBC feeds/o/v	(none)	Data Transmissions	CNBC [V2+]	The Weather Channel [V2+]	Encore [GI Digicipher]	Travel Channel [V2+]	SC Chicago [V2+]	13
(none)	Data Transmissions	Cancom [SA MPEG]	XEW canal 2	(none)	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Blackout [V2+]/SAH	Fit TV	KUSA-NBC Denver [V2+]	14
Gospel Music TV Network (occ)/o/v	Multivision [GI Digicipher]	CBFT-CBC (French)	Data Transmissions	Data Transmissions	HBO East [V2+]	Showtime East [V2+]	CNN International/CNN fN [V2+]	WWOR-Ind New York [V2+]	SC Cincinnati/Ohio [V2+]	15
CTV (Green)	Data Transmission	CBC Newsworld [Dak]	Canal 22 o/v	FLIX [V2+]	Cinemax West [V2+]	MTV West [V2+]	Turner Classic Movies [V2+]	Request TV 1 [V2+]	PS-SC Alt/o/v	16
Climaxxx (adult) [V2+]	(none)	CBC feeds/o/v	o/v	o/v	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	MTV East [V2+]	SSN Prime Sports (various) [V2+]/Cal-Span/o/v	17
Video Catalog Channel	o/v	Cancom [SA MPEG]	Clara Vision (Rel)	Showtime 2 [V2+]	TNN [V2+]	Nickelodeon West [V2+]	HBO Multiplex [GI Digicipher]	Viewer's Choice [digicipher]	Prime Sports Showcase	18
TV Northern Canada (TVNC)	Multivision [GI Digicipher]	CBC feeds/o/v	(none)	Data Transmissions	USA East [V2+]	Showtime/MTV [GI Digicipher]	Cinemax East [V2+]	C-SPAN 2	FOXNet [V2+]	19
CJON-TV Newfoundland TV (NTV)	(none)	CBMT-CBC (English)	Data Transmissions	adulTVision/TVN Theatre 10 (Adult) [V2+]	BET [V2+]	Jones Intercable [GI Digicipher]	Home and Garden Network	Showtime West [V2+]	o/v	20
Telesat Digital Video Compression	(none)	SCPC services/ Data Transmissions	(none)	Data Transmissions	MEU	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	Prime Sports West [digicipher]	21
RPTI	(none)	Cancom [SA MPEG]	XHIMT canal 7/TeleCasa	Antenna TV [V2+]/HRT Croatia TV/o/v	CNN/HN [V2+]	Your Choice TV [Digicipher]	Nostalgia Channel	Movie Channel West [V2+]	SSN PSNW [V2+]/o/v	22
Exxxtreme TV/The Cupid Network (adult) [V2+]	(none)	CBC-North Atlantic feed	(none)	Data Transmissions	A&E [V2+]	E! Entertainment TV [V2+]	o/v	VH-1 [V2+]	KWGN-Ind Denver [V2+]	23
CTV (Red)	(none)	Cancom (BCTV CITV) [SA MPEG]	XHDF canal 13	TVN Promo Channel	Showtime/Movie Channel [SA MPEG]	Digital Music Express Radio (DMX) [Digital]	Speedvision [digicipher]	CMT [V2+]	SSN Sunshine [V2+]	24

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Geostationary Satellite Locator Guide

By Larry Van Horn

This guide shows the orbital locations of 235 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: Molniya Space Consultancy: Mr. Phillip Clark; Kaman Sciences Corporation: Dr. Nicholas Johnson; University of New Brunswick: Mr. Richard B. Langley; U.S. Space Command/Public Affairs: Major Don Planalp; Naval Space Command/Public Affairs: Gary Wagner; NASA NSSDC/WDC-A, Goddard Space Flight Center; and *Satellite Times* staff.

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

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
23712	1995-060A USA 115 (DFS-2/Milstar-2)	4.0E	Mil-Comm (P/S/K)
19919	1989-027A Tele X (Sweden)	5.2E	Reg DTH/FSS (Ku)
20193	1989-067A Sirius/Marcopolo 1(BSB R-1)	5.3E	Reg DTH (Ku)
22921	1993-076A USA 98 (NATO 4B)	6.0E/i	Mil-Comm (P/S/X)
22028	1992-041B Eutelsat II F4	7.0E	Reg FSS (Ku)
21056	1991-003B Eutelsat II F2	10.2E	Reg FSS (Ku)
19596	1988-095A Raduga 22 (Russia)	11.2E/i	Dom FSS/Gov-Mil (X/C)
22269	1992-088A Cosmos 2224 (Russia)	11.9E#	Mil-Earl Warning (X)
22557	1993-013A Raduga 29 (Russia)	12.6E#	Dom FSS/Gov-Mil (X/C)
21055	1991-003A Italsat 1 (Italy)	13.2E	Dom-Telephone (S/K/Ka)
20777	1990-079B Eutelsat II F1	13.8E	Reg FSS (Ku)
23686	1995-055A Astra 1E	14.4E	Reg DTH (Ku)
23537	1995-016B Hot Bird 1 (Eutelsat II F6)	14.7E	DTH (Ku)
21803	1991-083A Eutelsat II F3	16.3E	Reg FSS (Ku)
23331	1994-070A Astra 1D	19.1E	Reg DTH (Ku)
22653	1993-031A Astra 1C	19.1E	Reg DTH (Ku)
19688	1988-109B Astra 1A	19.2E	Reg DTH (Ku)
21139	1991-015A Astra 1B	19.5E	Reg DTH (Ku)
14234	1983-077A Telstar 3A (301) (USA)	20.0E#	Dom FSS-Saudi Arabia (C)
19331	1988-063B Eutelsat 1 F5	21.6E#	Reg FSS (VHF/Ku)
13010	1981-122A Marecs 1 (ESA)	22.2E/i	Int Mar-EUR (L/C)
22175	1992-066A DFS 3 (Germany)	23.5E	Dom BSS (S/Ku/K)
20659	1990-054A Gorizont 20 (Russia)	25.5E/i	Dom/Gov FSS (C/Ku)
18351	1987-078B Eutelsat 1 F4 (ECS 4)	25.7E/i	Reg FSS (VHF/Ku)
20706	1990-063B DFS 2 (Germany)	28.4E	Dom BSS (S/Ku/K)
21894	1992-010B Arabsat 1C	31.0E	Reg FSS/BSS (S/C)
20041	1989-041B DFS 1 (Germany)	33.7E	Dom BSS (SKu/K)
19765	1989-004A Gorizont 17 (Russia)	34.1E/i	Dom/Gov FSS (C/Ku)
21821	1991-087A Raduga 28 (Russia)	35.3E#	Dom FSS/Gov-Mil (X/C)
20953	1990-102A Gorizont 22 (Russia)	39.5E/i	Dom/Gov FSS (C/Ku)
23200	1994-049B Turksat 1B (Turkey)	42.8E	Reg FSS (Ku)
19928	1989-030A Raduga 23 (Russia)	45.0E/i	Dom FSS/Gov-Mil (X/C)
14421	1983-105A Intelsat 507	47.0E/i	Int FSS/Mar (L/C/Ku)
22981	1994-008A Raduga 1-3 (Russia)	48.5E#	Dom FSS/Gov-Mil (X/C)
21038	1990-116A Raduga 1-2 (Russia)	49.2E/i	Dom FSS/Gov-Mil (X/C)
22245	1992-082A Gorizont 27 (Russia)	52.7E#	Dom/Gov FSS (C/Ku)
19687	1988-109A Skynet 4B (UK)	52.9E/i	Mil-Comm (P/S/X/Ka)
15629	1985-025A Intelsat 510	56.9E/i	Int FSS (C/Ku)
20667	1990-056A Intelsat 604	60.0E	Int FSS (C/Ku)
14675	1984-009A DSCS III A2 (USA)	60.0E/i	Mil-IOR primary (P/S/X)
20315	1989-087A Intelsat 602	63.0E	Int FSS (C/Ku)
20918	1990-093A Inmarsat 2 F1	64.6E#	Int Mar-IOR (L/C)
13595	1982-097A Intelsat 505	64.8E/i	Int FSS/Mar (L/C/Ku)
13636	1982-106A DSCS II F16 (USA)	64.9E/i	Mil-IOR reserve (S/X)
23461	1995-001A Intelsat 704	66.0E	Int FSS (C/Ku)
23636	1995-040A PanAmSat 4 (PAS 4)	68.5E	Int FSS (C/Ku)
20083	1989-048A Raduga 1-1 (Russia)	69.5E/i	Dom FSS/Gov-Mil (X/C)
23448	1994-087A Raduga 32 (Russia)	70.2E#	Dom FSS/Gov-Mil (X/C)
22963	1993-002A Gals 1 (Russia)	71.1E	Dom BSS (Ku)
20410	1990-002B Leasat 5 (USA)	71.6E/i	Mil-IOR reserve (P/S/X)
22787	1993-056A USA 95 (UFO-2)	71.8E/i	Mil-IOR primary (P/S)
23589	1995-027A USA 111 (UFO-5)	71.9/i	Mil-IOR reserve (P/S/K)
23717	1995-063A Gals 2 (Russia)	72.4E	Dom BSS (Ku)
08882	1976-053A Marisat 2	72.7E/i	Int Mar-IOR (P/L/C)
22027	1992-041A Insat 2A (India)	73.9E	Dom FSS/BSS/Met (S/C)
23327	1994-069A Elektro 1 (Russia)	76.0E#	Met (L)
23680	1995-054A Luch 1-1 (Russia)	76.8E/i	Tracking & Relay SDRN-2 (Ku)
21111	1991-010A Cosmos 2133 (Russia)	77.4E#	Mil-Early Warning (X)
22931	1993-078B Thaicom 1 (Thailand)	78.4E	Reg FSS (C/Ku)
23314	1994-065B Thaicom 2 (Thailand)	78.4E	Reg FSS (C/Ku)
23653	1995-045A Cosmos 2319 (Russia)	79.7E#	Data Relay (C)
21759	1991-074A Gorizont 24 (Russia)	80.1E#	Dom/Gov FSS (C/Ku)
20643	1990-051A Insat 1D (India)	82.8E	Dom FSS/BSS/Met (S/C)
19548	1988-091B TDRS F3 (USA)	84.9E/i	Gov (C/S/Ku)
22836	1993-062A Raduga 30 (Russia)	85.6E#	Dom FSS/Gov-Mil (X/C)
18922	1988-014A PRC 22 (China)	87.2E/i	Dom FSS (C)
22880	1993-069A Gorizont 28 (Russia)	90.2E#	Dom/Gov FSS (C/Ku)
12474	1981-050A Intelsat 501	91.5E/i	Int FSS (C/Ku)
23765	1995-003A Measat 1 (Malaysia)	91.5E	Dom FSS/DTH (C/Ku)
22724	1993-048B Insat 2B (India)	93.4E	Dom FSS/BSS/Met (S/C)
23731	1995-067B Insat 2C (India)	93.5E	Dom FSS/BSS/Met (S/C)
23426	1994-082A Luch 1 (Russia)	94.9E#	Tracking & Relay CSDRN (Ku)
20263	1989-081A Gorizont 19 (Russia)	96.1E/i	Dom/Gov FSS (C/Ku)
20473	1990-011A PRC 26 (China)	97.9E	Dom FSS (C)
22210	1992-074A Ekran 20 (Russia)	99.0E#	Dom BSS (P)
19683	1988-108A Ekran 19 (Russia)	99.4E/i	Dom BSS (P)
23723	1995-064A AsiaSat 2	100.0E	DTH (C/Ku)
21922	1992-017A Gorizont 25 (Russia)	103.2E#	Dom/Gov FSS (C/Ku)
20558	1990-030A Asiasat 1	105.4E	DTH (C/Ku)
20570	1990-034A Palapa B2R	108.0E	Reg FSS (C)
20771	1990-077A BS-3A (Yuri 3A)(Japan)	108.5E#	Dom BSS (Ku)
21668	1991-060A BS-3B (Yuri 3B)(Japan)	109.2E	Dom BSS (Ku)
23176	1994-040B BS-3N (Japan)	109.3E	Dom BSS (Ku)
19710	1988-111A PRC 25 (China)	110.6E#	Dom FSS (C)
17706	1987-029A Palapa B-2P	112.5E	Reg FSS (C)
------	1996-006A Palapa C-1	113.0E	Reg FSS (C/Ku)
14985	1984-049A Chinasat 5 (Spacenet 1)	115.5E	Dom FSS (C/Ku)
23639	1995-041A Koreasat 1 (Mugunghwa 1)	115.9E	Dom FSS (Ku)
23768	1996-003A Koreasat 2 (Mugunghwa 2)	116.0E	Dom FSS (Ku)
21964	1992-027A Palapa B4	117.8E	Reg FSS (C)
21132	1991-014A Raduga 27 (Russia)	127.6E/i	Dom FSS/Gov-Mil (X/C)
23649	1995-043A JCSAT 3 (Japan)	127.9E	Dom FSS (Ku)
22907	1993-072A Gorizont 29 (Rimsat 1)	129.6E#	Reg FSS (C/Ku)
14134	1983-059C Palapa B1 (Indonesia)	130.0/i	Reg FSS (C)
18877	1988-012A CS 3A (Sakura 3A)(Japan)	131.7E	Dom FSS (C/K)
23651	1995-044A N-Star A (Japan)	131.8E	Dom/Mob FSS (S/C/Ku/Ka)
19508	1988-086A CS 3B (Sakura 3B) (Japan)	135.7E	Dom FSS (C/K)
23185	1994-043A Apstar A1 (China)	137.9E	DTH (C)
20107	1989-052A Gorizont 18 (Russia)	139.7E/i	Dom/Gov FSS (C/Ku)
23522	1995-011B GMS-5 (Himawari 5)	140.0E#	Met (P/L)
23108	1994-030A Gorizont 30 (Rimsat 2)	142.5E#	Reg FSS (C/Ku)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
20923	1990-094A Gorizont 21 (Russia)	145.1E/i	Dom/Gov FSS (C/Ku)
19874	1989-020A JCSAT 1 (Japan)	149.9E	Dom FSS (Ku)
18316	1987-070A ETS V (Japan)	150.2E/i	Experimental (L/C)
18350	1987-078A Optus A3 (Aussat K3)	152.0E	DTH (Ku)
20402	1990-001B JCSAT 2 (Japan)	153.9E	Dom FSS (Ku)
23227	1994-055A Optus B3 (Australia)	155.9E	DTH/Mob (L/Ku)
22253	1992-084A Superbird A1 (Japan)	157.9E	Dom FSS (Ku/K)
22087	1992-054A Optus B1 (Aussat B1)	159.9E	DTH/Mob (L/Ku)
21893	1992-010A Superbird B1 (Japan)	162.0E	Dom FSS (Ku/K)
16275	1985-109C Optus A2 (Aussat 2)	164.0E/i	DTH (Ku)
23175	1994-040A PanAmSat 2 (PAS-2)	169.0E	Int FSS (C/Ku)
12046	1980-087A OPS 6394 (FltSatCom F4) (USA)	171.6E/i	Mil-POR reserve (P-Bravo/S/X)
22871	1993-066A Intelsat 701	173.9E	Int FSS (C/Ku)
20202	1989-069A DSCS III B9 (USA)	175.0E/i	Mil-WPAC primary (P/S/X)
23305	1994-064A Intelsat 703	177.0E	Int FSS (C/Ku)
21814	1991-084B Inmarsat 2 F3	177.9E#	Int Mar-POR (L/C)
15873	1985-055A Intelsat 511	179.9E/i	Int FSS (C/Ku)
16117	1985-092C DSCS III B5 (USA)	180.0E/i	Mil-WPAC reserve (P/S/X)
09478	1976-101A Marisat 3	178.6W/i	Int Mar-POR (P/L/C)
15236	1984-093C Leasat 2 (USA)	177.9W/i	Mil-POR primary (P/S/X)
19121	1988-040A Intelsat 513	177.0W#	Int FSS (C/Ku)
23467	1995-003A USA 108 (UFO-4) (USA)	176.5W/i	Mil-POR (P/S/K)
21639	1991-054B TDRS F5 (USA)	174.4W	Int FSS/Gov (C/S/Ku)
20499	1990-016A Raduga 25 (Russia)	170.5W/i	Dom FSS/Gov-Mil (X/C)
18631	1987-100A Raduga 21 (Russia)	170.1W/i	Dom FSS/Gov-Mil (X/C)
23696	1995-057A USA 114 (UFO-6)	167.7W/i	Mil-CONUS (P/S/K)
23613	1995-035B TDRS F7 (USA)	149.7W#	Int FSS/Gov (C/S/Ku)
13969	1983-026B TDRS F1 (USA)	139.7E/i	Gov (Ku)
21392	1991-037A Satcom C5 (Aurora II)(USA)	138.8W	Dom FSS (C)
20945	1990-100A Satcom C1 (USA)	136.8W	Dom FSS (C)
17561	1987-022A GOES 7 (USA)	135.4W/i	Met (P/L/S)
22096	1992-057A Satcom C4 (USA)	134.9W	Dom FSS (C)
22915	1993-074A DSCS III B14 (USA)	135.0W/i	Mil-EPAC primary (P/S/X)
23016	1994-013A Galaxy 1R (USA)	133.0W	Dom FSS (C)
22117	1992-060B Satcom C3 (USA)	130.9W	Dom FSS (C)
13637	1982-106B DSCS III A1 (USA)	130.1W/i	Mil-EPAC reserve (P/S/X)
21906	1992-013A Galaxy 5 (USA)	125.1W	Dom FSS (C)
16649	1986-026A Gstar 2 (USA)	124.8W#	Dom FSS (Ku)
15826	1985-048D Telestar 3D (USA)	123.0W#	Dom FSS (C)
19484	1988-081B SBS 5 (USA)	123.0W	Dom FSS (Ku)
22988	1994-009A USA 99 (DFS-1/Milstar 1)	120.0W	Mil-Comm (P/S/K)
23754	1995-073A EchoStar 1 (USA)	119.0W	DTH (Ku)
16274	1985-109B Morelos B (Mexico)	116.8W	Dom FSS (C/Ku)
13652	1982-110C Anik C3 (Canada)	114.9W/i	Dom FSS (Ku)
23313	1994-065A Solidardad 2 (Mexico)	113.0W	Dom FSS (L/C/Ku)
21726	1991-067A Anik E1 (Canada)	111.1W	Dom FSS (C/Ku)
22911	1993-073A Solidaridad 1 (Mexico)	109.2W	Dom FSS (L/C/Ku)
21222	1991-026A Anik E2 (Canada)	107.3W	Dom FSS (C/Ku)
08747	1976-023B LES 9 (USA)	106.5W/i	Mil-Exp comm (P/Ka)
15643	1985-028C Leasat 3 (USA)	106.1W/i	Mil-CONUS reserve (P/S/X)
08697	1976-017A Marisat 1	105.7W/i	Int Mar-AOR (P/L/C)
20946	1990-100B Gstar 4 (USA)	105.1W	Dom FSS (Ku)
03029	1967-111A ATS 3 (USA)	104.4W/i	Exp comm (VHF/C)
08746	1976-023A LES 8 (USA)	103.4W/i	Mil-Exp comm (P/Ka)
15677	1985-035A Gstar 1 (USA)	103.0W	Dom FSS (Ku)
22930	1993-078A DBS 1 (USA)	101.2W	DTH (Ku)
21227	1991-028A Spacenet 4 (USA)	101.1W	Dom FSS (C/Ku)
23553	1995-019A MSAT-2 (USA)	101.0W	Mobile (L/X)
23598	1995-029A DBS 3 (USA)	100.9W	DTH (Ku)
23192	1994-047A DBS 2 (USA)	100.8W	DTH (Ku)
22796	1993-058B ACTS (USA)	100.0W	Exp Comm (C/K/Ka)
17181	1986-096A USA 20 (FltSatCom F7)(USA)	99.4W/i	Mil-CONUS primary (P/S/X /K)
22694	1993-039A Galaxy 4 (USA)	99.0W	Dom FSS (C/Ku)
22927	1993-077A Telstar 401 (USA)	97.0W	Dom FSS (C/Ku)
23741	1995-069A Galaxy 3R (USA)	95.0W	Dom/DTH (C/Ku)
19483	1988-081A Gstar 3 (USA)	93.1W/i	Dom FSS/Mob (L/Ku)
16650	1986-026B SBTS 2 (Brazil)	92.2W#	Dom FSS (C)
22205	1992-072A Galaxy 7 (USA)	91.0W	Dom FSS (C/Ku)
23581	1995-025A GOES 9 (USA)	90.0W	Met (P/L/S)
23670	1995-049A Telstar 402R (USA)	89.0W	Dom FSS (C/Ku)
18951	1988-018A Spacenet 3R (USA)	87.1W	Dom FSS (L/C/Ku)
15237	1984-093D Telestar 3C (302) (USA)	85.1W#	Dom FSS (C)
16482	1986-003B Satcom K-1 (USA)	85.0W	Dom FSS (Ku)
16276	1985-109D Satcom K-2 (USA)	81.0W	Dom FSS (Ku)
15235	1984-093B SBS 4 (USA)	77.1W/i	Dom FSS (Ku)
14133	1983-059B Anik C2 (Argentina)	75.9W/i	Dom FSS (Ku)
23051	1994-022A GOES 8 (USA)	75.9W#	Met (P/L/S)
12309	1981-018A Comstar D4 (USA)	75.7W/i	Dom FSS (C)
20873	1990-091B Galaxy 6 (USA)	74.2W	Dom FSS (C)
20872	1990-091A SBS 6 (USA)	74.1W	Dom FSS (Ku)
15642	1985-028B Anik C1 (Argentina)	71.9W	Dom FSS (Ku)
12855	1981-096A SBS 2 (USA)	70.8W/i	Dom FSS (Ku)
23199	1994-049A Brazilsat B1 (Brazil)	70.2W	Dom FSS (C)
15385	1984-114A Spacenet 2 (USA)	70.0W	Dom FSS (C/Ku)
23536	1995-016A Brasilsat B2 (Brazil)	65.4W	Dom FSS (C/X)
15561	1985-015B SBTS 1 (Brazil)	63.1W#	Dom FSS (C)
21940	1992-021B Inmarsat 2 F4	54.0W/i	Int Mar-AOR-W (L/C)
23571	1995-023A Intelsat 706	53.1W	Int FSS (C/Ku)
20203	1989-069B DSCS III B10 (USA)	52.5W/i	Mil-WLANT primary (P/S/X)
23528	1995-013A Intelsat 705	50.1W	Int FSS (C/Ku)
22314	1993-003B TDRS F6 (USA)	45.9W/i	Gov (C/S/Ku)
19217	1988-051C PanAmSat 1 (PAS 1)	45.1W	Int FSS (C/Ku)
23764	1996-002A PanAmSat 3R (PAS 3R)	43.0W	Int FSS (C/Ku)
16116	1985-092B DSCS III B4 (USA)	42.5W/i	Mil-ATL reserve (P/S/X)
19883	1989-021B TDRS F4 (USA)	41.1W	Int FSS/Gov (C/S/Ku)
12089	1980-098A Intelsat 502	40.4W/i	Int FSS (C/Ku)
23413	1994-079A Orion 1 (USA)	37.6W	Int FSS (Ku)
20523	1990-021A Intelsat 603	34.6W	Int FSS (C/Ku)
20401	1990-001A Skynet 4A	34.0W/i	Mil-comm (P/S/X/Ka)
14077	1983-047A Intelsat 506	31.4W/i	Int FSS/Mar (L/C/Ku)
22723	1993-048A Hispasat 1B (Spain)	30.2W	Dom BSS/FSS (Ku)
22116	1992-060A Hispasat 1A (Spain)	30.1W	Dom BSS/FSS (Ku)
21765	1991-075A Intelsat 601	27.6W	Int FSS (C/Ku)
21653	1991-055A Intelsat 605	24.6W	Int FSS (C/Ku)
20253	1989-077A USA 46 (FltSatCom 8)	24.5W/i	Mil-AOR primary (P-Charlie/ S/X/K)
23168	1994-038A Cosmos 2282 (Russia)	24.2W#	Mil-Early Warning (X)
22112	1002-059A Cosmos 2209 (Russia)	24.0W#	Mil-Early Warning (X)
21989	1992-032A Intelsat K	21.6W	Int FSS (Ku)
16101	1985-087A Intelsat 512	21.4W#	Int FSS (C/Ku)
15391	1984-115A NATO III D	21.1W/i	Mil-Comm (P/S/X)
20705	1990-063A TDF 2 (France)	18.8W	DTH (Ku)
19621	1988-098A TDF 1 (France)	18.8W	DTH (Ku)
19772	1989-006A Intelsat 515	18.0W	Int FSS (C/Ku)
21047	1991-001A NATO IV A	17.8W/i	Mil-Comm (P/S/X)
20391	1989-101A Cosmos 2054 (Russia)	16.4W/i	Tracking & Relay WSDRN (Ku)
21149	1991-018A Inmarsat 2 F2	15.6W/i	Int Mar-AOR-E (L/C)
10669	1978-016A Ops 6391 (FltSatCom 1) (USA)	15.4W/i	Mil-AOR reserve (P-Alpha/S/X)
15386	1984-114B Marecs B2	15.0W/i	Int Mar-AOR (L)
23132	1994-035A USA-104 (UFO-3)(USA)	14.6W/i	Mil-AOR primary (P/S)
23267	1994-060A Cosmos 2291 (Russia)	14.6 W#	Data Relay (C)
23319	1994-067A Express 1 (Russia)	13.9W	Int FSS (C/Ku)
21789	1991-079A Cosmos 2172 (Russia)	13.4W#	Data Relay (C)
22009	1992-037A DSCS III B12 (USA)	12.0W	Mil-ELANT primary (P/S/X)
22041	1992-043A Gorizont 26 (Russia)	11.3W#	Dom/Gov FSS (C/Ku)
22912	1993-073B Meteosat 6 (ESA)	10.0W#	Met (L)
21813	1991-084A Telecom 2A (France)	8.0W	Dom FSS/Gov-Mil (X/C/Ku)
21939	1992-021A Telecom 2B (France)	5.0W	Dom FSS/Gov-Mil (X/C/Ku)
23124	1994-034A Intelsat 702	1.0W	Int FSS (C/Ku)
20776	1990-079A Skynet 4C (UK)	0.9W#	Mil (P/S/X/Ka)
20762	1990-074A Thor/Marcopolo 2 (BSB R-2)	0.8W	Reg BSS (Ku)
20168	1989-062A TV Sat 2 (Germany)	0.6W	Dom BSS (Ku)

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Frequencies

OSCAR 13 (AO-13) (Notes 1 & 13)

Mode																	
B (u/V)	Dn	145.828	838	848	858	868	878	888	898	908	918	928	938	948	958	968	145.978
	Up	435.570	560	550	540	530	520	510	500	490	480	470	460	450	440	430	435.420
Bcns		145.812 (RTTY, CW, PSK)															145.985
S (u/S)	Dn	2400.711	720	730	740	2400.747											
	Up	435.601	610	620	630	435.637											
Bcn		2400.650 (RTTY, CW, PSK)															

OSCAR 10 (AO-10) (Notes 2 & 13)

Mode																	
B (u/V)	Dn	145.825	835	845	855	865	875	885	895	905	915	925	935	945	955	965	145.975
	Up	435.179	169	159	149	139	129	119	109	099	089	079	069	059	049	039	435.029
Bcn		145.810 (Steady unmodulated carrier)															145.987

RS 10/11 (Notes 3, 4, 5 and 13)

Mode							Robot (CW)
A (v/A)	Dn	29.360	370	380	390	29.400	29.403
	Up	145.860	870	880	890	145.900	145.820
Bcn		29.357 (CW)					

RS-12/13 (Notes 3, 6 & 7)

Mode							Robot (CW)
K (h/A)	Dn	29.410	420	430	440	29.450	29.454
	Up	21.210	220	230	240	21.250	21.129
Bcn		29.408					

RS-15 (Note 13)

Mode						
A (v/a)	Dn	29.354	29.364	29.374	28.384	29.394
	Up	145.858	145.868	145.878	145.888	145.898

UoSat 11 (UO-II) (Note 14)

Mode				
Bcns	Dn	145.826	435.025	2401.500
	Up	None		

PACSAT (AO-16) (Notes 8, 9 & 11)

Mode					
[a]	Dn	437.025 (Sec) 437.050			
	Up	145.900	145.920	145.940	145.960

DOVE (DO-17) (Notes 10 & 11)

Mode			
[b,c]	Dn	145.825	2401.220
	Up	None	

WEBERSAT (WO-18) (Note 11)

Mode			
[a]	Dn	437.075	437.100 (Sec)
	Up	None	

LUSAT (LO-19) (Notes 8 & 11)

Mode					
[a]	Dn	437.125	437.150 (Sec)		
	Up	145.840	145.860	145.880	145.900

NOTES

1. AO-13 carries a 70 cm trammitter for Modes J and L. However, this transmitter failed in mid-1993 and has been inoperative since.
2. The AO-10 beacon is an unmodulated carrier. This satellite has suffered computer damage making it impossible to orient the satellite for optimum service or solar illumination. In order to preserve it as long an possible, do not transmit to it when you hear the beacon FMing.
3. RS-10/11 and RS-12/13 are each mounted on common spaceframes, along with comunication and navagation packages.
4. RS-10 has been in Mods A for some months, but also has capability for Mode T (21.160-21.200 Uplink, 145.860-145.900 Downlink), Mode K (21.160-21.200 Uplink, 29.360-29.400 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
5. RS-11 is currently turned off. If activated, it has capability for Mods A (145.910-145.950 Uplink, 29.410-29.450 Downink), Mode T (21.210-21.250 Uplink, 145.910-145.950 Downlink), Mode K (21.210-21.250 Uplink, 29.410-29,450 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
6. RS-12 has been in Mode K for some months, but also has capability for Mode A (145.910-145.950 Uplink, 29.410-29.450 Downlink), Mode T (21.210-21.250 Uplink, 145.910-145.950 Downlink) an well as combined Modes K/A and K/T using these same frequency combinations.
7. RS-13 is currently turned off. If activated, it has capability for Mode A (145.960-146.000 Uplink, 29.460-29.500 Downlink), Mode K (21.260-21.300 Uplink, 29.460-29.500 Downlink), Mode T (21.210-21.250 Uplink, 145.960-146.000 Downlink) as well as combined Modes K/A and K/T using these same frequency combinations.
8. Transmitters on both AO-16 & LU-19 are currently using Raised Cosine Mode.
9. AO-16 users are encouraged to select 145.900, 145.920 and 145.940 for uploading and 145.960 for directory and/or file requests.
10. DOVE is designed to transmit digital voice messages, but due to hardware and software difficulties, it has not yet met this objective except for a few short tests. Recently, it has been transmitting telemetry in normal AX-25 AFSK packet.
11. Letters in [ ] represent digital formats, as follows:
    [a] 1200 bps PSK AX-25
    [b] 1200 bps AFSK AX-25
    [c] 9600 bps FSK
    [d] Digitized voice (Notes 8 & 9)
12. PO-28 is available to amateurs on an intermittent, unscheduled basis.
13. Modes of operation used include: CW,/USB/FAX/Packet/RTTY
14. Modes of operation used include: FM (AFSK) & PSK Data.
15. Modes of operation used include: Packet & FM Voice.

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Satellite	Mode		Frequencies										
JAS-Ib (FO-20) (Notes 11 & 13)	JA Linear	Dn	435.800	810	820	830	840	850	860	870	880	890	435.900
		Up	146.000	990	980	970	960	950	940	930	920	910	145.900
	Bcn		435.795 (CW)										
	JD [a] Dgtl	Dn											435.910
		Up	145.850		145.890		145.910						
OSCAR 22 (UO-22) (Note 11)	[c]	Dn		435.120									
		Up	145.900		145.975								
KITSAT A (KO-23) (Note 11)	[c]	Dn		435.173									
		Up	145.850		145.900								
KITSAT B (KO-25) (Note 11)	[c]	Dn	435.175		436.500								
		Up	145.870	145.980									
IT-AMSAT (IO-26) (Note 11)	[a,c]	Dn		435.820 (Sec.)	435.867								
		Up	145.875	145.900	145.925		145.950						
EYESAT /AMRAD (AO-27) (Note 11)	[b,a]	Dn	436.800										
		Up	145.850										
POSAT (PO-28) (Notes 11 & 13)	[c]	Dn	435.250	435.280									
		Up	145.925	145.975									
MIR (Note 15)	[b]	Up & Dn & FM voice		145.550									
SHUTTLE (SAREX) (Note 15)	[b]	Dn	145.840										
		Up	144.450	144.470									

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

Satellite Launch Schedules

By Keith Stein

Space Transportation System (STS-NASA)

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

Mission Number	Launch Date/ Orbiter	Inclination Altitude	Mission Duration	Mission/Cargo Bay/Payloads
STS-76	March 1996/ Atlantis*	51.6/160	10 days	S/MM-03
STS-77	April 1996/ Endeavour**	28.4/160	9 days	SpaceHab-04

*Crew Assignment: CDR-Kevin P. Chilton, PLT-Richard A. Searfoss, MS-Shannon W. Lucid, MS-Linda A. Godwin, MS-Michael R. Clifford, MS-Ronald M. Sega.

**Crew Assignment: CDR-John Casper, PLT-Curtis Brown, MS-Daniel Bursch, MS-Mario Runco, MS-Marc Garneau (CSA), MS-Andrew Thomas.

STS Downlink Frequency Assignment:
VHF/UHF Voice: 145.55, 145.84, 243.0 (AM), 259.7 (AM), 279.0 (AM), and 296.8 MHz (AM)
UHF FCC: 416.5 MHz
S-band TLM: 2217.5, 2250.0, and 2287.5 MHz
C-band TRK: 5400-5900.0 MHz

MIR Downlink Frequency Assignment:
VHF band: 121.125 MHz, 121.750, 130.167, 139.208, 143.625, and 145.550 MHz
UHF band: 231.0, 233.0, 247.0, 249.0, 417.0, and 463.0 MHz
S-band: 2025-2100 and 2200-2290 MHz
Ku-band: 13 and 15 GHz

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March	Delta II	VAFB	MSX
March	Pegasus XL	VAFB	TOMS
March	Titan 4	CCAS	DSP 18
March	DC-X	WSTF	none
April	Atlas IIA	CCAS	INMARSAT 3 F1
April	Delta II	CCAS	Galaxy IX
April	Atlas I	CCAS	SAX
April	Delta II	CCAS	NAVSTAR GPS
April	Pegasus XL	VAFB	SWAS
April	Titan 4	???????	CLASSIFIED
May	Atlas IIA	CCAS	GE-1
May	Pegasus XL	VAFB	MSTI-3

Delta II Downlink Frequency Assignments:
S-band: 2244.5, 2241.5, and 2252.5 MHz telemetry
C-band: 5765.0 MHz tracking

MSX Downlink Frequency Assignment:
S-band: 2282.5 MHz
X-band: 8475.0 MHz

Pegasus XL Downlink Frequency Assignments:
S-band: 2288.5 MHz tracking transponder (transmit/downlink)
C-band: 5765.0 MHz

TOMS Downlink Frequency Assignments:
S-band: 2273.5 MHz telemetry

ORSTED Downlink Frequency Assignments:
S-band: 2290.0 MHz.

SAX Downlink Frequency Assignments:
S-band: 2245.5 MHz.

SWAS Downlink Frequency Assignments:
S-band: 2215.0 MHz.

GE-1 Downlink Frequency Assignments:
C-band: 3.7 - 4.2 GHz
Ku-band: 11.73 - 12.17 GHz.

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March	Proton	Baikonur	Priroda
March	Proton	Baikonur	Astra 1F
March	Cosmos	Plesetsk	Cosmos (Navigation)/ FAISAT 2V
April	Soyuz	Baikonur	Progress M-31

COSMOS (NAV) Downlink Frequency Assignment:
149.910-150.030 MHz, and 388-400.1 MHz.

FAISAT 2V Downlink Frequency Assignment:
400-401 MHz.

Progress M-31 Downlink Frequency Assignment:
165.0, 166.0, and 922.755 MHz.

Chinese Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March	Long March	Xichang	APSTAR A2

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
March	Ariane 42P	Guiana	MSAT-1
March	Ariane 4	Guiana	AMOS 1A
April	Ariane 4	Guiana	Palapa C2
May	Ariane 5	Guiana	CLUSTER (4), PHASE 3-D

Satellite Launch Schedules

Ariane 4 S-band:	**Downlink Frequency Assignments:** 2203.0, 2206.0 and 2218.0 MHz. telemetry
CLUSTER (4)	**Downlink Frequency Assignments:** CLUSTER 1-2242.0 MHz CLUSTER 2-2249.0 MHz CLUSTER 3-2277.0 MHz CLUSTER 4-2270.0 MHz CLUSTER SPARE-2256.0 MHz.

List of Abbreviations and Acronyms

AMOS	Israel telecommunications satellite
APSTAR A2	Asia Pacific Telecommunications Satellite owned by Chinese government-backed companies.
ARGOS	The Advanced Research and Global Observation Satellite will conduct global imaging of the ionosphere with eight experiments during a 3 year mission.
Astra 1F	These satellites will establish a medium-power DBS system for TV distribution from geostationary orbit.
C-band	3700-6500 MHz
CCAS	Cape Canaveral Air Station, Florida
CDR	Commander
CLASSIFIED	A classified U.S. Department of Defense payload.
CLUSTER	The four spacecraft will study the bow shock, dayside cusp, magnetopause, and the geomagnetic tail of Earth's electromagnetic field.
COSMOS	A Russian launcher and also the cover program name for Russian military and civilian satellites.
CSA	Canadian Space Agency
DC-X	Delta Clipper-X experimental single-stage-to-orbit vehicle.
DSP-18	These U.S. Department of Defense early warning satellites sense targets at two IR wavelengths to avoid laser jamming and improve discrimination. The satellites also carry nuclear explosion detectors for the U.S. Department of Energy.
FAISAT	The system will provide data acquisition services, remote monitoring, tracking, personal and business non-voice messaging, and emergency communications/distress calls.
FCC	Flight Control Command
Galaxy IX	Hughes telecommunications satellite with principal applications including network TV, radio, VSAT, business video and data services.
GE-1	General Electric telecommunications satellite that will cover the continental United States including Alaska and Hawaii.
GHz	Gigahertz
INMARSAT	International Maritime Satellite, a commercial satellite series providing global maritime and aviation communications.
Ku-band	10.90 to 17.15 Ghz
MHz	Megahertz
MS	Mission Specialist.
MSAT-1	MSAT is a joint Canada-NASA project that will provide voice, message, and data communications.
MSTI-3	Planning to be launched into the same orbit as MSTI-2, MSTI-3 satellite will conduct dynamic stereo observations of tactical missile launches and Earth backgrounds.
MSX	Midcourse Space Experiment is designed to detect, acquire, and track targets and to discriminate lethal from nonlethal objects.
NAVSTAR	U.S. Air Force Global Positioning Satellite for military and civilian navigation services.
ORSTED	This satellite from Denmark will map Earth's magnetic field and charged particle environment.
PALAPA	Geosynchronous satellite communication system for the Republic of Indonesia.
AMSAT PHASE 3-D	Fourth launch of the third generation of amateur radio satellites.
PLT	Pilot
Priroda	A new module for the Russian space station Mir that will perform remote sensing of land, oceans and atmosphere.
Progress	An unmanned supply satellite used to bring food, fuel, and equipment to crew aboard the Russian Mir space station.
RNG	Ranging.
SAX	This Italian-Dutch spacecraft will conduct X-ray observations of binaries, pulsars, transients, supernovas remnants and stellar coronae.
S-band	2000 to 2300 Mhz
SMM-03	Shuttle MIR Mission-03 is a flight to the Russian Space Station MIR, to support design and assembly of the international space station.
SpaceHab	Commercially-owned pressurized module for conducting experiments in a man-tended environment. Also a series of payloads to be flown on the Space Shuttle.
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.
TDRSS	Tracking & Data Relay Satellite System
TLM	Telemetry
TOMS	Total Ozone Mapping Spectrometer will study stratospheric ozone.
TRK	Tracking
TT&C	Tracking, Telemetry and Command.
TTC&V	Tracking, Telemetry, Commanding and Voice.
UHF	Ultra High Frequency (300-1000 MHz)
VAFB	Vandenberg Air Force Base, California
VHF	Very High Frequency (30 to 300 MHz)
WTSF	White Sands Test Facility, New Mexico.

Keith Stein is a space analyst/freelance writer based in Woodbridge, Virginia.

![SI] # 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 and December 1995. The format of the listing is as follows:

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

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

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

Launch Date/Time / Epoch	Inclination	Intl Designator / Period	Satellite Name / Perigee	Mass / Apogee
1995 Nov 4/1422		1995-059A	RADARSAT 1	2,729 kg
1995 Nov 4.64	98.58 deg	100.43 min	774 km	784 km
1995 Dec 1.55	98.59 deg	100.68 min	788 km	794 km
1995 Nov 4/1422		1995-059B	Delta-2 2nd stage/ SURFSAT	960 kg ?
1995 Nov 4.64	98.59 deg	107.79 min	786 km	1,463 km
1995 Nov 4.71	98.59 deg	100.57 min	784 km	788 km

Radarsat 1 is an Earth observation satellite developed in Canada and managed by the Canadian Space Agency. Using Synthetic Aperture Radar (SAR), it will be used for environmental monitoring, coastal surveillance, ice reconnaissance, geology and mining, oceanography and fisheries, agriculture and forestry. Two packages, mass 19 kg each, comprised SURFSAT (Summer Undergraduate Research Fellowship Satellite) which remained attached to the Delta second stage. SURFSAT is to be used as a test vehicle by NASA, supporting deep space communications research and the training of station personnel at NASA's Deep Space Network. Launch from Vandenberg.

Launch Date/Time / Epoch	Inclination	Intl Designator / Period	Satellite Name / Perigee	Mass / Apogee
1995 Nov 6/0515		1995-060A	MILSTAR DFS 2	4,670 kg
No orbital data available				

Also called USA 115, second flight of the MILSTAR-1 satellite in the DFS (Development Flight Satellite) series of military communications satellites. Mass quoted above includes propellant. Reportedly located over 4 deg E. Launched by Titan-4/Centaur from Cape Canaveral: third stage entered geosynchronous orbit with the satellite.

Launch Date/Time / Epoch	Inclination	Intl Designator / Period	Satellite Name / Perigee	Mass / Apogee
1995 Nov 12/1231		1995-061A	Atlantis (STS-74)	93,000 kg
1995 Nov 12.55	51.64 deg	90.51 min	294 km	306 km
1995 Nov 15.27	51.65 deg	92.43 min	391 km	396 km
1995 Nov 18.66	51.64 deg	91.39 min	337 km	349 km
1995 Nov 12/1231		"1995-061B"	Docking Module (316GK)	4,087 kg
1995 Nov 15.82	51.64 deg	92.42 min	391 km	395 km

SMM-2 (Shuttle-Mir Mission), carrying five astronauts: K D Cameron (commander), J D Halsell (pilot), C A Hadfield (Canadian astronaut, mission specialist, MS-1), J L Ross (MS-2) and W S McArthur (MS-3). Orbiter carried in its payload bay a Russian-supplied Docking Module which has an androgynous docking unit at each end. One unit was docked with Atlantis and when the orbiter docked with the Mir Complex the other unit was docked with the multiple docking adapter on the Kristall module. Docking came Nov 15 at 0628 UTC. Astronauts and cosmonauts worked aboard the joint orbiter-Mir complex for two days and then Atlantis undocked Nov 18 at 0816 UTC leaving the Docking Module as a permanent part of the Mir Complex — it will be used for the future shuttle orbiter dockings with the Mir Complex. Atlantis remained in orbit for two further days. Mass quoted above is that projected for the time of landing. Returned to Earth at Kennedy Space Center Nov 20: main gear touchdown 1701:27s UTC, nose gear touchdown 1701:33 UTC and wheel stop at 1702:24s UTC. Since the Docking Module was never in independent flight it has not been assigned an international designator or a catalogue number, therefore the designator "1995-061B" shown above should be considered to be completely unofficial. The orbit quoted above for the Docking Module is actually that of the Mir Complex shortly after Atlantis docked with it.

Launch Date/Time / Epoch	Inclination	Intl Designator / Period	Satellite Name / Perigee	Mass / Apogee
1995 Nov 17/0120		1995-062A	ISO	2,498 kg
1995 Nov 17.02	5.35 deg	1,425.65 min	582 km	70,582 km
1995 Nov 28.66	5.17 deg	1,436.94 min	1,038 km	70,569 km

ISO is an *InfraRed Space Observatory*.science payload comprises four instruments mounted in a liquid helium cryotast beneath the telescope mirror: ISOCAM camera and polarimeter, ISOPHOT imaging polarimeter, SWS short-wave spectrometer and LWS long wave spectrometer. Launched by an Ariane 44P from Kourou: Ariane third stage left in an orbit similar to the first one shown for ISO.

Launch Date/Time Epoch	 Inclination	Intl Designator Period	Satellite Name Perigee	Mass Apogee
1995 Nov 17/1425		1995-063A	Gals 2	2,500 kg
1995 Nov 17.59	0.20 deg	1,443.09 min	35,799 km	36,048 km
1995 Nov 28.86	0.17 deg	1,440.26 min	35,787 km	35,949 km
1995 Dec 7.80	0.18 deg	1,436.27 min	35,773 km	35,807 km

Second flight of new-generation Russian direct broadcast satellite. Satellite reportedly to be used by Global DBS Company. Located over 71 deg E. Launched from Tyuratam using a four-stage Proton-K: third stage discarded in a 51.63 deg, 88.37 min, 188-200 km orbit, fourth stage (Block DM-2) in an orbit similar to the first one listed for Gals 2.

1995 Nov 28/1130		1995-064A	AsiaSat 2	3,379 kg
1995 Nov 28.34	25.58 deg	617.02 min	221 km	35,039 km
1995 Nov 30.05	14.04 deg	700.99 min	5,266 km	34,258 km
1995 Dec 17.79	0.41 deg	1,436.05 min	35,780 km	35,791 km

Launched for Asia Satellite Telecommunications Co Ltd in Hong Kong. Located over 100 deg E. Launched from Xi Chang using Chang Zheng 2C (CZ-2E) vehicle using the first Chinese-built EPKM.CZ-2E second stage left in a 28.01 deg, 89.31 min, 188-293 km orbit: EPKM (CZ-2 — E Perigee Kick Motor) uses an SPTM-17 solid propellant motor and was left in a 25.58 deg, 616.91 min, 214-35,040 km orbit.

1995 Dec 2/0808		1995-065A	SOHO	1,875kg
No orbital data issued				

Solar Heliospheric Observatory (SOHO) to operate at the L1 libration point, 1.5 million km from Earth on the Earth-Sun line. Science mission includes the continuous observation of the solar surface, corona and wind to permit investigation of the processes which form and heat the corona, create the solar wind and investigate the internal structure. Payload mass 640 kg. Launched from Cape Canaveral using an Atlas 2AS: the Centaur second stage was left in a highly eccentric orbit.

1995 Dec 5/2118		1995-066A	USA 116	13,500 kg ?
1995 Dec 6	98.7 deg ?	95.7 min ?	156 km ?	976 km ?
1995 Dec 31	98.7 deg ?	97.2 min ?	250 km ?	1,000 km ?

Photo reconnaissance satellite: no orbital data was issued for this launch, and the orbits listed above were quoted by ITAR-TASS. Launched from Vandenberg AFB using a Titan-4: Titan-4 second stage was probably left in an orbit similar to the first one listed above for the satellite.

1995 Dec 6/2323		1995-067A	Telecom 2C	2,283 kg
1995 Dec 7.21	6.99 deg	630.11 min	224 km	35,713 km
1995 Dec 21.74	0.14 deg	1,435.91 min	35,765 km	35,801 km
1995 Dec 6/2323		1995-067B	NSAT 2C	2,050 kg
1995 Dec 7.21	6.99 deg	630.23 min	224 km	35,719 km
1995 Dec 21.35	0.16 deg	1,436.12 min	35,756 km	35,818 km

Telecom 2C is a telephone and television communications satellite operated by France Telecom and Ministere Francais de la Defense. Mass quoted above is at launch: on-station the mass is 1,360 kg at the beginning of operations and the dry mass is 1,120 kg. Initially located over 0-1 deg E, but to be operated over 3 deg E. INSAT 2C is a business communications and television/radio broadcast satellite, operated by ISRO (Indian Space Research Organization). Mass of the satellite quoted above is at launch: dry mass is 980 kg. Initially located close to 92.5 deg E, but to be operated over 93.5 deg E. Launched by an Ariane 44L from Kourou: third stage discarded in an orbit similar to the first one listed for the satellites.

Launch Date/Time Epoch	 Inclination	Intl Designator Period	Satellite Name Perigee	Mass Apogee
1995 Dec 14/0610		1995-068A	Cosmos 2323	1,300 kg ?
1995 Dec 14.47	64.86 deg	675.24 min	19,102 km	19,132 km
1995 Dec 23.62	64.83 deg	666.85 min	18,679 km	19,133 km
1995 Dec 14/0610		1995-068B	Cosmos 2324	1,300 kg ?
1995 Dec 14.47	64.86 deg	675.24 min	19,102 km	19,132 km
1995 Dec 15.35	64.75 deg	675.84 min	19,112 km	19,154 km
1995 Dec 14/0610		1995-068C	Cosmos 2325	1,300 kg ?
1995 Dec 14.47	64.86 deg	675.24 min	19,102 km	19,132 km
1995 Dec 24.12	65.08 deg	675.87 min	19,118 km	19,149 km

Three *Uragan* navigation satellites, launched into plane 2 of the GLONASS system to complete the network with 24 operating satellites. Launched using a four-stage Proton-K from Tyuratam: third stage discarded in a 64.81 deg, 87.71 min, 154-169 km, fourth stage (Block DM-2) in an orbit similar to the first one for the satellites.

1995 Dec 15/0023		1995-069A	Galaxy 3R	2,980 kg ?
1995 Dec 15.13	26.94 deg	603.37 min	201 km	34,349 km
1995 Dec 29.06	0.07 deg	1,435.74 min	35,753 km	35,806 km

Galaxy 3R is a telecommunications satellite, operated by Hughes Communications Inc: originally built as a ground spare for Galaxy 4 and Galaxy 7. Mass quoted above is at launch: at the beginning of operations on station the mass is about 1,690 kg and at the end of life about 1,320 kg. Satellite located over 265 deg E.Launched from Cape Canaveral using an Atlas 2A: second stage (Centaur) in an orbit similar to the first one listed for the satellite.

1995 Dec 18/1432		1995-070A	Progress-M 30	7,250 kg ?
1995 Dec 18.78	51.61 deg	89.61 min	194 km	316 km
1995 Dec 20.84	51.65 deg	92.46 min	391 km	399 km

Unmanned cargo freighter, carrying supplies to the cosmonauts aboard the Mir Complex. Docked with the Mir Complex at the -X port (at the rear of Kvant 1) Dec 20 at 1610 UTC. Launched from Tyuratam using a Soyuz-U: third stage (Block I) left in an orbit similar to the initial one listed for the satellite.

1995 Dec 20/0052		1995-071A	Cosmos 2236	3,150 kg ?
1995 Dec 20.15	65.02 deg	92.78 min	407 km	415 km

*US-P*EORSAT (ELINT Ocean Reconnaissance Satellite), launched to operate with Cosmos 2293 (1994-072A) and Cosmos 2313 (1995-028A). In addition to the standard military payload, this EORSAT also carries KONUS-A (mass 131 kg), a gamma-radiation payload developed by the Ioffe Physics Institute of St Petersburg together with KB Arsenal: KONUS-A carries a gamma radiation spectrometer, detector and a small steerable telescope. Launched from Tyuratam using Tsyklon-M: second stage discarded in a low 65.00 deg, 89.58 min, 112-395 km orbit.

Launch Date/Time Epoch	Intl Designator Inclination	Period	Satellite Name Perigee	Mass Apogee
1995 Dec 28/0645	1995-072A		IRS 1C	1,250 kg
1995 Dec 28.75	98.59 deg	101.12 min	806 km	818 km
1996 Jan 1.75	98.59 deg	101.24 min	816 km	818 km
1995 Dec 28/0645	1995-072B		Skipper	230 kg
1995 Dec 28.75	98.59 deg	101.12 min	807 km	817 km
1995 Dec 28.82	98.57 deg	101.06 min	804 km	813 km

IRS 1C (Indian Remote Sensing) is the third satellite in the series to be launched on a commercial basis using Russian launch vehicles: the first two launches used the Meteor variant of the Vostok launch vehicle. Skipper is a joint US-Russian satellite: Utah State University provided the forward instrument section and the Moscow Aviation Institute the satellite bus. Satellite is to investigate aero thermo chemistry and aero braking as it dips into the atmosphere. After check-out, the satellite will manoeuvre to a 150 km perigee orbit and then perigee will be reduced in 10 km steps until orbital decay takes place. Completely new launch profile for the Molniya-M vehicle, with the fourth stage (Block 2BL) being used for orbital injection (orbit similar to the first one listed above for each satellite), all other stages being sub-orbital.

1995 Dec 28/1150	1995-073A		EchoStar 1	3,288 kg
1995 Dec 28.79	24.39 deg	617.86 min	222 km	35,081 km
1996 Jan 4.57	3.07 deg	1,105.37 min	22,970 km	35,100 km

EchoStar 1 is a telecommunications satellite, launched for the EchoStar Satellite Corporation. Mass quoted above is at launch. Satellite to be operated over 241 deg E. Launched from Xi Chang using a CZ-2E with the first EPKM third stage: CZ-2E second stage discarded in a 28.00 deg, 89.31 min, 191-290 km orbit, EPKM left in an orbit similar to the first one listed for the satellite.

1995 Dec 30/1348	1995-074A		X-Ray Timing Explorer	3,035 kg
1995 Dec 30.55	28.73 deg	92.25 min	160 km	609 km
1995 Dec 30.73	22.99 deg	96.18 min	565 km	585 km

XTE (X-ray Timing Explorer) carries equipment for the detailed monitoring of the X-ray universe. Launched from Cape Canaveral using a Delta-2 (7920-10) vehicle: second stage discarded in a 24.95 deg, 92.29 min, 178-596 km orbit. Initial orbit quoted for XTE is for the Delta-2 second stage/XTE assembly before the second stage performed manoeuvres to change the orbital inclination and circularize the orbit: usually this orbit is not catalogued for Delta-2 missions.

Updates and Additions (Note: All dates refer to 1995 unless otherwise specified.)

International Designation	Comment
1983-026B	It was previously reported that TDRS 1 manoeuvred off-station over 83-84 deg E approximately May 9, but no up-date showing the relocation of the satellite has been included.The orbital location of TDRS 1 was stabilized over 220-221 deg E approximately Aug 6. Approximately Dec 11 the satellite was again manoeuvred off-station and still was drifting to the east at the beginning of 1996.
1983-059C	The location of Palapa-B 1 was maintained over 133-134 deg E until mid-October when the satellite began to drift off-station. At the end of November it was located over approximately 129.5 deg E and still drifting to the west.
1984-101A	Galaxy 3 was retired from service Sep 30 and boosted into a drift orbit approximately Oct 3 (although a Hughes Communications press release suggests that the satellite was also de-activated on September 30). Add the following retirement orbit: 1995 Nov 2.46, 0.68 deg, 1,442.37 min, 35,876 km, 35,943 km
1984-114A	It was previously noted that Spacenet 2 had apparently manoeuvred off-station over 290-291 deg E. In fact, the satellite is still located at this longitude and the apparent *manoeuvre* appears to have been a bad two-line orbital element set.
1985-025A	It was previously reported that INTELSAT 510 had manoeuvred off-station over 65-66 deg E approximately Mar 5-6, but no up-date showing the relocation of the satellite has been included. The satellite's longitude was re-stabilized over 55-56 deg E approximately Mar 21.
1985-086C	It was previously noted that ASC 1 had drifted off-station in October 1994. Since the satellite performed no orbital manoeuvres during 1995 it can be assumed that the satellite is dead.
1987-022A	It was previously reported that GOES 7 had manoeuvred off-station over 246-247 deg E during 1994 Dec 20-30, but no up-date showing the relocation of the satellite has been included. The satellite's longitude was stabilized over 224-225 deg E at the end of January 1995.
1988-051A	METEOSAT 3 has been retired after being boosted off-station Nov 21. Add the following retirement orbit data: 1995 Nov 22.93, 2.82 deg, 1,485.26 min, 36,725 km, 36,762 km
1989-020B	It was previously reported that METEOSAT 4 had manoeuvred off-station over 352 deg E approximately May 11-12, but no up-date showing the relocation of the satellite has been included. The satellite's longitude was stabilized over 8-9 deg E approximately Jun 24. METEOSAT 4 has been retired after being boosted off-station Nov 7. Add the following retirement orbit data: 1995 Nov 9.00, 1.50 deg, 1,482.89 min, 36,619 km, 36,777 km
1989-041B	DFS 1 was manoeuvred off-station over 32 deg E during Dec 13-14 and was still drifting to the east at the beginning of 1996.
1989-070A	It was previously reported that Himawari 4 had manoeuvred off-station over 139 deg E approximately Jun 9, but no up-date showing the relocation of the satellite has been included. The satellite's longitude was stabilized over 119-120 deg E approximately Jul 20.
1990-016A	It was previously reported that Raduga 25 had manoeuvred off-station over 69-70 deg E approximately Feb 26-27, but no up-date showing the relocation of the satellite has been included. The satellite's longitude was stabilized over 189-190 deg E approximately Apr 14.
1991-010A	Cosmos 2133 drifted off-station over 80 deg E during August 1995 and appears to be no longer operating.
1994-009A	The name of the satellite is MILSTAR DFS 1 ("Development Flight Satellite"): reportedly located over 240 deg E.
1994-012A	It was previously reported that Raduga 31 had drifted off-station over 44-45 deg E, with the final orbital correction having taken place in mid-May 1995. The satellite continued to drift through to the end of 1995 and therefore it is deemed to be no longer operating.
1994-022A	It was previously reported that GOES 8 had manoeuvred off-station over 268-269 deg E approximately Feb 2, but no up-date showing the relocation of the satellite has been included. The satellite's longitude was stabilized over 284-285 deg E approximately Mar 30.
1994-060A	Cosmos 2291 was re-located over 345-346 deg E approximately Nov 4.
1994-088A	Cosmos 2305 was de-orbited Dec 18. If it re-entered the atmosphere during a nominal recovery pass then re-entry would have been Dec 18.9.
1995-025A	GOES 9 was manoeuvred off-station over 269-270 deg E approximately Dec 5, and was still drifting to the west at the beginning of 1996.
1995-053A	Progress-M 29 undocked from Kvant 1 at the rear of the Mir Complex (-X port) Dec 19.39 at 0915 UTC and was de-orbited at 15.26 UTC. The mass of the spacecraft at the time of undocking was 5.694 kg.
1995-057A	Add the following orbital data for UFO 6: 1995 Nov 5.92, 5.10 deg, 1,436.01 min, 34.985 km, 36,585 km. The satellite is located over 190 deg E.

GROVE
COMMUNICATIONS
EXPO

Expo '96 Dates and Keynote Speaker Announced

By Larry Van Horn
Expo '96 Publicity Chairman

"Share the experience, bring a friend" is the theme for the 7th annual *Grove Communications Expo* that will be held on October 18-20, 1996 in Atlanta, Georgia.

In commenting on this year's theme Bob Grove, President of Grove Enterprises said, "Just as we host the Expo as a gesture of good will to the radio hobby community, you can be an ambassador for recreational monitoring by bringing a friend to the Expo. With growing pressure from commercial interests to own the radio spectrum and lock out listeners, our numbers are what speaks loudly to the law makers. I'm looking forward to seeing you all this year, and to seeing fresh faces as well."

Formerly known as the *Monitoring Times* convention, the name of this popular annual event was changed in 1995 to the *Grove Communications Expo.* The name change was made to broaden the scope of the annual event to cover new and emerging communications technologies.

To help foster the Expo theme, Grove is offering special rates to convention registrants who bring along someone who has not attended a previous convention. If you bring a full registrant to the Expo you can take $10.00 off your regular registration fee of $55.00 for the weekend full of activities. In order to get the special rate, both registrants must register at the same time.

The highlight of this year's Expo is the Saturday night banquet. NASA astronaut and astronomer, Ron Parise, WA4SIR will deliver the keynote speech. Dr. Parise has made two trips into space aboard the space shuttle and during those missions operated the shuttle amateur radio experiments (SAREX). Tickets for the Saturday night banquet are $25.95 and seating is limited, so make your banquet and convention reservations early.

Astronaut Ron Parise

Prizes are a standard feature at the Expo!

Several special events will be conducted in conjunction with this year's Expo. The Society of Amateur Radio Astronomers (SARA) will be conducting their fall conference for their members during the Expo weekend. Members of SARA can attend their conference for a $25.00 fee. SARA will also be conducting radio astronomy workshops, forums and exhibiting at the Expo throughout the weekend. Full registrants to the Grove Expo are welcome to attend any of these forums and workshops as part of their registration fee.

On Friday night, October 18, the Expo will sponsor an International Shortwave Broadcasters forum that will be hosted by noted broadcast host Ian McFarland. We expect broadcasters from stations around the world to be in attendance. Some of these broadcasters will also have exhibits at the Expo.

Exhibitors have already started signing up for displays at this year's Expo. AMSAT, Bay Area Scanning Enthusiast (B.A.S.E.), Computer Aided Technologies, Dallas Remote Imaging Group, (D.R.I.G.), Grove Enterprises, *Monitoring Times*, Optoelectronics, Radio Astronomy Supplies, *Satellite Times*. Signal Intelligence (ScanStar), the Society of Amateur Radio Astronomers, Sony, Swagur Enterprises (manufacturer of weather satellite receiving systems), and Worldwide UTE News Club are just a few of the companies and organizations that have signed up for booths. Companies, clubs, and broadcasters can get more information or secure exhibition space by contacting one of the following:

Debbie Davis — *Satellite Times*
Advertising Manager
704-837-6412; e-mail:
debbie@grove.net

Beth Linebach — *Monitoring Times*
Advertising Manager
704-389-4007; e-mail:
beth@grove.net

This year's seminar program has been expanded greatly. Over 40 seminars covering topics on computers, the Internet, radio astronomy, satellites and space, and scanning and shortwave radio by some of the world's leading experts in their fields will be conducted. Live demonstrations of equipment and listening techniques by convention speakers and exhibitors at the Grove Listening Post will also be a part of the program. Future *Expo Update* columns will have complete details on these seminars and the speakers.

"We are going to have the biggest and best Expo ever this year," said Judy Grove, this year's Grove Comm Expo coordinator. "We had a low turnout last year, due to some mistakes on our part, but that will change this year."

The Expo will be held at the Atlanta Airport Hilton and the hotel is offering a special convention rate of $76.00 plus tax per day, single or double occupancy. To make your hotel reservation for the three day event call the Hilton hotel chain toll free number 1-800-Hiltons. You must mention the Grove Communications Expo to receive the special convention rate.

Complete details on the Expo 96 are available at the Grove Internet home page on the Internet. Point your web browser to URL address: ***http://www.grove.net/hmpgexpo.html*** for the latest information and Expo updates. You can also register for the Expo by sending e-mail to the following address: ***expo96@grove.net***. An automatic Expo information service is available by sending e-mail to ***expo96-info@grove.net***. To register by phone, call the Grove order line at 1-800-438-8155 or by fax at 1-704-837-2216.

In the words of one attendee from last year's Expo, "The *Grove Communications Expo* is truly a unique event. I enjoyed the experience of meeting all the friendly hobbyists in a very relaxed atmosphere of learning, seeing, doing, and sharing. I will never miss another one." And neither should you.

ST AMATEUR RADIO SATELLITES

By John A. Magliacane, KD2BD

Contacting The Mir Orbital Complex

Ever since its launch in February 1986, the Russian space station Mir has held special interest among space enthusiasts. Mir is the world's first permanently manned spacestation. Its high orbital inclination takes it over most populated regions of the globe, and its large size makes it easily visible in the early evening and early morning skies. Except for several brief periods of time, the Mir orbital complex has been occupied on a full-time basis by various crews for the past ten years. But just what do Mir cosmonauts do for recreation after their daily work is complete?

Since the installation of a VHF-FM amateur radio station on Mir in November 1988, a favorite recreational activity for every crew inhabiting the Mir orbital complex has been establishing amateur radio contacts with ham radio operators all over the world. In this issue of *Satellite Times*, we will discuss the proper operating procedures for contacting the cosmonauts on Mir.

A Brief History

The majority of the amateur radio activity from Mir over the years has been centered on the use of one of several 2-meter FM voice transceivers. The first transceiver, a 2.5-watt Yaesu FT-290R, provided limited coverage of the 2-meter amateur band, but allowed many exciting voice contacts to be made with ground stations. A ground plane antenna was mounted outside the Mir spacecraft for use with this transceiver by cosmonauts Vladimir Titov and Musa Manarov in November 1988.

Three years later, a second transceiver, an ICOM 228A/H, was brought to Mir along with a PacComm "Handipacket" packet radio Terminal Node Controller (TNC) and an AT-class laptop computer to provide wireless electronic mail capabilities. The addition of the packet radio TNC allowed the operation of a Personal Message System (PMS) on Mir so hams on Earth could exchange e-mail messages with the cosmonauts whenever it was most convenient.

The Mir cosmonauts typically use 145.550 MHz as a simplex communications frequency with hams on the ground. The term "simplex" means that a single frequency, in this case 145.550 MHz, is used as both a downlink and as an uplink frequency to the Mir orbital complex. In an effort to dodge some of the interference on this popular frequency, Mir occasionally switches to unpublished frequencies, just as the SAREX experiments on the U.S. Space Shuttles do for special purposes. Last year, several voice contacts were made between school children and the cosmonauts on the Mir orbital complex using a pre-arranged schedule and an unpublished operating frequency. The success of these contacts brought great joy not only to the school children on the ground, but also to the cosmonauts in space.

How Much Power?

A frequently asked question is, "How much transmitter power is required to reach the Mir orbital complex?". Based on the slant range to Mir during a typical pass, the frequency and mode of operation, the antennas used, and the sensitivity of the receiver used on Mir, the transmitter power required is only several milliwatts.

Narrowband FM voice signals can be easily copied with a signal level that is only 10 dB above the sum total of all noise received or generated by the front-end of the receiver. With no interference, the transmitter power level required to achieve this signal level is remarkably low. Once the signal level exceeds the noise threshold of the receiver, the capture effect starts suppressing the receiver noise, causing the desired signal to be heard loud and clear.

What happens when multiple signals are received at similar signal levels on the same frequency? The capture effect still takes place, but it takes a signal level at least 10 dB above the sum total of ALL other

The IC-228 receiver. (Photo by ICOM America)

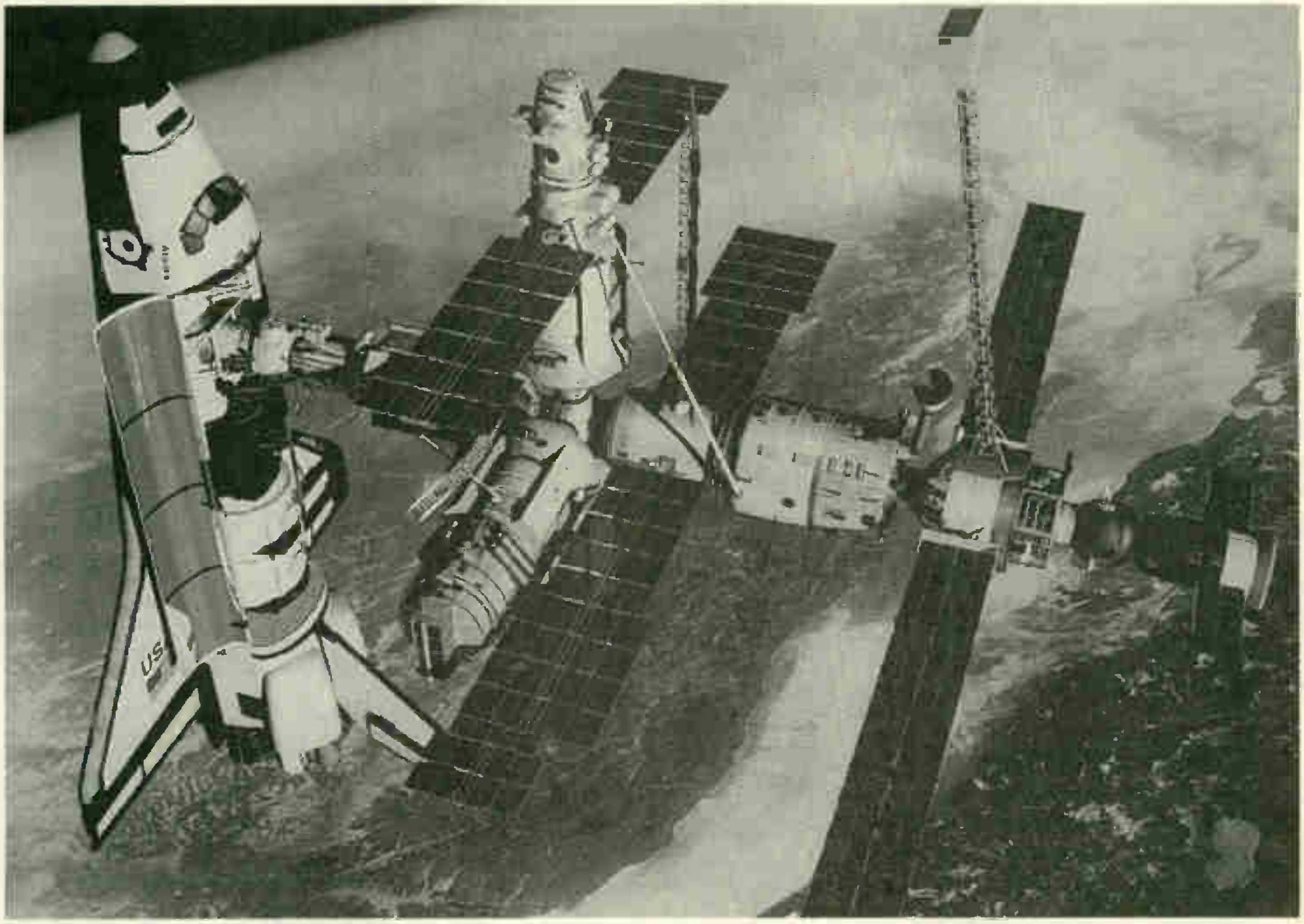


Photo by NASA.

signals on frequency to be heard. So, if ten stations, each with an effective radiated power (ERP) of 100-watts were competing with one another on Mir's uplink frequency, none would be heard. It would take a signal level of at least 10 dB above the sum total of all signals to be heard. In this case, that's 10 dB above 1000 watts, or an ERP of at least 10,000 watts to be heard on Mir — a far cry from just a few milliwatts!

On packet radio, the situation is worse. Packet radio communications is a strong signal mode that is very suseptible to corruption by noise. It only takes one corrupt bit in a packet radio frame to destroy the integrity of the entire frame. A signal level that produces at least 25 dB of receiver quieting is required for acceptable packet radio communications performance.

If ten packet radio stations are competing with one another on Mir's uplink frequency as in the example above, the signal level required to get through the interference equates to over 300,000 watts! Since packet radio uses short transmission times, the probability of transmitters from all groundstations under the footprint of Mir firing simultaneously is remote. There is a much greater probability that packets can be successfully received by Mir if they are carefully timed to interleve between those of other groundstations, allowing contact even with low transmitter power levels.

Mir Operating Procedures

Communicating with the cosmonauts on the Mir orbital complex is a very simple matter, and success is not hard to come by provided some simple operating procedures are followed and common sense is used. As the above examples show, the effects of interference between a high volume of groundstations trying to contact Mir can be very damaging to everyone's effort. Interference between groundstations competing with one another to contact Mir, especially over populated areas of the world such as North America and Europe, is the cosmonauts biggest criticisms of groundstations. Lets look at some operating procedures that can help reduce interference between groundstations, and increase everyone's chance of successfully contacting Mir.

The first "common sense" rule for contacting the Mir orbital complex is to make orbital predictions very carefully using the latest available Keplerian orbital data for Mir, and listen very carefully to Mir's downlink frequency to determine what mode of communications is being used by Mir when it comes into range.

Since Mir is capable of several different operating modes, it would be foolish to attempt a packet radio contact with Mir if the cosmonauts are engaged in a voice contact. Only if a cosmonaut is heard calling CQ is it wise to call Mir on voice. Keeping the call short and waiting a few

TABLE 1: Commands for Mir's Personal Message System (PMS)

B(ye)	B [CR] disconnects you from PMS.
H(elp)	H [CR] or ? [CR] displays this help file.
J(log)	J [CR] displays a list of callsigns heard (optional date/time)
K(ill)	K n [CR] deletes message number n (only to/from your callsign).
KM(ine)	KM [CR] deletes all READ messages addressed to your callsign.
L(ist)	L [CR] lists the 10 latest messages.
M(ine)	M [CR] lists the 10 latest messages to/from your callsign.
R(ead)	R n [CR] reads message number n.
S(end)	S (callsign) [CR] begins a message addressed to (callsign).
	Subject: max 28 characters ending with [CR].
	Text: End each line with [CR].
	End message by typing /ex [CR] or CTRL-Z [CR] at the beginning of a new line.
SR(eply)	SR n [CR] Sends a reply to message n prompting only for text.
V(ersion)	V [CR] displays the software version of the PMS system.

TABLE 2: Euromir Operating Frequencies

2m-Band

Voice:

Downlink 145.850 MHz
Uplink 145.250 MHz

Packet Radio:

Downlink 145.550 MHz
Uplink144.625 MHz,
145.550 MHz

Addtional Uplinks:
145.200 MHz, 145.225 MHz, 144.675 MHz, and 144.725 MHz

70cm-Band

Voice:

Downlink 437.925 MHz
Uplink 435.725 MHz

Packet Radio:

Downlink 437.775 MHz
Uplink 435.775 MHz

Additional Uplinks:
435.800 to 436.000 MHz with 25 kHz spacing

TABLE 3: Mir QSL information for all regions of the world

Please send a business-sized SASE along with your QSL.

Sergej Samburov, RV3DR
P.O. Box 73
Kaliningrad-10 City
Moscow Area, 141070, Russia
Russia only

Amateur Radio Station DF0VR at GSOC Control Center, Oberpfaffenhofen,
Munich, Germany

Thomas Kieselbach, DL2MDE
Joerg Hahn, DL3LUM
DLR Amateurfunkstation Oberpfaffenhofen
P.O. Box 1116
82230 Wessling, Germany
All of Europe except Russia

Contact with Thomas Reiter [DP0MIR]

Dave Larsen, N6JLH
P.O. BOX 1501
Pine Grove, California 95665
USA
All of USA, Canada, Australia, New Zealand & South America

seconds before transmitting will increase the chance of being heard by Mir as this will tend to intersperse the transmissions made by groundstations.

Also keep in mind that most cosmonauts speak Russian and are only confortable in their native language. Use standard phonetics where appropriate to make it easier for the cosmonauts to understand what is being said. Also, keep in mind that in space it's hard to tell whether a groundstation that has "disappeared" has gone out of range of Mir, or is simply being "covered up" by interference from other groundstations. Be patient, and avoid the temptation of picking up the microphone and calling Mir if you find the cosmonaut is losing contact with a groundstation. Follow the directions of the cosmonauts whenever possible.

Packet Radio On Mir

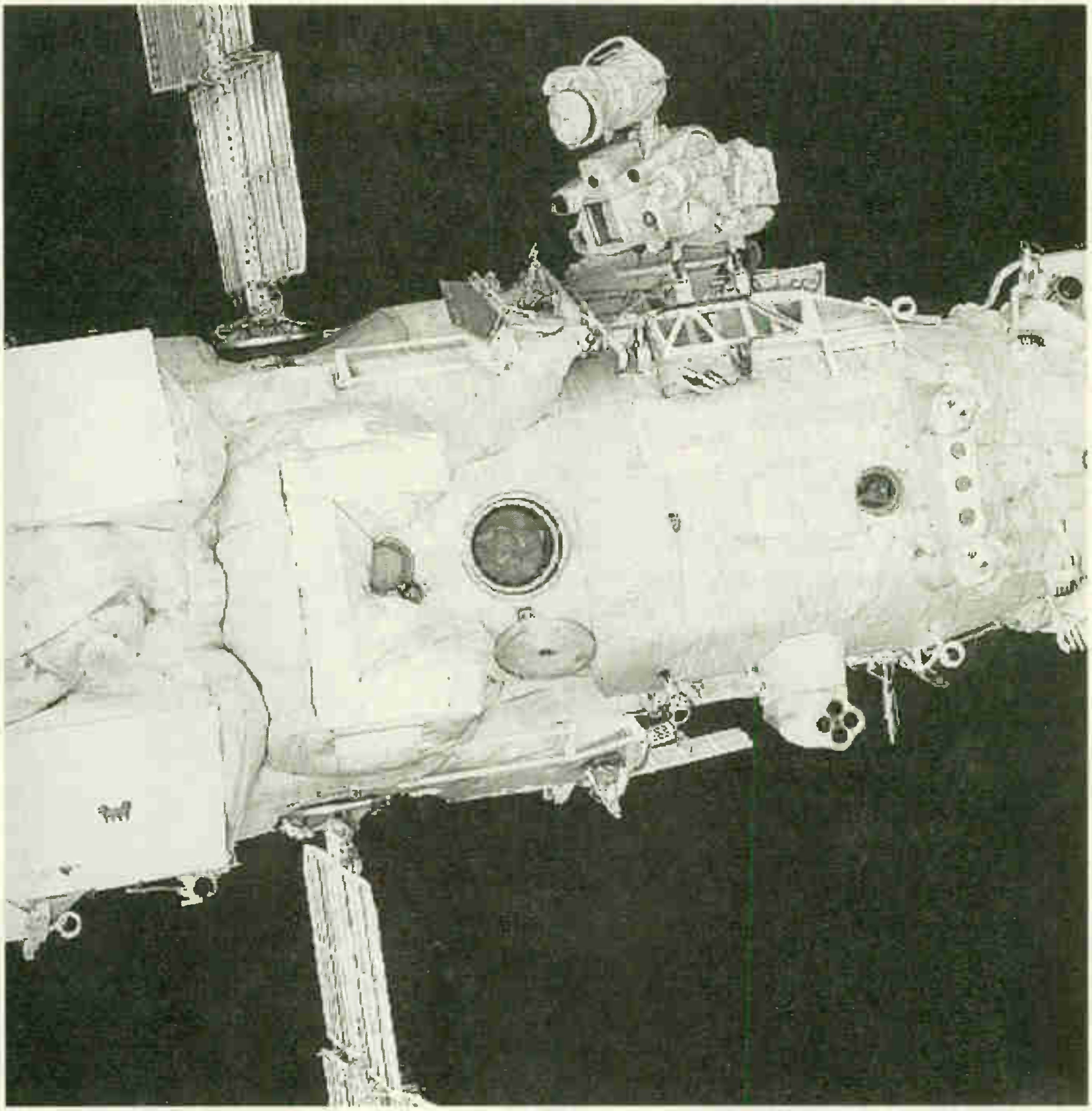
There are basically three different types of packet radio communications that can take place via the amateur radio station on Mir. Groundstations may access the Personal Message System (BBS mailbox) on Mir, they may establish a live keyboard "chat" with one of the cosmonauts, or they may use the Mir packet radio station as a digital repeater to establish live contacts with other groundstations too distant to allow a direct contact by way of groundwave propagation. Although these features exist, the packet radio station on Mir should only be used to exchange short electronic mail messages with the cosmonauts, and nothing else.

There are some very important reasons for limiting packet radio activity to cosmonaut e-mail only. The Personal Message System on Mir has a very limited storage capacity of only 22 kilobytes. This is adequate for several brief messages, but not much more. The Mir PMS should not be used to exchange messages between groundstations. Digital store-and-forward communication satellites called "Pacsats" have been designed, built, and are available for this purpose and should be used instead. Messages on the Mir PMS should also be deleted once they are read to free-up storage space on the PMS.

The Mir PMS should not be used as a digipeater, since the efficiency of Mir as a digipeater has been shown to be low, and digipeating off Mir only causes interference with the groundstation who is connected to the PMS. Again, Pacsat satellites can be used for this purpose, if needed.

The Mir PMS is very limited in that it is a single-user electronic message system. Only one groundstation may connect to the PMS at a time. All others must wait their turn. Attempts to contact the Mir PMS while it is in use will only cause interference with the current PMS user and result in a <BUSY> signal from Mir.

Careful monitoring of Mir's downlink



MIR STATION. Photo by NASA

packets can show if the PMS is actually connected to a groundstation. Groundstations MCOM TNC parameter should be turned ON. This will allow the monitoring of all packet frames coming from Mir, including connect and disconnect packets.

The packet radio station on Mir uses callsigns with two different secondary station identifiers (SSID). The PMS uses an SSID of '1', while the keyboard port uses an SSID of '0' (SSIDs of 0 are not normally displayed by terminal node controllers). Connections with the keyboard port should be avoided, unless it is obvious that a cosmonaut is at the keyboard and is looking to make a contact with a groundstation.

The proper procedure for contacting the Mir PMS is to wait until the current user disconnects from the PMS, and then initiate a connect request with the Mir PMS. Of all the groundstations attempting connections with Mir, only one will be successful. All others will receive a <BUSY> signal.

LOS

These restrictions may sound less than pleasant, but it is important to realize that the packet radio station on Mir is a single user system and is not designed for operation from an orbital complex. It works well and is a great asset to the cosmonauts, but only if proper operating procedures are closely followed. ST

ST THE VIEW FROM ABOVE

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

High-Resolution Image Systems (HRPT) Part II

In this edition of *The View From Above* we will continue our discussion on the high resolution weather satellite receiving systems, and specifically the ground station components for the High Resolution Picture Transmission (HRPT) images from the National Oceanographic and Atmospheric Administration (NOAA) polar orbiters.

HRPT visible image of the MidWest U.S. during the 1991 flooding period. Note the details in the rivers and areas sorrounding the rivers.

HRPT image of the English Channel supplied by the Remote Imaging Group in the U.K.

HRPT Groundstation Equipment:

Our last column we covered the basic components of a High Resolution Picture Transmission (HRPT) groundstation, including:

- Four foot parabolic dish
- Feed horn and quadrature combiner
- Low Noise Amplifier (LNA)
- Down converter
- Phase Lock Loop Demodulation section
- Bit Synchronization board
- Personal computer

In 1991, Dr. John DuBois provided a simple block diagram of an HRPT system, which has been reproduced here in Figure 1. Since that time more sophisticated commercial systems have been developed, but John's design is still an excellent starting point for a 'home-brew' system at minimal costs.

The Advanced Very High Resolution Radiometer (AVHRR) instrument onboard the NOAA polar orbiters transmit the imagery in real time — direct readout to the user groundstation — at 1698 MHz or 1707 MHz at 665.4 kbps.

This is a digital format as described in the January/February 1996 *ST* column. Due to the nature of the digital signal and high data rate, the HRPT imagery is simply more complex to receive than the analog Automatic Picture Transmission (APT) imagery, and thus, the groundstation equipment will be more complex and costly.

Once the digital signal is received by a parabolic dish — loop yagi antennas are very marginal in receiving NOAA HRPT transmissions — it must be amplified by an LNA and typically run through a down conversion stage to reduce signal loss in the coax. The downconversion allows for more conventional phase demodulation techniques to be used, again keeping the costs down for the amateur

The HRPT data stream is typically phase modulated onto the radio frequency (RF) carrier with a wing of +/- 67 degrees. By limiting the modulation to less then 90 degrees, the demodulation process is simplified. A well designed phase lock loop (PLL) circuit can lock onto the HRPT downlink signal and deliver the split phase bit stream from the phase detector.

The next stage of signal detection is to separate the HRPT bit stream into the clock and data components by synchronizing a local clock rate to the clock rate of the satellite transmitted data. The local clock is used to process the image data and to strip away the split-phase (Manchester) encoding employed by the AVHRR transmitter. HRPT data must then be massaged further to be able to identify the start of each image scan line and to separate the five wavelengths channels which were previously commutated together in one data stream. The personal computer software can then take these five separate channels of image data and display them as required.

Some specifics on the hardware:

Antenna and Feedhorn

Most HRPT groundstations typically use a least a four foot diameter parabolic antenna and some means of tracking the satellite. Many amateurs use small four foot TVRO type antennas with Yaesu or Imoto az/el rotators driven by the personal computer. Some amateur have tried to use a pair of loop yagi antennas, but typically the gain is just not sufficient for a good lock on the Binary Phase Shift Keying (BPSK) data, a gain of at least 24 dB is required, and the circular polarization can be a problem.

The feedhorn design used by DuBois and others is typically the *coffee can* design as used in many WEFAX installations. Two probes will be needed and placed 90 degrees apart around the outer diameter of the can. The coax from the two probes are combined into a quadrature combiner, also known as a 90 degree hybrid. The signal level coming out of the antenna, feedhorn, and combiner should be at least -116 dBm in the middle of the satellite pass with at least 35 degrees elevation.

Preamplifier

For those systems that will use a four foot parabolic dish, the preamp will require at least 30 dB gain and a noise figure of 0.8 dB or less. Several commercial preamps are readily available with this type of gain.

Down Conversion stage

Amateur systems typically use a downconversion stage to reduce the signal loss in coax from the antenna to the station in the shack. Earlier designs took the 1698 MHz signal and downconverted to 133 MHz and the 1707 MHz signal to 142 MHz. Several commercial designs downconvert to 137.5 MHz which is useful due to the fact one can use a regular APT receiver for the final receiver stage. A final stage of downconversion brings the VHF signal down to a convenient frequency for PLL demodulation. A typical choice in the earlier amateur units was 21.4 MHz which is a common IF frequency for microwave equipment. Newer designs vary in the specific frequencies used.

Demodulation Board

The schematic in Figure 1. shows the demodulator section, bit synch, and frame synch as being the final components in the HRPT signal processing agenda. The demodulator section acts as an amplifier-filter to raise the signal level and establish the final system bandpass for the phase demodulator, with 10-15 dB of gain required with a bandpass of around 3 MHz. These figures will provide a -30 dBm signal to the PLL demodulator.

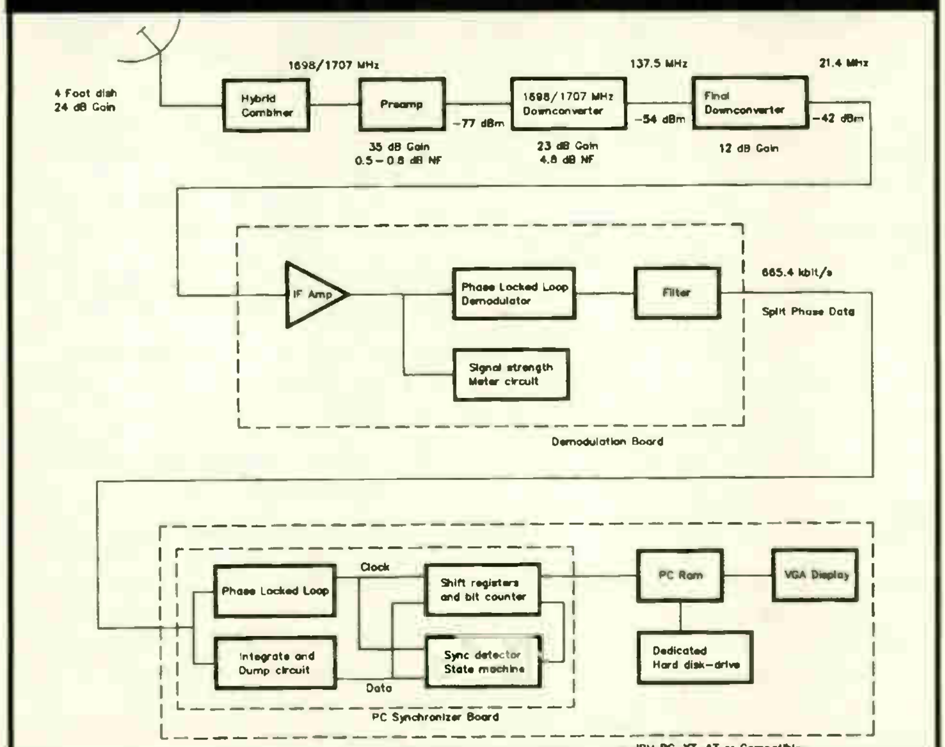
Bit and Frame Synchronizer board

This final system component extracts the 665 kbps clock rate and provides some means of decommutating the telemetry and different wavelengths of the HRPT scan lines (4 or 5 wavelengths, depending on the satellite AVHRR instrument capabilities).

The bit-synchronizer and DMA port board take the split phase HRPT signal from the demodulator board and process it. The clock is derived by a phase lock loop which ignores the data transitions and the data is extracted by means of a digital integrate and dump technique. Frame synchronization is accomplished by a state machine that examines the 60 bit pattern at the start of each HRPT scan line (minor frame). The minor frame contains one scan line of 2048 pixels of the four or five channel AVHRR data. The clock and data signal also go to a series of shift registers which form the byte or words that are brought into the personal computer memory by direct memory access techniques. Several variants of these circuits are used in commercial systems, but the overall design requirements remain similar.

HRPT image of the Iberian peninsula supplied by the Remote Imaging Group in the U.K.

FIGURE 1
Basic HRPT Ground Station



Personal Computer

The final system component is the personal computer, which has the software to display the HRPT scan lines and separate out the various wavelengths into different and/or combined images. These days an IBM 80486 computer with 16 megabytes of RAM, and at least 250 Mbytes of disk are required. Typically a satellite pass of 15 minutes can yield over 100 Mbytes of data for all five channels!

Various image processing programs can then be used to manipulate the HRPT images for vegetative indices, sea surface temperatures, etc.

Commercial Systems

Since the early DuBois HRPT design, many commercial systems have appeared on the marketplace that provide a fully integrated system with antenna, tracking, HRPT feedhorn, preamplifier, demodulator, bit and frame synch boards all included. This is not an inexpensive proposition, however. Most commercial HRPT systems start at over $ 10,000.00 and continue up from there!

What about kits? Several vendors will sell individual components for the home builder, including the receivers, demod board, bit/frame synch boards, and software to drive it. Spectrum International in the U.S. and TimeStep in the U.K. both market HIRPT system components at affordable rates.

Table 2 provides a sample listing of some of the HRPT system vendors. This list is not intended to be all inclusive, and a listing does not imply an endorsement of any of the companies in the list.

POES User Meeting June, 1996

The fourth International Satellite Direct Broadcast Services Symposium for the NOAA Polar-orbiting Observational Environmental Satellites (POES) will be held June 10-12, 1996 at Annapolis, Maryland.

This much heralded event will feature a panel of international speakers to inform users of current and future plans of United Sstates and international polar satellite systems. The core themes at this meeting will cover changes occurring with NOAA's new series of polar orbiting satellites, including NOAA K, L, M, and the changes to direct broadcast systems in the NOAA KLM era. Program registration information can be requested from:
Informatics, Inc., Attn: Judy Rumerman, 7501 Greenway Center Drive, Suite 700, Greenbelt, MD. 20770 USA, Tel. 301-345-2000 ext. 135, E-mail: **poesuser@infrmtcs.com**

Satellite and Education Conference to be held

The 9th annual West Chester Satellite and Education meeting will look at sharing environmental and communications satellite technology — *Technologies in the Classroom.* The dates for this meeting is set for March 20-22, 1996.

A broad series of presentations on Earth science, Internet, and remote sensing will examine classroom applications for elementary schools through universities, and lessons plans will be presented. The Dallas Remote Imaging Group (DRIG) will present a full-day lecture on the basics of weather satellite reception, satellite tracking, and digital image processing of satellite data.

For information, please contact:
Director, Educational Center for EOS, 304 Recitation Hall, West Chester University, West Chester, PA. 19383 USA, Tel. 610-436-2393, E-mail: **nmcintyre@wcupa.edu**

NOAA K slated for late 1996 or early 1997 launch

NASA's Jet Propulsion Laboratory (JPL), NOAA, and the U.S. Air Force continue testing of the NOAA-K spacecraft. Based on inputs from the USA concerning their most likely Titan-IV launch schedule, it now appears that the 1996 launch window for NOAA K will extend only through early October 1996. The next launch opportunity would begin in mid-February, 1997.

The AVHRR instrument for NOAA K has experienced some anomalies in the vibration testing, and the contractor has indicated that the instrument's delivery date will not be until March, 1996. Further thermal vacuum testing will need to be accomplished prior to integration with the NOAA K bus.

Next month we will review the high resolution GOES imagery, starting with Visual Atmospheric Sounder and ending with the new GOES 8 and 9 GVAR imaging systems.

We welcome your comments and questions about weather satellite imaging systems. Please direct them to Jeff Wallach at: **jwallach@drig.com**, or telnet into the bulletin board system at **bbs.drig.com** and have a personal chat with the Group! ST

POLAR ORBITER SATELLITE STATUS:

NOAA 9	137.620 MHz	OFF
NOAA 10	137.500 MHz	OFF
NOAA11	137.620 MHz	OFF
NOAA12	137.500 MHz	ON
NOAA14	137.620 MHz	ON
Meteor2-21	137.850 MHz	On as of Feb. 5, 1996
Meteor3-5	137.850 MHz	ON
Meteor3-6	137.850 MHz	OFF
Okean1-7	137.400 MHz	ON over Europe
SICH-1	137.400 MHz	ON over Europe

TABLE 1
Satellite Equipment Manufacturer's List — HRPT Systems

Array Systems Computing, Inc., 5000 Dufferin Street, Downsview, Ontario, M3H 5T5 Canada, (416) 736-0900

CTA Space Systems, Steven J. Talabac, Ground Systems Product, 6116 Executive Boulevard, Rockville, MD 20852, (301) 816-1385

Dawn Engineering Laboratories, Inc., Clara Vermillion, President, 2905 Mitchellville Rd., #101, Bowie, MD 20716, (301) 249-0670

Dornier GmbH, P.O. Box 1420, D-7990 Friedrichshafen, Federal Republic of Germany, (49) 7545-82290

Harris Corporation, Government Information Systems Div., P. O. Box 98000, Melbourne, FL 32902, (407) 242-4428

Information Processing Systems of California Inc., Jack Bottoms. 70 Glenn Way, Belmont, CA 94002, (415) 592-1742

ISSI — International Systems d Software, Inc., Rt. 3 Okaloosa Co., Industrial Park, 5749 John Givens Road, Crestview, FL 32536, (904) 682-2506
MacDonald Dettwiler & Associates, 13800 Commerce Parkway, Richmond, British Columbia Canada V6V 2J3, (604) 278-3411

MetSat, 515 South Howes, Fort Collins, CO 80521, (303) 221-5420

PCM Electronics Pty. Ltd., 6 Hood St., Collingwood Vic 3066, Australia
(03) 419 9088

Quorum Communications, Inc., Richard M. Fogle, 8304 Easters Boulevard
Suite 850, Irving, TX 76051, (214) 915-0256

Resource Systems , P.O. Box 723, Newtown, CT 06470, (203) 426-2127

SOFREAVIA, 75 ru La Boetie, 75008 Paris, France, 33 14 59 22 93

Sea Scan, 16065 Fifth Line Albion, R3 Caledon East, Ontario, Canada LON 1F0 (416) 880-0528

Sea Space,3655 Nobel Dr., Suite 160, San Diego, CA 92122, (619) 578-4010

Sinclair Communications, Inc., 51 Commerce Street, Springfield, NJ 07081, (201) 376-1272

Softworks, Inc. Weathertrac, P.O. Box 3114, Allentown, PA 18106, (215) 395-4441

Smartech, Kevin Davis, President, 1725 Signal Pont Road Charleston, SC 29412, (803) 795-5621

Systems West, Ken Ruggles, President, 27880 Dorris Drive, P.O. Box 222019, Carmel, CA 93922, (408) 625-6911

Telonics, Dave Beatty, 932 E. Impala Avenue, Mesa, AZ 85204-6699, (602) 892-4444

UKW-Technik Electronics GmbH, Janusz Sztajer, P.O. Box 60 *, Jahnstrasse 14 D-91083 Baiersdorf, Germany, (+49)9133-77940

VCS GmbH, Klaus M. Heidrich Borgmannstr. 2, D-4630 Bochum 7, Federal Republic of Germany, +49 234 26 36 88 23 30 41

This list may be downloaded from the DRIG FTP site as hrptvend.zip at **ftp.drig.com /pub/wefax**

Donald E. Dickerson, N9CUE

OmniTRACS®

When the Federal Emergency Management Agencies (FEMA) mobile emergency response support (MERS) unit arrived at the Federal Building in Oklahoma City, just after the bomb blast last year, their immediate concern was the establishment of communications systems that would be required to assure a reasonable response to the emergency could be mounted. Fortunately FEMA MERS units are equipped with OmniTRACS, a commercial radiolocation and messaging service provided by Qualcomm of San Diego, California.

This state of the art system , using GTE's GStar Ku-band satellites, provided the only communications link for FEMA during the first 18 hours of the emergency. Other FEMA systems failed to preform on this occasion.

The ease and reliability of the OmniTRACS system played a major role in FEMA's response. According to FEMA's communications manager Gene Davenport, "If it had not been for the flawless operation of the OmniTRACS system, we would not have been able to coordinate our communications and logistics support for the disaster."

FEMA is not the only government agency to take advantage of this satellite based data communication and radiolocation service. The Military Traffic Management Command (MTMC) has been using the OmniTRACS system to keep an eye on the transportation of munitions and explosives as they crisscross the country from one military instillation to another. The Department of Energy also uses this system to monitor the shipment of nuclear materials and radioactive waste. Both agencies have been using the OmniTRACS satellite system since 1989.

Qualcomm, OmniTRACS parent company, was formed in 1985 and the OmniTRACS service began operation in 1988. Since then they have made steady progress in establishing a worldwide network of satellites and ground stations capable of providing instantaneous data and radiolocation services for mobile users. To date there are over 150,000 transportation vehicles equipped with OmniTRACS data terminals worldwide which generates just under 2 million messages a day for over 450 transportation companies and other mobile users.

OmniTRACS was designed to provide data and radiolocation services to the backbone of our consumer driven distribution system, the trucking industry. Before you relegate OmniTrac as inconsequential to your consumer driven interest (most of you I am sure do not own a trucking company), take a look at the technology, hardware and the software used in the OmniTRACS system and let your imagination do the rest.

First, lets take a look at the hardware. The mobile terminal is an oxymoron, both simple and complex. It is simple in that it consist of a user friendly lap-top size keyboard, a radio transceiver and a roof mount antenna. That is where the simplicity ends.

In-cab communications using the OmniTRACS system ensures that drivers are never out of touch. The user-firendly keyboard prompts the operator with simple, straight forward language and commands.

The 22.86 by 30.48 cm (9- by 12-inch) keyboard can hold 99 messages at 600 lines and has a memory capacity of 4MB. It uses a microprocessor based system of highly advanced encoding/decoding circuitry and utilizes Qualcomm's exclusive Code Division Multiple Access (CDMA) technology. CDMA is becoming popular because of its ability to send large amounts of information over narrow bandwidths. It also allows the simultaneous use of the same frequency by several users without interference.

Sprint Telecommunications, Cox Communications, Comcast Corp. and Tele-Communications Inc. have recently announced that they will be using Qualcomm's CDMA technology in their Personal Com-

Three hardware components comprise the OmniTRACS Mobile Communications Terminal (MCT). The optional enhanced display unit (right) features a 15-line by 40-character screen that permits both text and high definition graphics.

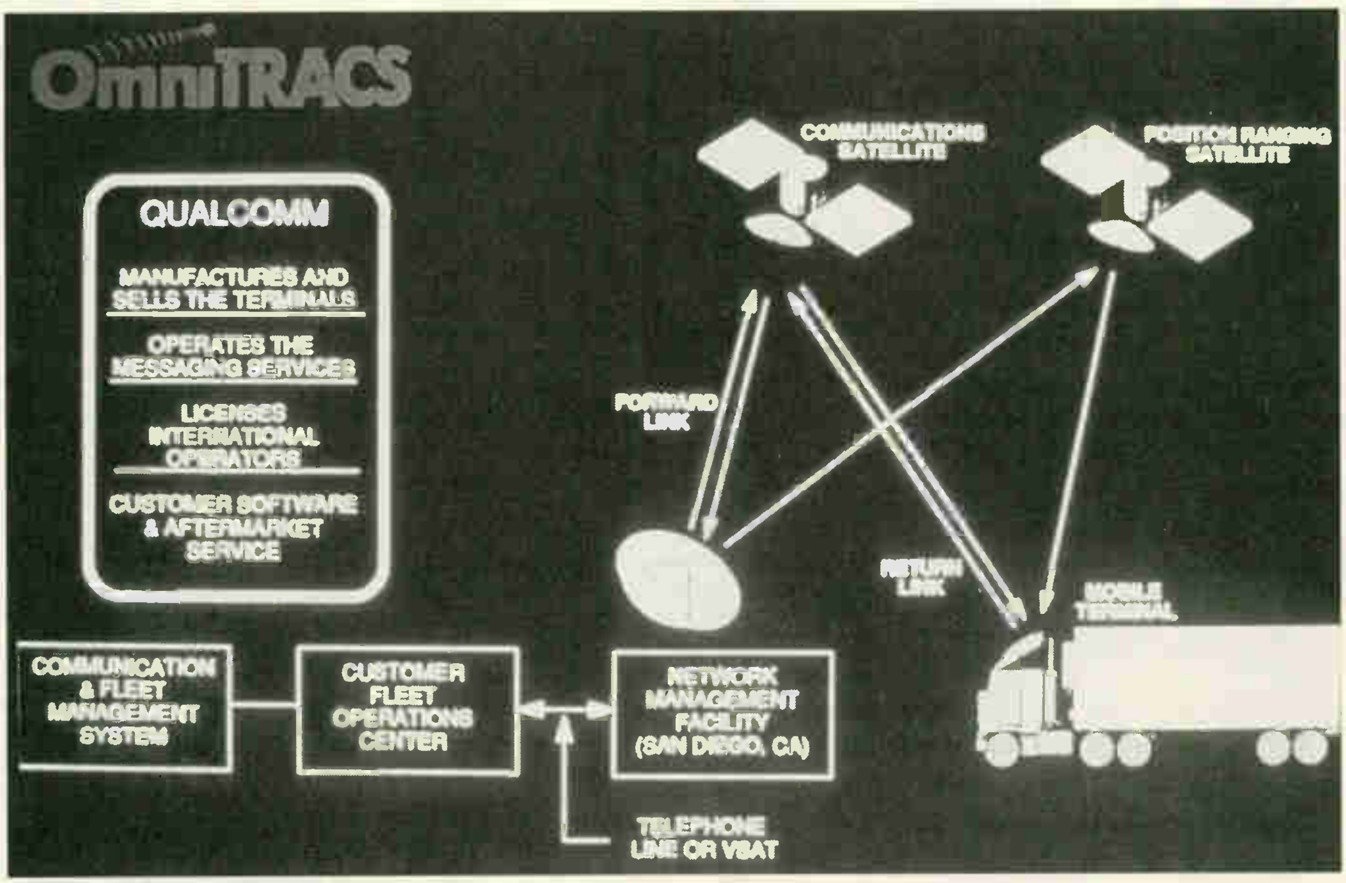


Diagram of the OmniTRACS system.

munications Services (PCS) markets in the US. Sprint will be offering local, long distance, wireless communications and cable video service packages to consumers and businesses alike. Deployment of CDMA cellular based phone systems is already underway.

The Omni Mobile Communications Terminal (MCT) automatically transmits precise vehicle location information hourly or on demand. The dispatch center can program the MCT to operate anytime independently of engine cut-off. It can be turned on and off from the dispatch center to take messages. The volume and frequency of the audio signal "beep", which indicates incoming message, can also be controlled at the dispatch center. The MCT can provide receipts for messages received and has the capability to send secure messages which requires a pass word to access.

The roof mounted antenna electronically tracks the GStar geostationary satellite while the vehicle is moving, not an easy task. It consists of several stacked yagi antenna of the strip-line design and is 29.21 cm (11.5-inches) in diameter and 15.24 cm (6-inches high). Of course, it is a Ku-band antenna.

OmniTRACS also offer three vehicle information system packages. SensorTRACS ™ is a comprehensive performance reporting system that functions much like a trip recorder or the black box which is carried by airlines. By monitoring onboard data, SensorTRACS ‡ helps reduce fuel costs and improves driver performance. Speed, idle time and mileage are among the items routinely monitored with this system. This type of information could be used to help lower fuel and maintenance costs and monitor driver performance.

JTRACS ™ is a vehicle diagnostics reporting system. With multiple sensor attached to the vehicle the engine systems, brakes, fuel battery, oil and other vital systems can be monitored with real time information being transmitted back to the dispatch center automatically.

The third system , TrailerTRACS ™ provides trailer identification, location and load status. Positive identification of each trailer with every connect or disconnect from a tractor is possible. A refrigerated trailer can also be electronically monitored with alarms being triggered when temperature or other conditions warrant.

The information collected by OmniTRACS systems allows the users to collect a great deal of information on both their drivers and equipment. It assist in inventory, maintenance, payroll, taxes, sales, and other business and accounting functions. This is pretty comprehensive data collection, but Qual comm's Decision Support System (QDSS) takes control of assets a step further. This software systematically considers key facts, forecasts and management priorities to recommend the right truck for the right load. The system uses sophisticated optimization of algorithms to maximize utilization of trucks to increase productivity. It can provide realtime recommendations for putting the right truck with the right load on the right road as efficiently and cost effectively as possible.

For example the QDSS software can make you aware of the fact that you are going to have say, six trucks passing through St. Louis tomorrow. You will know which ones are empty and which to try to find another load for. Or you may find it is advantageous to have drivers swap loads when their paths cross. This to can be done with the help of QDSS. This helps planners to better optimize freight selection, routes and vehicle utilization while considering customer needs while maintaining 100 percent on time delivery. QDSS even considers the driver hours, off time and other regulatory factors. QDSS will uncover more profitable ways to control your fleet. This is what makes the system unique. OmniTRACS system is not just a glorified, satellite-based beeper system. It is a high-tech, state-of-the-art management tool.

These programs are based on OmniTRACS's QTRACS software. Mobile messaging, position reports, trip reports, vehicle diagnostics and other customized information services can be integrated into your existing computer software system. QTRACS software is designed to support communications from your computer to the Qualcomm Network Management Center (NMC). The QTRACS program is available for a variety of platforms, including, PC, PC/LAN, midrange and mainframe systems in a variety of formats; DOS, OS/400, S36, ESA, PICK and UNIX. This allows dispatchers to send and receive messages through software and computer terminals you already have in the office. Messages can be grouped for simultaneous broadcast to specific individuals; drivers, sales reps etc.

Radiolocation is a standard feature of the OmniTRACS system. It allows precise satellite location of vehicles and displays, in text form, the number of miles to the nearest city or land mark such as a customers location or warehouse. A mapping capability is standard on PC/LAN systems for midrange and mainframe systems. With a VGA color monitor color graphics a US map can be displayed with a pan and zoom function which allows you to zero in on a specific vehicle locations.

OmniTRACS Network Management Center is located in San Diego and is the communications hub for all messages. The uplink facility transmits formatted messages to the Ku-band satellite located in the Clark belt. The MNC is fully redundant. It has duplicate computer systems and back up generators to maintain the control center in San Diego. A second fully equipped and backed up hub (MNC) is located in Las Vegas. There is also a redundancy build in to the satellite portion of the system. If a transponder on a particular satellite or a whole satellite is lost backups are available to prevent an loss or interruption in service.

Qualcomm is one of 10 companies in a limited partnership which will be launching a satellite system called Globalstar. Globalstar has received FCC license authorization to launch 48 satellites into low Earth orbit (LEO). Theses satellites will provide voice, data, fax and radiolocation services on a worldwide basis. Globalstar already has agreements with 73 countries to provide satellite services and is moving toward full financing.

Qualcomm has also recently entered into an agreement with Orbcomm. Orbcomm already has two of its own satellites in space with plans for 24 more in the future. Orbcomm has given Qualcomm exclusive resale rights to their radiolocation services. Globalstar will be a Big Leo system. This means it will use higher frequencies and data rates than the Orbcomm system.

You might think than Amtrak, America's national passenger rail service, is an unlikely candidate for OmniTRACS, but you would be wrong. Amtrak recently signed a contract with OmniTRACS to equip nearly half of their diesel locomotive fleet with satellite gear. They will be doing the same kind of things with the system that the trucking industry is doing with a couple of differences. Enhanced customer service is one of their top priorities. Passengers will be able to make use of this system much like airline passengers can pick up a phone and make a call from 40,000 feet.

There is one last application of the OmniTRACS system I would like to tell you about. It is taking place in Brazil. The Rio de Janeiro's police department has equipped its 600 patrol cars with OmniTRACS. It uses one of the C-band Brazilsat satellites. The applications being devised with this system are nearly endless. Remember I told you to let your imagination do the rest......till next time around. ST

RADIO ASTRONOMY

Jeff Lichtman

Bits and Pieces

On a recent trip to the Silicon Valley, for the first western regional meeting of the Society of Amateur Radio Astronomers (SARA), I met a group of very interesting and enthusiastic SARA members.

One of the members was Jeremy Nichols of Santa Clara, California. During our discussion we talked about various methods of recording radio astronomy data. Jeremy mentioned about the use of the family VCR. I thought I would share a few of his ideas in this issue of *Satellite Times*.

For data to be acceptable to professional astronomers or interchangeable among amateurs radio astronomers, a record of radio astronomy findings must be time stamped. Standard time and frequency radio stations such as WWV, CHU, or JJY are commonly used for this purpose. By using a two-channel recorder, the data can be recorded in one channel while the time stamp goes on the other.

An audio recorder (stereo) can be used, but without special modifications, it's limited to recording times of an hour or two. A better choice is a video cassette recorder (VCR). The commonly used (in almost all countries) VHS format machine can record up to six hours on a two hour tape in the SLP mode. A VCR capable of stereo sound recording provides the necessary two channels for recording data plus a time stamp. A VCR canbe connected to a radio telescope as illustrated in figure 1.

Since many homes already contain a VCR, the budding amateur radio astronomer only needs to borrow it during non-family viewing hours. Should the pressure for a dedicated recorder become irresistible, a used machine may be obtained for a very reasonable price. No fancy features such as, remote control or picture-in-picture are required; only the stereo audio is necessary for use as a radio astronomy data gathering system. If your lucky, you may even find a used portable video recorder (left over from the pre-camcorder period). These are battery powered and are quite suitable for field work.

So, talk it over with your family. Don't they deserve a new VCR this year? And the old one will then become an addition to your radio observatory.

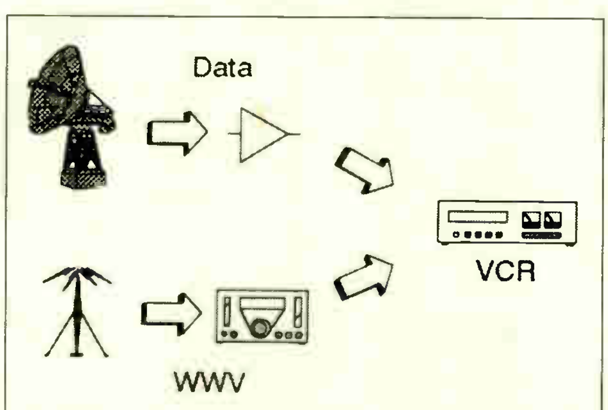


FIGURE 1: Two Channel Hookup to VCR

News from the VLA (Very Large Array)

When the Galileo Atmospheric Probe becames the first spacecraft to enter the atmosphere of Jupiter, the Socorro, New Mexico VLA facility had its electronic ears pointed toward Jupiter to monitor the event.. The signals from the Galileo spacecraft, that was launched in 1989, transmitted very faint radio signals. The data sent by these signals expect to help the program scientists to measure the giant planets climate, chemical composition, and wind speeds.

The probes radio signals transmitted this vital information as it descended towards its searing death under the tremendous heat in Jupiters lower atmosphere. The main Galileo spacecraft is currently relaying the probes data to earth. No direct transmission to Earth from the probe was originally planned.

The VLA observations recorded the shift in frequency of the probes radio signals as Jupiter's winds buffet the probe. Doppler shiftis the apparent shift in wavelength or frequency as a result of relative line-of-sight motion between the observer and the source of radiation. By monitoring the Doppler shift of the Galileo Atmospheric Probe scientists will be able to calculate the wind speeds on Jupiter.

The 335.7 kg (746 lbs) probe sent information about the Jovian atmosphere for 58 minutes during the parachute descension. Jose Navarro along with Preston and Folkner received information from the probe for the first 20 to 30 minutes of the decent.

The technical difficulties in receiving the signal were great. The probe had a 25-watt transmitter that was aimed at the main spacecraft, which is 90 degrees away from the direction of earth. This effectively reduced the apparent power to observers on Earth down to 7 watts.

Only a large radio telescope is capable of receiving such a faint signal, more than 100,000 times weaker than the faintest signal that a home FM radio is capable of receiving.

NRAO Makes Astronomical Data Available on the Internet

An original and comprehensive data set potentially full of scientific surprises now is available to astronomers, students and the public through the information superhighway. Radio images of the sky produced by the Very Large Array radio telescope — one of the premier astronomical instruments in the world — as part of a massive survey now are stored in an electronic repository available over the Internet computer communications network.

"Each of these sensitive new sky maps shows about a thousand radio-emitting objects, most of which have never been seen before," said Dr. J. J. Condon, leader of the National Radio Astronomy Observatory (NRAO) survey team. "We are releasing them as soon as they are completed because they contain more data than we could possibly analyze by ourselves."

"By using electronic distribution, we can open this tremendous resource of information for computer analysis by all astronomers immediately, without waiting for traditional publication," Condon added. The radio images are copyright NRAO/AUI. Permission is granted for use of the material without charge for scholarly, educational and private non-commercial purposes.

"It is entirely conceivable — even probable — that valuable discoveries will be made by students or amateur astronomers who devote the time to study these maps carefully," said team member Dr. W. D. Cotton. "Making this new information available electronically means that more people can participate in adding to its scientific value."

The maps are a product of the NRAO VLA Sky Survey (NVSS), which began its observational phase in September of 1993 and will cover 82 percent of the sky when completed by the end of 1996. The NVSS is expected to produce a catalog of more than two million radio-emitting objects in the sky, and it is the first sky survey sensitive to linearly polarized emission from radio sources beyond our own Milky Way galaxy. "The NVSS is being made as a service to the entire astronomical community," Condon said. The survey will require about 2,500 hours of VLA observing time to complete.

The data from the NVSS will become available in several forms, including complete processed maps, lists of the radio-emitting objects found, and data from which astronomers may produce maps tailored to their own interests. The data products are being placed in the public electronic repository as soon as NRAO scientists have verified their accuracy. Those interested should contact Condon at Internet address jcondon@nrao.edu for more information about accessing the data.

Education Programs at NRAO

In addition to the scientific research done at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia,they also host a number of educational activities through out the year. The largest of these is the science teacher training, a series of programs conducted in partnership with West Virginia University. These programs have been in existence since 1987 and are supported by the education division of the National Science Foundation (NSF) and the Benedum Foundation.

The training is directed to the middle and high school science teachers from whom most of the students get their initial exposure to science in the classroom. The goal is to increase teacher's understanding of science and technology, and their ability to teach it, by exposing them to real scientific research at the observatory. Teachers receive college credit from West Virginia University for their participation in the NRAO programs.

Since its beginning in 1987, the science teacher training programs have brought more than 440 teachers to Green Bank for the two-week summer courses that involve lectures on radio astronomy, actual scientific research using the 40 foot diameter radio telescope, detailed discussions about science education, and the construction of scientific instruments for use in the classroom. The teachers work very close with the NRAO scientists They also have a chance to interact with many professional astronomers who come from around the United States, and from other countries to use the modern facilities at Green Bank. After participation, in an NRAO training program, teachers host workshops for other teachers in their home district to spread information about the effective ways to present scientific information in the classroom. It is estimated that more than 15,000 teachers have benefitted from these programs.

This teacher training was initially concentrated on science teachers from the state of West Virginia. Shortly after the program began, it was broadened to include participants from the entire United States.

In addition, to science teacher training, there a number of other educational programs at the NRAO Green Bank.

Workshops for College Teachers: The observatory hosts two 3-day workshops for the science faculties of small colleges throughout the country to share results of current research in astronomy with as wide an audience as possible. This program is partially funded by the NSF (National Science Foundation).

Research Experiences for Undergraduates: This NSF funded program gives the undergraduate students in science, engineering and computer science the chance to work in a summer job one-on-one with observatory staff on a project related to their major field of study.

Public Tour Program: The public is invited to visit the Green Bank site. Hourly tours are given each day during the summer months, and tours can be scheduled for groups at any time of the year. Special in-depth tours are also occasionally arranged. Nearly 20,000 people visit the observatory each year. At present, the public tour program is being upgraded. Long-range plans include hands-on educational exhibits, historical material, and even the chance to watch observations in progress on the newly-constructed GBT (Green Bank Telescope).

Elderhostel Program: NRAO and Glenville State College host a one week workshop at the observatory. Participants receive instruction in basic astronomy and can use the 40-foot diameter radio telescope.

Local Outreach: The NRAO staff volunteers to be leaders of an after-school "science for fun" class for local elementary students. One 8 week session is held each year.

Special Events: In 1994, NRAO celebrated the 30th birthday of the 140-foot radio telescope. As part of the festivities, NRAO hosted an open house for West Virginia school children. Over 1100 students participated in hands-on activities and toured the 140 foot telescope.

For those of you interested in any of the above science teacher programs and who like to attend some of these events, an application form is available from Dr. Pat Obenauf, Associate Director NSF Institute, 604 Allen Hall, PO Box 6122, West Virginia University, Morgantown, WV 26506-6122. For additional information on this or any of the other above programs mentioned, please contact Ms. Sue Ann Heatherly, NRAO Educational Director, PO Box 2, Green Bank, WV 24944-0002.

I would like to thank Dr.J. Lockman (NRAO Green Bank Director), Ms. Sue Ann Heatherly (NRAO Green Bank Educational Director), Dave Finley (NRAO VLA Socorro) for the material used in this issue of *ST*'s Radio Astronomy column. ST

ST WHAT'S NEW

by Wayne Mishler, KG5BI

What's New?

Turn your computer into an armchair spacecraft

Take a spin around our solar system. Peek into a time capsule destined for Mars. It's all possible through your computer if you have a couple of interactive multimedia CD-ROM disks from Virtual Reality Laboratories.

"Distant Suns - First Light," a US $65 program on CD-ROM available from software stores or Virtual Reality, takes you on an interactive tour of the solar system and even lets you land on Mars.

You can hover over the planet of your choice from any vantage point in any year, season, or time of day. You'll see astronauts doing space walks, NASA simulations, and actual footage from the Apollo 13 mission. Or if you are really adventurous, you can strap onto the Galileo space probe and plunge into Jupiter's atmosphere. You can ride Haley's comet. Or your can stow away aboard the Voyager spacecraft.

And that's just the beginning.

The more studious armchair astronauts will probably find themselves turning the Milky Way on end to see what makes it tick. You can rotate it on your computer screen to see what it looks like from the other side – all sides, actually. And talk about your average every day time travel: this interactive desktop planetarium lets you see the heavens from any point on earth from 4713 BC to 10,000 AD (There's optimism for you.) See the sky from your own backyard (on screen) with planets and stars labeled so you can identify them. And of course you can print out star charts or display the Hubble Guide Star Catalog of 16 million stars. That should keep you busy until dinner.

A mouseclick brings up detailed information about any star, nebula, galaxy, pulsar, quasar or any other celestial object you could imagine.

You space historians out there can take a peek into the future at what the first Mars settlers will see when they discover a time capsule containing the CD-ROM disk entitled "Vision of Mars."

Conceived by the Planetary Society and produced by Time Warner, the US $69.95 interactive program, available only from Virtual Reality, will travel aboard the Russian space mission to Mars this year and be left there in a time capsule attached to the Mars '96 Lander.

Colonists who discover the disk may hear and see Astronomer Carl Sagan, writers Arthur C. Clarke and Judith Merril, and chief scientist of the Mars '96 mission Russian Vyacheslay Linkin speak to them about our hopes for their success, assuming of course that computers of that era will know what to do with a CD-ROM.

Also included is the audio of the Orson Welles' "War of the Worlds" radio broadcast that panicked America in 1938, and earth's reaction to the first images of Mars captured by the Viking space probe which landed on that planet in 1976.

Visions of Mars contains photos of space, artists renderings of Mars, and more than 70 books, short stories and articles written about Mars by well known authors.

Jon Lomberg directed the project. He was co-creator of the "Interstellar Record" which traveled aboard Voyager in the 1970s with highlights of life on Earth for any extraterrestrial beings who might discover it.

Because of its historical message to future space pioneers, Visions of Mars explains how it was created and lists the names of its creators. It comes with instructions written in Russian, English, French, German, and Fin. Those five countries were involved in its production.

Visions of Mars is available on CD-ROM for PC and Mac exclusively from Virtual Reality Laboratories. You can call them at 1-800-829-8754 from anywhere in the U.S.

Buy and sell satellite gear online

Looking to buy or sell satellite reception equipment or radio gear? Check out a new online classified advertising service called NET$MART. To advertise or shop nationwide all you need is a PC computer, modem and telephone. This is a dedicated online service specializing in advertising and marketing. You don't have to go through any other online service or the Internet to reach it. You can simply dial direct. There are no online charges. And right now the price of placing an ad is zero.

"Putting your ad on our online service is like posting it on a nationwide bulletin board," says the originator of NET$MART. "It features easy access without online charges or Internet fees."

There's no charge for connecting with the service and taking it for a test drive. You can get full access by paying a one-time registration fee of US $15. The price of placing ads, when the company begins charging for them, will vary with the number of ads you have running, ranging from 30 cents a day for one ad to 12 cents per day per ad for more than 10.

"The registration fee is good for as long as you remain current in our database by checking in at least once every 90 days," says NET$MART. "If we don't hear from you in that length of time you will need to re-register."

When you connect with the service and go to the classifieds, you will see on your screen a simple menu from which you can select search, enter, edit, delete or quit. You can search by category either nationwide, statewide or by zip code. When you choose "enter", you are presented with a form on your screen in which you type your ad. You can enter up to 535 characters (about 100 words.) When you save the ad, it goes into a hold file until the next workday to give the editorial staff time to approve and place it online. At any time before approval, you can pull up your ad and change it yourself by selecting that option from the menu. You can also delete any of your ads at any time just as easily. Selecting "quit" returns you to the online menu.

Once your ad is online, it is available to all other registered users nationwide. NET$MART empowers anyone to buy and sell nationwide through their home computers.

Connecting with NET$MART is as easy as calling your Aunt Maud (almost). The service is online from 6 p.m. to 8 a.m. daily central time. It works with high-speed modems to 14.4 bps. Have your computer dial the online phone number, 1-501-253-7172. In logging in the first time, you'll be asked for an access code. Visitors can use courtesy access code 55. When you register, you will be given your own code with full access to all of NET$MART's services.

Your own closed-circuit TV!

With the push of a button on your remote you can now switch from a satellite TV program on one channel to video cameras eyeing your front door and baby's room on other channels from your easy chair.

A tiny digital channel modulator from NetMedia displays standard video and audio from satellite receivers, home video cameras and even computers) on any TV screen. It's suggested retail price of US $225 brings closed-circuit TV within reach of any home or business.

Contained within The Micro Modulator MMOD70's 3.4 x 2.2 x 0.9 inch case is a built-in video sequencer for watching multiple video sources on a single channel. There are even optional provisions for audio alerts and automatic channel switching when triggered by security sensors such as motion detectors, door and window contacts, and pressure mats.

The unit modulates video to UHF or cable with digital controlled frequencies. Internally generated test bars and audio tones are useful for setting up the system even with no external video source connected. An internal video amplifier drives long cables or multiple video splitters without the need for additional amplification. The unit can be powered by a camera power supply or by its own, which is included.

Optional MS-DOS software and cable for use in programming multiple units is US $50. Information is available from NetMedia at 1-520-544-4567.

AEA data controllers now include GPS firmware

Advanced Electronic Applications (AEA) is now including Global Positioning System (GPS) firmware in its data controllers.

The new GPS firmware in the PK-232MBX and PK-900 data controllers automatically detect on powerup whether or not a GPS receiver is connected. If so, an initialization string is sent and the controller is made ready for GPS work. Otherwise the unit sets itself up for traditional packet data work.

The biggest feature of these two units is that the GPS commands can be remotely programmed. That is, in stand-alone installations where the controller, GPS receiver, and radio are not connected to a computer, such as when mounted in a vehicle, GPS parameters can be changed remotely. The units can also be remotely polled for GPS data at any time.

Other features of the new GPS firmware include setting the time and date from a GPS receiver, remote programming of the GPS receiver itself, and operation as a wide and relay digipeater. This means that mobile packet users can transmit and serve as a message forwarding mailbox – all while mobile.

AEA has developed new technology in its controllers for GPS packet usage. Digital users can now choose between units with simultaneous or switchable ports. Both units work with AEA's adapter cable which allows a data controller and GPS receiver to connect to a single computer communication port. This is especially important when the computer is a laptop with only one free port.

Upgrades are available through AEA. Prices range from US $35.50 to US $100.50 depending on which unit you wish to upgrade. For information call 1-800-432-8773. ST

By Dr. T.S. Kelso

System Benchmarking

Throughout the development of this column, we have been faced with two inescapable conclusions: satellite tracking can be computationally intensive and requires careful attention to ensure accurate results. These conclusions are inescapable regardless of whether you are developing your own satellite tracking software or using someone else's.

As a result of these conclusions, it becomes important at some point to consider the issue of benchmarks to assess certain performance characteristics of any satellite tracking system. As we shall see, benchmarks can be used for a variety of purposes: evaluating the performance of a particular hardware configuration, operating system, programming language, or specific satellite tracking application. Which consideration—speed or accuracy — is most important to you will depend upon your needs, but we will address several approaches to assess each.

Which benchmark is best to use depends heavily on the application. In the area of satellite tracking, we would expect the best benchmarks to be floating-point intensive, that is, to make heavy use of real calculations as opposed to integer calculations. We would also expect them to make heavy use of trigonometric and other mathematical functions. While we could use existing standard benchmarks, the drawback to this approach is that often it is not clear what the basis of the benchmark calculation is and, hence, how appropriate it is to assessing the performance of a particular class of applications.

This column (and the next) will endeavor to provide you with a suite of benchmarks that are not only simple but will also allow you to assess performance across the spectrum of operations. We will begin by developing a set of benchmarks with known solutions. The easiest of these is something known as the Savage benchmark.

The Savage benchmark is a particularly good benchmark for the fields of satellite tracking and astronomy. The reason it is so good is that it relies entirely on the repeated use of mathematical functions which yield a known (and easily calculable) numerical result. This benchmark is based on the use of matching inverse mathematical functions. Sample code, written for Borland Pascal 7.0, is provided in figure 1 below. Note that units from the SGP4 Pascal Library have been used to time the calculation.

The heart of the calculation consists of taking the variable *a*, starting with a value of one, and incrementing it by one 2,499 times until *a* = 2,500. To make things more interesting, though, we evaluate *a* using a set of three matching inverse functions: square and square root, exponential and logarithm, and tangent and arc tangent. The result of each pair of matching inverse functions *should* be the original value of *a* and the result of all the calculations should equal exactly 2,500. Of course, due to limitations of the hardware, operating system, and programming language the result will not yield exactly the expected result. How close we get to the approved solution and how quickly we can calculate it are the two dimensions of this benchmark. Table 1 shows the results for a range of systems in current use for differing levels of numerical precision.

The results are actually rather illuminating. Even the slowest machine beats the time of a Cray X-MP/24 from a decade ago.[5] And while the accuracy isn't quite as high as with the Cray, the adoption of standards for numerical processing has resulted in consistent results for standard data types. Finally, the use of numeric coprocessors allows high preci-

FIGURE 1: Pascal Code for the Savage Benchmark

```
Program Savage_Benchmark;
{$N+,E+}
  Uses
CRT,Support,SGP_Time,SGP_Init;
type
  test_type = extended;
var
  i,j                 : word;
  a                   : test_type;
  start,stop,dt       : double;
  time1,time2         : time_set;
Function Tan(arg : test_type) :
test_type;
  begin
  Tan := Sin(arg)/Cos(arg);
  end; {Function Tan}
BEGIN
  Program_Initialize('SAVAGE');
  Get_Current_Time(time1);
{*** Begin main program loop ***}
  for j := 0 to 9 do
    begin
    a := 1;
    for i := 1 to 2499 do
      a :=
tan(arctan(exp(ln(sqrt(a*a))))) + 1;
    end; {for j}
{*** End main program loop ***}
  Get_Current_Time(time2);
{** Calculate elapsed time **}
  with time1 do
    start := Julian_Date_of_Year(yr)
+ DOY(yr,mo,dy)
          +
Fraction_of_Day(hr,mi,se,hu);
  with time2 do
    stop  := Julian_Date_of_Year(yr)
+ DOY(yr,mo,dy)
          +
Fraction_of_Day(hr,mi,se,hu);
  dt := 86400*(stop - start);
{** Output elapsed time and result
**}
  GotoXY(31,12);
  Write('Elapsed time ',dt:8:2,'
seconds');
  GotoXY(31,13);
  Write('Answer is ',a:19:14);
  Program_End;
END.
```

FIGURE 2: SGP4 Test Program

```
Program SGP4_Test;
{$N+}
  Uses CRT,SGP_Intf,
       SGP_Init,SGP_Conv,
       SGP_Math,SGP_Time,
       SGP4SDP4;
var
  satnumber,interval,i : integer;
  delta,tsince,k1,k2   : double;
  pos,vel              : vector;
BEGIN
  sat_data[1,1] := '1 88888U
80275.98708465  .00073094  13844-3  66816-4 0
8 ';
  sat_data[1,2] := '2 88888  72.8435 115.9689
0086731  52.6988 110.5714 16.05824518  105 ';
  sat_data[2,1] := '1 11801U
80230.29629788  .01431103  00000-0  14311-1
';
  sat_data[2,2] := '2 11801  46.7916 230.4354
7318036  47.4722  10.4117  2.28537848      ';
  delta := 360;
  for satnumber := 1 to 2 do
    begin
    ClrScr;
    Writeln(sat_data[satnumber,1]);
    Writeln(sat_data[satnumber,2]);
    Writeln;
    Writeln('      TSINCE              X
Y              Z');
    GotoXY(1,12);
    Writeln('                         XDOT
YDOT            ZDOT');
    Convert_Satellite_Data(satnumber);
    for interval := 0 to 4 do
      begin
      tsince := interval * delta;
      if ideep = 0 then
        begin
        GotoXY(1,4);
        Write('SGP4');
        SGP4(tsince,iflag,pos,vel);
        end {if SGP4}
      else
        begin
        GotoXY(1,4);
        Write('SDP4');
        SDP4(tsince,iflag,pos,vel);
        end; {else SDP4}
      Convert_Sat_State(pos,vel);
      GotoXY(1,6+interval);
  Writeln(tsince:16:8,pos[1]:17:8,pos[2]:17:8,pos[3]:17:8);
      GotoXY(1,14+interval);
      Writeln('
',vel[1]:17:8,vel[2]:17:8,vel[3]:17:8);
      end; {for int}
    repeat until keypressed;
    end; {for satnumber}
END.
```

TABLE 1: Salvage Benchmark Results for Current Systems

Precision		386DX-33[1]	486DX2-66[2]	P/90[3]	P/133[4]
Single	*Time*	6.70s	1.21s	0.55s	0.38s
(4 bytes, 7-8 digits)	*Result*	2476.51342773437500	Same	Same	Same
Real	*Time*	7.47s	1.43s	0.61s	0.38s
(6 bytes/ 11-12 digits)	*Result*	2499.99997197091579	Same	Same	Same
Double	*Time*	6.81s	1.26s	0.55s	0.38s
(8 bytes/ 15-16 digits)	*Result*	2500.00000000117734	Same	Same	Same
Extended	*Time*	6.86s	1.27s	0.55s	0.38s
(10 bytes/ 19-20 digits)	*Result*	2500.00000000001267	2499.99999999999981	Same	Same

sion (certainly compared to the single-precision results) for very little additional time.

How might this benchmark be used? Well, because of its simplicity—relying entirely on number crunching—it can be used to demonstrate anything from the 18-fold improvement in performance going from a 386DX-33 to a Pentium/133, to the difference in programming languages (e.g., Pascal vs. C), or even the differences between operating systems (e.g., Windows 95 vs. Unix). The Savage benchmark is a straightforward way of assessing the kind of computational speed and accuracy required for satellite tracking precisely because it avoids measuring things like disk throughput or video performance.

Let's put aside the issue of speed for a moment and address the issue of accuracy. Of course, we've been assessing accuracy throughout the history of this column. Each time we've presented the theory behind a particular aspect of satellite tracking, we've followed up with a specific numerical example to ensure you can implement the theory from start to finish. These examples are usually fairly simple because we're only looking at a small piece of the larger picture. However, as we pull these smaller pieces together, it becomes increasingly important to be able to assess the accuracy of the resulting complex procedures. We do this through the use of standard test cases.

An example of a standard test case would be to provide element sets for a particular orbital model (e.g., NORAD two-line element sets for the SGP4 orbital model) and the output from a known correct implementation of the orbital model. An example of such test cases is included in the appendix of *Spacetrack Report Number 3.*[6] The sample test cases in this report include an element set for one near-earth and one deep-space satellite and the resulting SGP4 state vectors (ECI position and velocity) at points over a specific time interval. These test cases can be used to verify the proper implementation of the SGP4 (near-earth) and SDP4 (deep-space) portions of the current NORAD orbital model for a particular satellite tracking application.

For example, we can verify the implementation of the SGP4 model used by *TrakStar* by running the code in figure 2 with the data in *Spacetrack Report Number 3* (included in the code).

The results show agreement at the meter-level in position and millimeter/second-level in velocity. Most of the disparity comes from refinements to the constants used in the model together with modifications to the code since its initial release. Obviously, it is important to have good current test cases to use to verify your software. Perhaps not so obvious is the need to have a more diverse set of orbital elements to test against. Such a set would go further toward testing all aspects of the complicated SGP4 model and provide better confidence in a particular implementation.

Now that we have at least a basic means of assessing the overall accuracy of a particular implementation of an orbital model, let's return to the question of speed. Our ultimate benchmark would be to run a standard set of orbital elements—for satellites in various orbits—over a specific interval and count how many state vectors can be computed per unit time. That is exactly what SGP4-BM does. The code in figure 3 is run with the NORAD two-line orbital elements for the satellites listed in figure 4 to calculate the state vectors for each satellite at one-minute intervals for the entire day of 1993 March 11. By measuring how long it takes to do these 14,400 calculations, we come up with a figure of how many SGP4 calculations per minute are computed.

FIGURE 3: SGP4 Benchmark (SGP4-BM.PAS)

```
Program SGP4_Benchmark;
{$N+,E+}
  Uses CRT,Support,
       SGP_Init,SGP_In,
       SGP_Time,SGP_Math,
       SGP_Conv,SGP4SDP4;
var
  i,j               : word;
  nr_sats           : word;
  start,stop,
  jtime,jt,dt       : double;
  time1,time2       : time_set;
  sat_pos,sat_vel : vector;
BEGIN
  Program_Initialize('SGP4-BM');
  nr_sats := Input_Satellite_Data('BM.TLE');
  jtime :=
Julian_Date_of_Epoch(93070.00000000);
  dt := 1/1440;
  Get_Current_Time(time1);
  for i := 0 to 1439 do
    begin
    jt := jtime + i*dt;
    for j := 1 to nr_sats do
      begin
      Convert_Satellite_Data(j);
      SGP(jt,sat_pos,sat_vel);
      end; {for j}
    end; {for i}
  Get_Current_Time(time2);
  with time1 do
    start := Julian_Date_of_Year(yr) +
DOY(yr,mo,dy)
           + Fraction_of_Day(hr,mi,se,hu);
  with time2 do
    stop  := Julian_Date_of_Year(yr) +
DOY(yr,mo,dy)
           + Fraction_of_Day(hr,mi,se,hu);
  dt := 1440*(stop - start);
  GotoXY(31,12);
  Write(((i+1)*j/dt):3:1,' SGP4/SDP4
calculations per minute');
  Program_End;
END.
```

For the four systems we looked at earlier, the results are compiled in table 2 below.

It should be obvious that this benchmark is best suited to determining the number-crunching ability of any satellite tracking system since that is exactly what it tests. Interestingly enough,

FIGURE 4: Satellites Used for SGP4 Benchmark Test

LAGEOS	GRO
LandSat 5	NOAA 12
GPS-0009	TOPEX
Mir	LAGEOS II
GOES 7	GPS BII-16

though, we see the same 18-fold improvement between the 386DX-33 and the Pentium/133 with SGP4-BM as we did with the much simpler Savage benchmark.

TABLE 2: SGP4 Benchmark Results

	386DX-33	486DX2-66	P/90	P/133
Calculations per minute	9,285.3	43,221.6	113,089.1	167,441.2

If you think we haven't quite finished our discussion of satellite tracking benchmarks yet, you're absolutely right. While we've looked at system benchmarks, we haven't even addressed the need for benchmarking against real-world data. System benchmarks can only verify that our application is consistent with existing models but cannot validate that the application actually works. Next time we'll look at some real-world data sets and see how to test an application against that data using *TrakStar* as an example. We will also discuss various types of real-world data which may be used for this purpose, depending on your requirements.

As always, if you have questions or comments on this column, feel free to send me e-mail at **tkelso@afit.af.mil**, **tkelso@mindspring.com**, or write care of *Satellite Times*. Until next time, keep looking up! ST

[1] 33 MHz 386DX running MS-DOS 6.20 with a 387 coprocessor.

[2] 66 MHz 486DX2 running Windows 95 in MS-DOS mode.

[3] 90 MHz Pentium running Windows 95 in MS-DOS mode.

[4] 133 MHz Pentium running Windows 95 in MS-DOS mode.

[5] T.S. Kelso, "Astronomical Computing Benchmarks," *Sky & Telescope*, March 1986.

[6] Felix R. Hoots and Ronald L. Roehrich, *Spacetrack Report No. 3: Models for Propagation of NORAD Element Sets*, December 1980.

SPACE NET

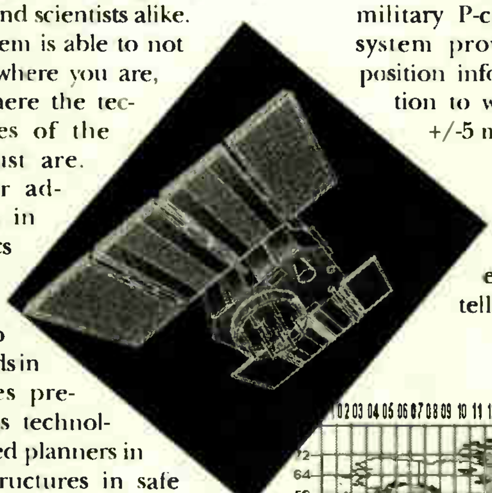
By Bill Grove
bill@grove.net

Where In the World Am I?

Since the early 1970s, the United States government has been developing a really nifty bit of technology. This new technology, called GPS or Global Positioning System, has been use by the Department of Defense (DoD) for quite some time. Now that the system is fully operational, we have seen an explosion of civilian applications for GPS that allows you to spot your place on the earth within a hundred meters.

The NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning System) was developed for defense purposes, but is now being used by the consumer and scientists alike.

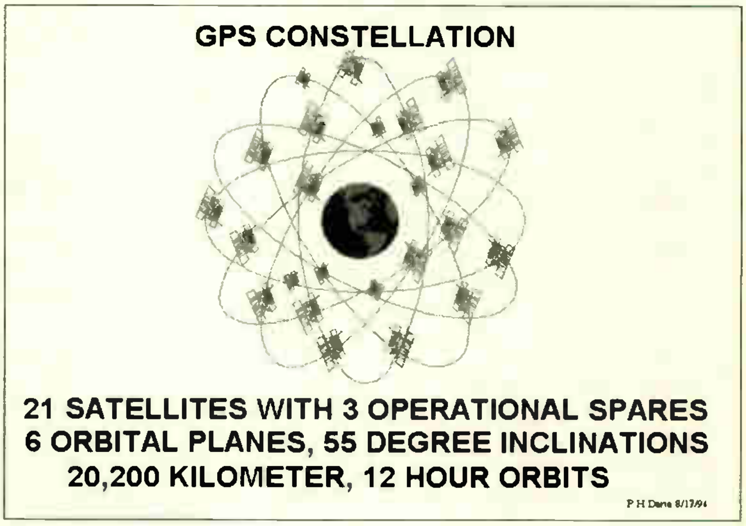
The system is able to not only track where you are, but also where the tectonic plates of the earth's crust are. This major advancement in geodynamics has allowed scientists to make inroads in earthquakes prediction This technology has aided planners in building structures in safe places, and evacuate areas that are considered unsafe before they become unneeded disasters.



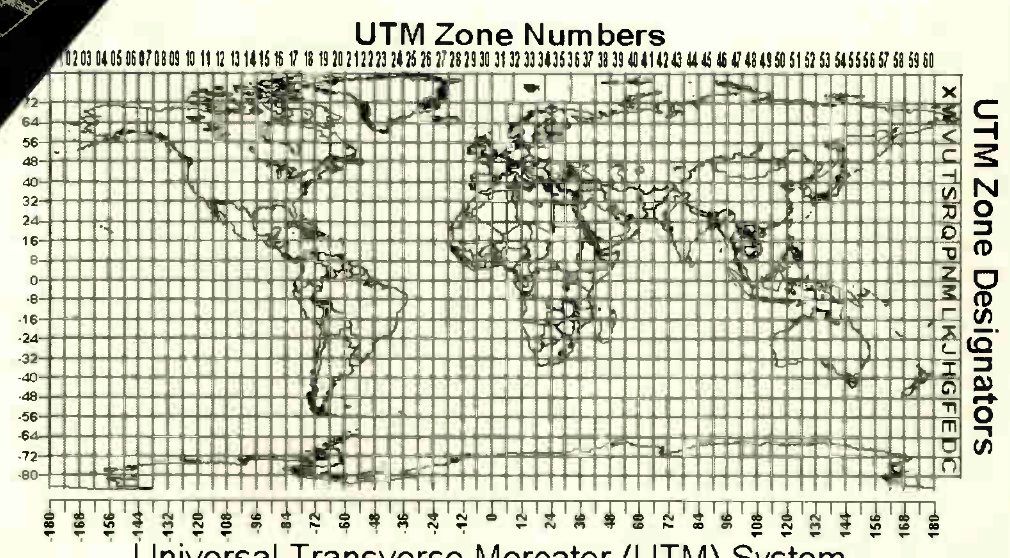
The Jet Propulsion Laboratory at NASA has dedicated a site at **http://milhouse.jpl.nasa.gov/** that shows what is being worked on in the way of geodynamic study with the GPS system. They give a brief background of the GPS system and additional information in the field of geodynamic studies.

At **http://www.soonet.ca/eliris/GPS.htm,** the ELIRIS (Earth, Land and Integrated Resources Information Systems) has devoted a page to describing the GPS system and how the military and consumer versions differ. According to ELIRIS, the consumer-grade GPS systems can provide positioning information to within 100 meters of your actual position on earth. The military P-coded system provides position information to within +/-5 meters.

According to the folks at ELIRIS, the GPS system triangulates your position by getting signals from multiple satellites and timing each signal, telling just how far you are from each. It then takes these signals and gives you precise (to within 100 meters) coordinates showing your location. The Global Positioning System can also track the speed that you are moving, as well as allowing you to follow waypoints to places you have been or to places that you are going. The system is quite ingenius and is ideal for not only scientific and military purposes, but also for the common fisherman or camper, who just wants to find their favorite fishing hole, or not get lost in the woods.

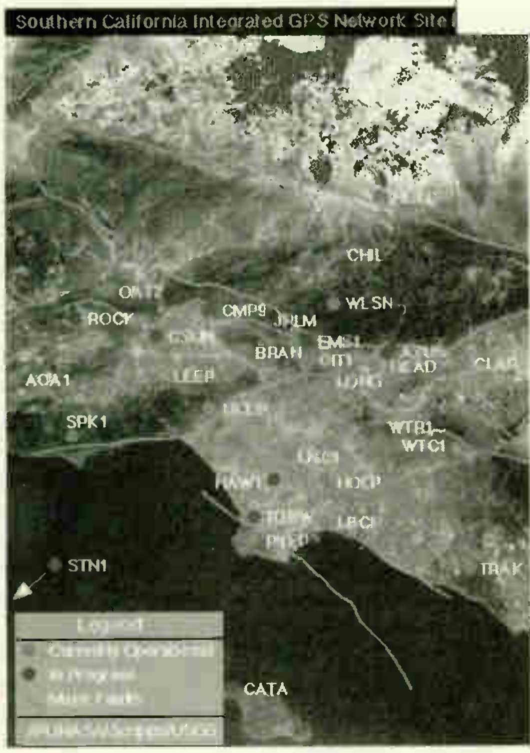


Don Bartlett offers some interesting insight for those of you who are considering buying a GPS for outdoor use. This information is available at: **http://io.datasys.swri.edu/GPS.html.** Bartlett offers his advise on which models to buy, what features to look for, and some basics on



how to operate the GPS. Although the information is a bit dated, you can pull some good, reliable facts from his web site.

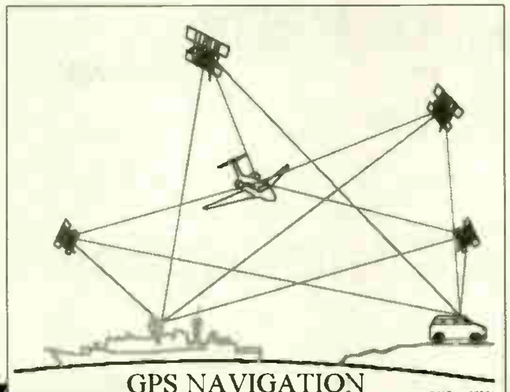
For more detailed descriptions of what GPS is and how it works, point your web browser to: **http://www.utexas.edu/depts/grg/gcraft/notes/gps/gps.html.** This site characterizes the precise difference in military and civilian systems, the changes in the satellites, how the signals operate, and many more technical aspects of the Global Positioning System. For



those of you just getting started in GPS, Peter H. Dana also offers a GPS acronym section as well as the current status of the GPS constellation.

Paul Tarr's page at: **http://www.inmet.com/~pwt/gps_gen.htm,** lists an immese amount of GPS information on the Net. His web pages are broken down into the areas of: introductory GPS material, general information sites related to GPS and navigation, non-commercial sites, commercial sites, related activities, and GPS business inquires. Be sure to bookmark this page, as you will be returning to it all the time for GPS information.

A second massive store of GPS information lies at: **http://galaxy.einet.net/editors/john-beadles/introgps.htm.** John T. Beadles is an industrial GPS user. His page mirrors much of the same information as

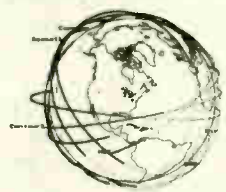

GPS NAVIGATION

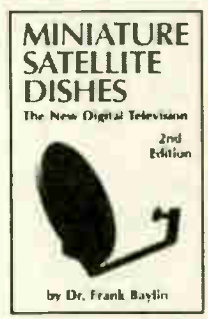
Paul Tarr, but offers many of his own experiences and information as well. His site is dedicated to new users of GPS , to help them get the most out of this new tool of technology.

There is a fascinating history of satellite navigation at: **http://galaxy.einet.net/editors/john-beadles/sum_his.htm#1957.** This site is a link from Mr. Beadles page. It covers space history from the launch of Sputnik on October 4, 1957 to July 17, 1995, when NAVSTAR officially announced that its system reached full operational capability. It's a wonderful walk through space and time.

The Internet has yet again proven to be an incredible resource for technological advances. From past satellite launches to the most up-to-date space images, we can watch our world from that amazing little box called the computer. If you have any suggestions or links for future articles, please direct your comments to: bill@grove.net. And remember - have fun out there! ST

*Bill Grove is the manager of computer services at Grove Enterprises and administrator of GroveLink (the Grove intenet system). Information on GroveLink can be found on the home pages of Grove Enterprises at: **http://www.grove.net.***



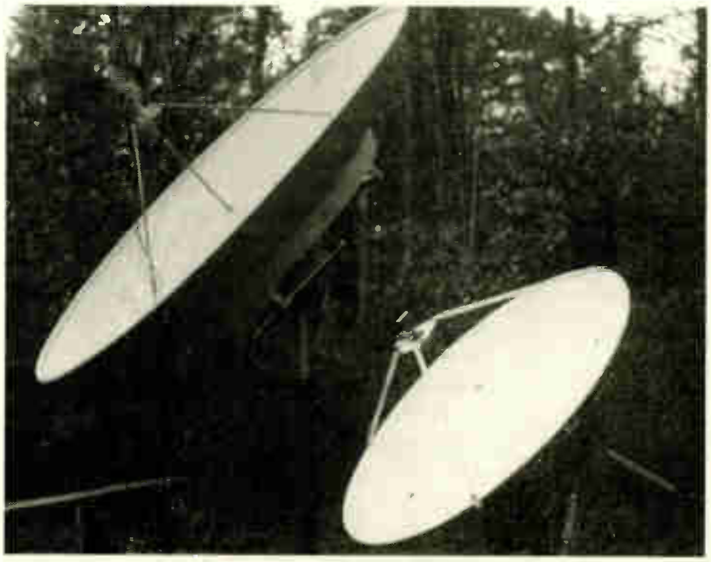


By Ken Reitz, KC4GQA

Tune into Ku-band Television

In the radio hobby, the AM broadcast band has become the forgotten band. Thanks to it's low fidelity characteristics, susceptibility to atmospheric noise, and erratic night-time reception qualities, AM has become the home of talk radio, sports radio and "all news, all the time" radio. Not that we don't all listen to AM at some time before we die, it's just not very glamorous compared to say the FM broadcast band.

The same can be said of Ku-band television. Twelve years ago, the Ku (11.7-12.7 GHz) spectrum was touted as the future of satellite TV, yet it took ten years before it really caught on. And the portion that caught on was the DBS or direct broadcast satellite portion of the band (12.2-12.7 GHz). DBS is not the same as C-band, but it is a whole new breed of satellite TV. Still the other Ku-band (11.7-12.2 GHz) is quite active with a range of transmissions from live news and sports feeds to regular network programming. In a way it continues to serve as the work-horse for satellites feeds like the early C-band systems did several years ago.



C-band dish on the left and Ku band dish on the right. Photo courtesy of Ken Reitz.

What Your Dealer Forgot to Show You

Most satellite TV dealers have pushed the C-band viewing option for its obvious entertainment value and, as a result, all the activity on the Ku-band (11.7-12.2 GHz) is ignored. Indeed, the industry doesn't even provide statistics on Ku-band equipment sales. The last 18 months saw an average of over 40,000 C-band satellite systems sold each month, yet few were configured for Ku-band reception.

Probably the main reason for the oversight on the part of the dealers is that most customers are looking for entertainment, a la cable TV fare and care little for the backhaul feeds of news and sports events. The second reason for this lack of enthusiam of adding Ku is the increase in the overall cost of the system. With prices for TVRO systems hovering around the US$1,500 to US$2,000 level, customers are ready to start trimming costs wherever they can.

In this month's column we will show you how to add Ku-band to your existing satellite TV system and where to go shopping for some good prices for Ku-band LNBs and feedhorns.

The Ku Universe

The Ku-band frequencies are in the 11 to 12 GHz range which makes them roughly one fourth the wavelength of C-band frequencies. This means that Ku-band feed horns will be considerably smaller than C-band. And, since, many Ku-band satellites operate at a higher power output than C-band, the dishes can be considerably smaller. Excellent video can be seen on a 3- or 4-foot diameter dish for Ku.

There are currently 23 Ku-band satellites in our neck of the Clarke Belt. Transponders for Ku-band are not standardized like C-band. Each Ku satellite has a different frequency plan with as few as four to as many as 32 transponders. The bulk of the transponders are not operated full time, but are used occassionally as needed by news and sports broadcasting organizations though there are some notable exceptions.

How To Receive Ku-band Satellites

If you already have a satellite TV system you're more than halfway there. If not, you'll need a Ku compatible dish in the 4 to 6 foot range. Virtually all TVRO dishes made today are Ku compatible. The only time you'll worry about compatibility is when you are buying a very old dish second hand. Black mesh dishes are usually the cheapest and have secondary value in that they blend in with the background. Solid aluminum dishes are better signal reflectors but also reflect the intense heat of the sun and can easily melt your coax or anything else in the way!

Once you have the dish then you'll need a Ku band feed horn. The feed horn is the round cup-like fixture which is set over the center of the dish and on which the LNB (Low Noise Block down converter) amplifier is attached. If you intend to have a stand-alone Ku system, you'll need a Ku band feed horn. If you are to add Ku to an existing C-band system you'll need a C/Ku feed. This is one feed on which both the C- and Ku-band LNBs are attached.

Regardless of whether or not you have an existing system, you'll need a Ku-band LNB. This is the device which amplifies the signal reflected in the dish. Typically, Ku-band LNBs are rated in terms of decibels (dB). The lower the dB rating, the lower the noise temperature, and the better the signal. A .9 dB Ku LNB will have considerably more noise than a .5 dB LNB. But you needn't get too excited about the difference. I've used a 1.9 dB LNB with very good results on a 4 foot dish. You'll notice that there is a price to be paid for the lower noise temperature. Expect to pay an extra $50 to $70 for the difference.

And, finally, you'll need an extra length of RG/6 coax cable to bring the signal into the house and to your receiver. If you recently installed your TVRO system you probably have an extra length of RG/6 to the dish whether or not Ku was initially installed. This makes retro-fitting for Ku that much easier on an existing installation.

Notes About Receivers

Most new integrated receiver decoders (IRDs), which is what satellite TV receivers are known as, have "F" connectors on the back for C- and Ku-band cables.if you have such a system there is likely to be a switch on your infrared remote control which allows you to switch between the C- and Ku-band. Some older receivers require an outboard C/Ku switch which must be manually flipped when you want to watch one or the other.

Many older receivers are not compatible with Ku and cannot be used for Ku-band reception and here's why: For reasons known only to the gremlins of satellite television, and possibly old Art Clarke himself, Ku band signals are inverted in form from their C-band counterparts. Some older receivers have an "invert video" switch on the back which, when enabled, allows the receiver to process the Ku transmissions correctly. Without that switch many older receivers will show what appears to be a scrambled signal. The audio, however, will be in the clear.

What You'll See

One reason I added Ku to my system had to do with changes at PBS. Years ago PBS carried four separate feeds on C-band and I found that there was quite a bit of programming that never made it to my local station. When PBS moved to Telstar 401 they kept only one C-band channel (PBS-X) and moved to T401 Ku. They use some of these channels to transmit educational channels via the General Instrument Digicipher system of video compression (which are not receivable on normal satellite receivers). Other channels remain in analog format and are easily seen on a Ku band receiver system.

Among the channels you'll see on Telstar 401 are South Carolina Educational TV (SCETV), PBS affiliate network programming, Georgia Public TV (GPTV), Peachstar (distance learning from Georgia), Bloomberg Information Television, ITN World News from England as well as news feeds from ABC News.

Other satellite have all kinds of interesting programming. The Ku side of Galaxy 4 has programming from Asia with CTN (Chinese Television Network) a 24 hour/day service from Hong Kong as well as news feeds from Fox News and CBS News.

SBS 6 often has a large number of sports events. On one evening I saw four college football games, five college basketball games, two NHL hockey games and one high school football state championship all being transmitted at the same time on SBS 6.

The Bottom Line

I know what you're thinking: "Yes, well, this is most amusing, but just how much is this going to set me back?" If you're starting from scratch and installing a completely new C/Ku system you should add about US$250 to the C-band system price tag. If you are thinking of putting together a stand-alone Ku system and can come up with a nice used 4 or 6 foot dish, it'll cost about US$65 for a feed horn and another US$90 for an LNB. If you can get a nice used receiver for about US$50 or US$100 you'll have a nice complete Ku system for about the price of a C-band upgrade.

Before you buy, do a little shopping around. First, call your local satellite dealers and find out what they've got. Ask about used equipment. Take notes about which dealer has which products. If you want to go for the new equipment, compare your local dealers' prices with the mail order firms'. Don't forget to add the cost of shipping and handling which will inevitably be added to your bill and may make the local dealer cheaper.

Doing a Ku-band retro-fit is very easy and there's no need for the extra expense of having a dealer do it for you. Just remember, when you're hooking up the LNBs, unplug your receiver as there is voltage on the coax to power the LNB and you could risk shorting out the receiver or LNB.

For product information on Ku equipment call: Skyvision 800-543-3025; Name Brands Only 800-604-2222; and Shop-At-Home 800-927-6468.

And The Down Side...

Ku band activity is not cable oriented. If it's HBO you're looking for then you need a DSS or C-band system. Ku-band is oriented towards sports and news feeds and individual station uplinks. Additionally, if you are interested in ethnic programming, Ku has quite a few channels to offer. There are a few audio subcarriers, but nothing like the proliferation of sound on C band. A complete list all of the video and audio services on Ku-band can found found in the SSG section in this issue of *Satellite Times*.

Another peculiarity about Ku band satellites is that many of the transponders are "spot beamed." That means that their power output is concentrated on a particular geographic area and not the entire Continental US (CONUS) beam typically found on C-band downlinks. Therefore, it's very difficult for those south of Canada to watch Ku programming on the Anik satellites.

And, finally, many Ku satellites use a half-transponder scheme which requires a receiver to tune off the factory preset channel center. These are not overwhelming problems, but merely "the nature of the beast" when you are talking about Ku-band transmissions.

Mail Bag

Many of our *ST* readers are interested in receiving foreign television from their homeland. Among them are Dr. Jan Leszczynski of New Haven, West Virginia, who would like to receive Polish Television, and Vaclav Pesek of Rochester, Michigan, who would like to receive Deutche Welle from Germany.

The bad news is that TV Polonia is not to be found on any of our domestic arc satellites, try as I might to find it. The good news is that Deutche Welle's 24 hour/day transmissions are readily available on Satcom C4 at 135 degrees west. It is not scrambled and there are three audio subcarriers on that channel including Radio Deutche Welle 's Foreign Language Service.

Robert Barbutas WA9LWC of Dolton, IL is trying to find radio telegraphy signals on satellite such as AP or UPI wire services.

Years ago AP and UPI wire services were available on C-band satellite and even though those services are still delivered via satellite, they are encrypted using proprietary software systems and unavailable to the general public. ST

If you have a question for Kousin Ken, you can write him at ST Beginner's Column, P.O. Box 98, Brasstown, NC 28902 or e-mail your questions to st@grove.net. Be sure to mark those e-mail questions for The Beginner's Column.

GOES 9 On Station at 135º West

By Jeff Wallach, PhD, Dallas Remote Imaging Group

GOES 9 is finally in operational status at 135° West longitude transmitting both GVAR and WEFAX imagery. GOES 9 has replaced GOES 7 which has been commanded off. GOES 9 is transmitting WEFAX imagery at 1691.0 MHz. The imagery is excellent and WEFAX image products are being transmitted based on the following schedule.

Use this schedule to determine which images are transmitted at specific times — most WEFAX reception programs have a scheduler that can be setup for automatic reception of specific images, and then provide an animation of the day's weather.

This schedule and that for GOES 8 may be obtained on the DRIG FTP site at: **ftp.drig.com/pub/wefax/wefaxscd.txt** or telnet to the bbs at **bbs.drig.com.**

West WEFAX GOES-9 Schedule as of January 18, 1996 (All time are UTC)

TIME	PRODUCT
0000	H 0000Z IR NW PS GMS
0005	I 0000Z VS NW PS GMS
0010	A 0000Z IR NW GMS
0015	B 0000Z IR NE GMS
0020	C 0000Z IR SW GMS
0025	D 0000Z IR SE GMS
0030	GOES-9 2300Z NH IR
0035	GOES 9 2300Z NH VS
0040	W484 PG-WDS & TEMP FL50
0045	W486 48HR 1000 STM/ISOTACHS
0050	W487 48HR 1000 STM/ISOTACHS
0055	W482 SIG WX PROG 400-70MB
0100	W483 SIG WX PROG 400-70MB
0105	W273 PG-WOS & TEMP FL100
0110	W473 PG-WDS & TEMP FL50
0118	GOES-9 0000Z NH IR
0122	GOES-9 0000Z NW IR
0126	GOES-9 0000Z SW IR
0130	GOES-9 0000Z NE IR
0134	GOES-9 0000Z SE IR
0138	GOES-9 0000Z FD IR
0142	GOES-9 0000Z NH VIS
0146	GOES 9 0000Z US IR
0150	GOES 9 0000Z NH WV
0154	GOES 9 0000Z NW WV
0158	GOES-9 0000Z SW WV
0202	GOES-9 0100Z NH IR
0206	GOES-9 0000Z NE WV
0210	GOES-9 0000Z SE WV
0214	POLAR DIR NH 010E 080W W028
0218	POLAR DIR SH 010E-080W W029
0222	POLAR DIR MER 010E-060W W030
0226	POLAR VIS MER 040W-110W W031
0230	POLAR NIR MER 140E-070E W032
0240	ICE CHART
0245	ICE CHART
0250	ICE CHART
0255	ICE CHART
0300	H 0300Z IR NW PS GMS
0305	I 0300Z VS NW PS GMS
0310	A 0300Z IR NW GMS
0315	B 0300Z IR NE GMS
0320	C 0300Z IR SW GMS
0325	D 0300Z IR SE GMS
0330	GOES-9 0200Z NH IR
0334	POLAR DIR MER 040W-110E W033
0338	POLAR VIS NH 080W-170W W034
0342	POLAR VIS SH 080W-170W W035
0402	GOES-9 0300Z NH IR
0406	GOES-9 0300Z NW IR
0410	GOES-9 0300Z SW IR
0414	GOES-9 0300Z NE IR
0418	GOES-9 0300Z SE IR
0422	GOES-9 0300Z FD IR
0426	GOES-9 0300Z US IR
0430	D2 0430Z IR METEOSAT
0434	D1 0430Z IR METEOSAT
0438	D3 0430Z IR METEOSAT
0442	E6 0430Z MOIST METEOSAT
0446	E7 0430Z MOIST METEOSAT
0450	E8 0430Z MOIST METEOSAT
0454	E9 0430Z MOIST METEOSAT
0458	GOES-9 0400Z NH IR
0522	POLAR NIR NH 080E 010E W036
0526	POLAR NIR SH 080E-010E W037
0530	POLAR VIS MER 100W-170W W038
0534	POLAR NIR MER 080E-010E W039
0538	POLAR DIR NH 080W-170W W040
0542	POLAR DIR SH 080W-170W W041
0554	GOES-9 0500Z NH IR
0600	H 0600Z IR NW PS GMS
0605	I 0600Z VS NW PS GMS
0610	A 0600Z IR NW GMS
0615	B 0600Z IR NE GMS
0620	C 0600Z IR SW GMS
0625	D 0600Z IR SE GMS
0630	D2 0630Z IR METEOSAT
0634	C02 0630Z VS METEOSAT
0638	C03 0630Z VS METEOSAT
0642	C3D 0630Z VS METEOSAT
0702	GOES-9 0600Z NH IR
0706	GOES-9 0600Z NW IR
0710	GOES-9 0600Z SW IR
0715	W301 ANAL 1000 STM/WDS
0720	W302 ANAL 1000 STM/WDS
0725	W303 ANAL 1000 STM/WDS
0730	W304 ANAL 1000 STM/WDS
0735	W305 ANAL 1000 STM/WDS
0740	W306 ANAL 1000 STM/WDS
0745	W307 ANAL 1000 STM/WDS
0750	W308 ANAL 1000 STM/WDS
0755	W309 PG-WDS & TEMP FL340
0800	GOES-9 0700Z NH IR
0805	W311 PG-WDS & TEMP FL240
0810	W210 PG-WDS & TEMP FL240
0818	GOES-9 0600Z NE IR
0822	GOES-9 0600Z SE IR
0826	GOES-9 0600Z FD IR
0830	GOES-9 0600Z US IR
0850	POLAR DIR MER 100W-170W W042
0854	GOES-9 0800Z NH IR
0900	H 0900Z IR NW PS GMS
0905	I 0900Z VS NW PS GMS
0910	A 0900Z IR NW GMS
0915	B 0900Z IR NE GMS
0920	C 0900Z IR SW GMS
0925	D 0900Z IR SE GMS
0930	POLAR DIR NDRTH POLE W043
0934	POLAR DIR SOUTH POLE W044
0958	GOES-9 0900Z NH IR
1002	GOES-9 0900Z NW IR
1006	GDES-9 0900Z SW IR
1010	GOES-9 0900Z NE IR
1014	GDES-9 0900Z SE IR
1018	GOES-9 0900Z FD IR
1022	GOES-9 0900Z US IR
1030	W214 PG-WDS & TEMP FL100
1035	W215 PG WDS & TEMP FL50
1040	W216 PG WOS & TEMP FL50
1045	W217 PG WDS & TEMP FL340
1050	W218 PG WDS & TEMP FL340
1055	W219 PG WDS & TEMP FL340
1100	GOES-9 1000Z NH IR
1105	W420 PG WDS & TEMP FL240
1110	W221 PG WDS & TEMP FL240
1115	W421 PG WDS & TEMP FL180
1120	W222 PG WDS & TEMP FL180
1125	W422 PG WDS & TEMP FL100
1130	W223 PG WDS & TEMP FL100
1135	W423 PG WDS & TEMP FL50
1140	W430 24HR 1000 STM/ISOTACHS
1145	W431 24HR 1000 STM/ISOTACHS
1150	W432 PG-WDS & TEMP FL50
1155	W440 SIG WX 400-70MB
1200	GOES-9 1100Z NH IR
1205	J 1200Z IR NW PS GMS
1210	A 1200Z IR NW GMS
1215	B 1200Z IR NE GMS
1220	C 1200Z IR SW GMS
1225	D 1200Z IR SE GMS
1230	POLAR VIS NH 170W-100E W001
1234	POLAR VIS SH 170W-100E W002
1238	POLAR NIR NH 010E-080W W003
1242	POLAR NIR SH 010E-080W W004
1246	POLAR VIS MER 170W-120E W005
1250	POLAR NIR MER 020E-050W W006
1302	GOES-9 1200Z NH IR
1306	GOES-9 1200Z NW IR
1310	GOES-9 1200Z SW IR
1314	GOES-9 1200Z NE IR
1322	GOES-9 1200Z SE IR
1326	GOES 9 1200Z FD IR
1330	GOES-9 1200Z US IR
1334	GOES-9 1200Z NH WV
1338	GOES-9 1200Z NW WV
1342	GOES-9 1200Z SW WV
1346	GOES-9 1200Z NE WV
1350	GOES-9 1200Z SE WV
1402	GOES-9 1300Z NH IR
1410	TBUS NOAA-9
1415	TBUS NOAA-10
1420	TBUS NOAA 11
1425	TBUS NOAA 12
1430	SCHEDULE FILE PART-1
1434	SCHEDULE FILE PART-2
1438	WEFAX MESSAGE FILE
1442	POLAR DIR NH 170W-100E W007
1446	POLAR DIR SH 170W-100E W008
1450	POLAR DIR MER 170W-120E W009
1454	GOES 9 1400Z NH IR
1500	H 1500Z IR NW PS GMS
1505	J 1500Z VS NW PS GMS
1510	A 1500Z NW IR GMS
1515	B 1500Z NE IR GMS
1520	C 1500Z SW IR GMS
1525	D 1500Z SE IR GMS
1530	POLAR VIS MER 130E-060E W010
1534	POLAR NIR MER 040W-110W W011
1538	POLAR DIR MER 130E-060E W012
1602	GOES-9 1500Z NH IR
1606	GOES-9 1500Z NW IR
1610	GOES 9 1500Z SW IR
1614	GOES-9 1500Z NE IR
1618	GOES-9 1500Z SE IR
1622	GOES-9 1500Z FD IR
1626	GOES-9 1500Z US IR
1634	GOES-9 1500Z NH VS
1638	GOES-9 1500Z NW VS
1642	GOES-9 1500Z SW VS
1646	GOES-9 1500Z NE VS
1650	GOES-9 1500Z SE VS
1702	GOES-9 1600Z NH IR
1706	GOES-9 1600Z NH VS
1715	W263 SIG WX 400-70MB
1720	W463 SIG WX 400 70MB
1730	W350 ANAL 1000 STM/WDS
1735	W351 ANAL 1000 STM/WDS
1740	W352 ANAL 1000 STM/WDS
1745	W353 ANAL 1000 STM/WDS
1750	W354 ANAL 1000 STM/WDS
1755	W355 ANAL 1000 STM/WDS
1800	H 1800Z IR NW PS GMS
1805	J 1800Z VS NW PS GMS
1810	A 1800Z IR GMS
1815	B 1800Z IR GMS
1820	C 1800Z IR GMS
1825	D 1800Z IR GMS
1830	GOES-9 1700Z NH IR
1835	GOES-9 1700Z NH VS
1840	W358 ANAL 1000 STM/WDS
1845	W359 PG WDS & TEMP FL340
1850	W360 PG WDS & TEMP FL340
1855	W361 PG WDS & TEMP FL340
1902	GOES-9 1800Z NH IR
1906	GOES-9 1800Z NW IR
1910	GOES-9 1800Z SW IR
1914	GOES-9 1800Z NE IR
1918	GOES-9 1800Z SE IR
1922	GOES-9 1800Z FD IR
1926	GOES-9 1800Z US IR
1930	GOES-9 1800Z NH VS
1934	GOES-9 1800Z NW VS
1938	GOES-9 1800Z SW VS
1942	GOES-9 1800Z NE VS
1946	GOES-9 1800Z SE VS
2002	GOES-9 1900Z NH IR
2006	GOES-9 1900Z NH VS
2010	POLAR VIS NH 100E 010E W013
2014	POLAR VIS SH 100E-010E W014
2018	POLAR NIR NH 080W 170W W015
2022	POLAR NIR SH 080W-170W W016
2026	POLAR VIS MER 070E-000E W017
2030	POLAR NIR MER 100W-170W W018
2034	POLAR DIR NH 100E 010E W019
2038	POLAR DIR SH 100E 010E W020
2042	POLAR DIR MER 070E 000E W021
2046	POLAR VIS NH 010E-080W W022
2050	POLAR VIS SH 010E-080W W023
2054	POLAR NIR NH 170W-100E W024
2100	H 2100Z IR NW PS GMS
2105	I 2100Z VS NW PS GMS
2110	A 2100Z IR NW GMS
2115	B 2100Z IR NE GMS
2120	C 2100Z IR SW GMS
2125	0 2100Z IR SE GMS
2130	GDES-9 2000Z NH IR
2134	GOES-9 2000Z NH VS
2150	POLAR NIR SH 170W-100E W025
2154	POLAR DIR NH 010E-080W W026
2158	POLAR DIR SH 010E-080W W027
2205	W268 PG-WDS & TEMP FL340
2210	W269 PG-WDS & TEMP FL340
2215	W270 PG WDS & TEMP FL240
2220	W470 PG WDS & TEMP FL240
2225	W271 PG WDS & TEMP FL240
2230	W471 PG WDS & TEMP FL180
2235	W272 PG WDS & TEMP FL180
2240	W474 PG WDS & TEMP FL100
2246	GOES-9 2100Z NH IR
2250	GOES 9 2100Z NW IR
2254	GOES-9 2100Z SW IR
2258	GOES-9 2100Z NE IR
2302	GOES-9 2200Z NH IR
2306	GOES-9 2100Z SE IR
2310	GDES-9 2100Z FD IR
2314	GOES-9 2100Z US IR
2318	GOES-9 2100Z NH VS
2322	GOES-9 2100Z NW VS
2326	GOES-9 2100Z SW VS
2330	GOES-9 2100Z NE VS
2334	GOES-9 2100Z SE VS
2338	GOES-9 2200Z NH VS

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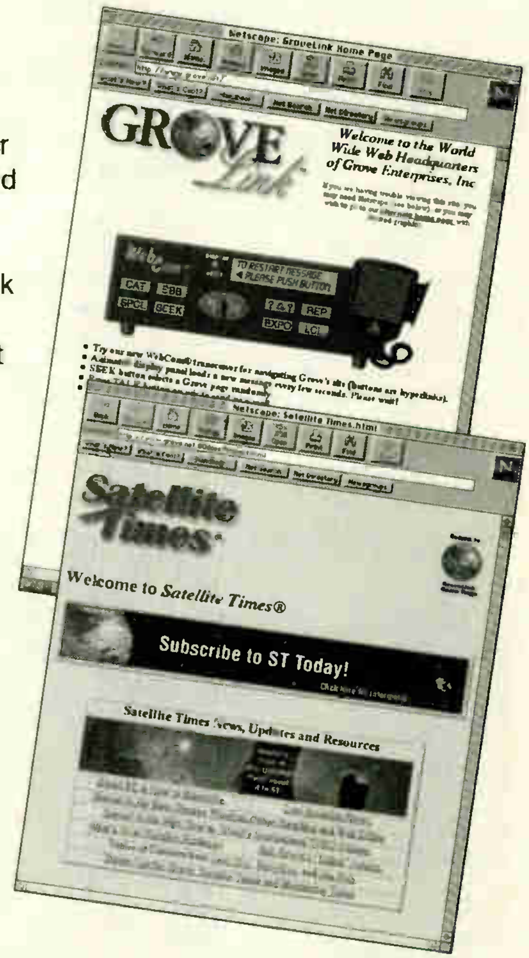

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By Larry Van Horn, N5FPW

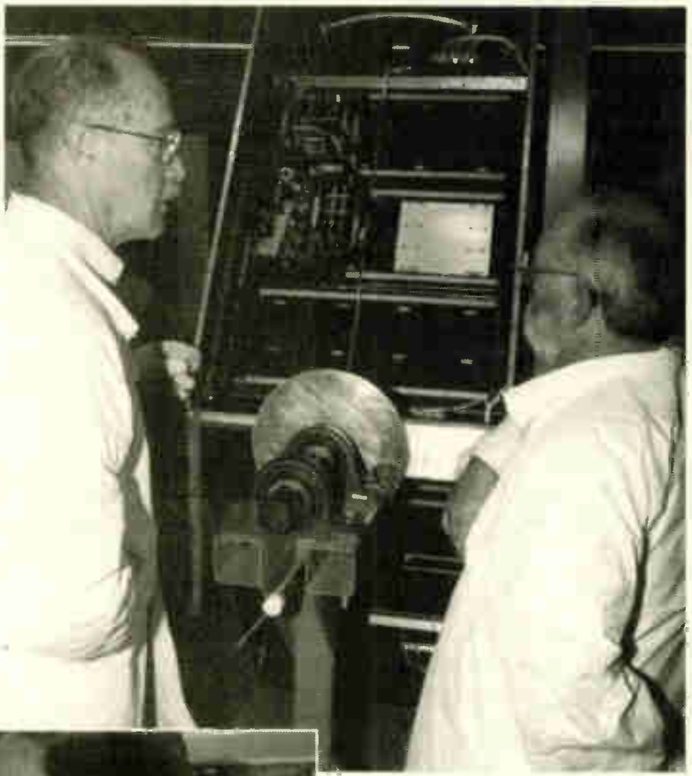
Phase 3D Construction Update

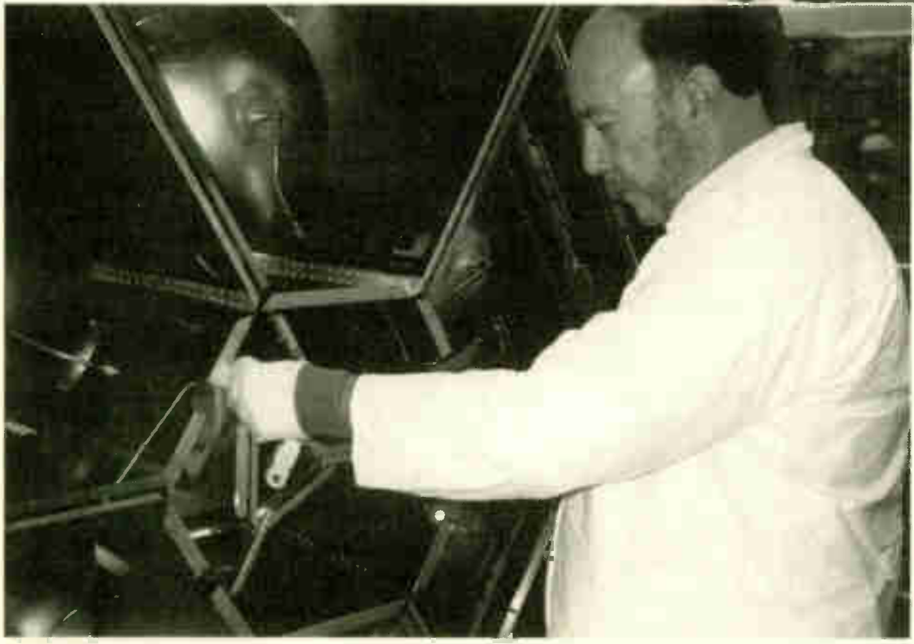
Work on amateur radio's newest satellite continues at the Phase 3D integration facility in Orlando, Fla. Phase 3D is currently scheduled to ride aboard the second Ariane 5 rocket test flight now scheduled for later this year.

AMSAT still needs funds to help launch Phase 3D. If you are interested in the future of amateur radio in space, you might consider donating to the AMSAT-NA Phase 3D launch fund. You can send your donations to AMSAT, P.O. Box 27 Washington, D.C., or call 301-589-6062. Your support is deeply appreciated.

The pictures on these two pages show some of the work that has been done in Orlando, Florida, and Ogden, Utah, by the assembly and integration team working on this ambitious project. Photos are courtesy of AMSAT-NA, Keith Baker-KB1SF, and Dick Jansson-WD4FAB.

Dick Daniels, W4PUJ (L) discusses placement and operation of the Phase 3-D Propellant Flow Assembly with Lou McFadin, W5DID, Phase 3-D Integration Manager (R). Portions of the installed power and IF wiring harnesses are also visible in the spacecraft. The curved shaped pipe in the structure near the top of the photo is one of the 6 Nutation Dampers that, together with Phase 3-D's torquing coils and momentum wheels, will control P3-D's altitude while in orbit.





Mike Garrity, N4OAC installs the mounting bracket for Phase 3-D's arc-jet positioning motor into the bottom of the spacecraft structure.

A close-up view of Phase 3D's flight model Propellant Flow Assembly (PFA). Valves and piping on the left side of the unit will be used to fuel the spacecraft's hypergolic propellant tanks on the ground prior to launch as well as control the flow of propellants to Phase 3D's 400 Newton kick motor while in orbit. Likewise, valves and piping located on the right side of the PFA will be used to fill the spacecraft's ammonia tanks and later, will control the flow of ammonia to the satellite's arc-jet positioning motor.

Jaim Parsons, Weber State University, poses with the Phase 3D Mass Mockup Unit (MMU) outside the P3D laboratory in Ogden, Utah. Made from over 495 kg (1,100 lbs) of concrete and steel, this ungainly apparatus simulates the exact weight and balance characteristics of a fully configured Phase 3D spacecraft. During recent tests, also done at Weber State, the MMU was successfully used to verify that the Phase 3D spacecraft should separate "cleanly" from its Specific Bearing Structure (SBS) carrying structure during launch.

Student project co-leaders Gene Hansen (left) and Richard Vanderford (right) inspect the completed flight model Phase 3D SBS in the P3D lab at Ogden, Utah. The SBS will be used to carry the spacecraft into orbit aboard its Ariane 5 launch vehicle.

Ralph Butler, project manager for construction of P3D's SBS, poses with the completed flight unit at Weber State University. One of three separation mountings that will secure the spacecraft inside the SBS during launch is clearly visible directly underneath Ralph's left hand.

ST SATELLITE PROFILE

By Philip Chien, Earth News

Precision Signals from Space — The GPS satellites

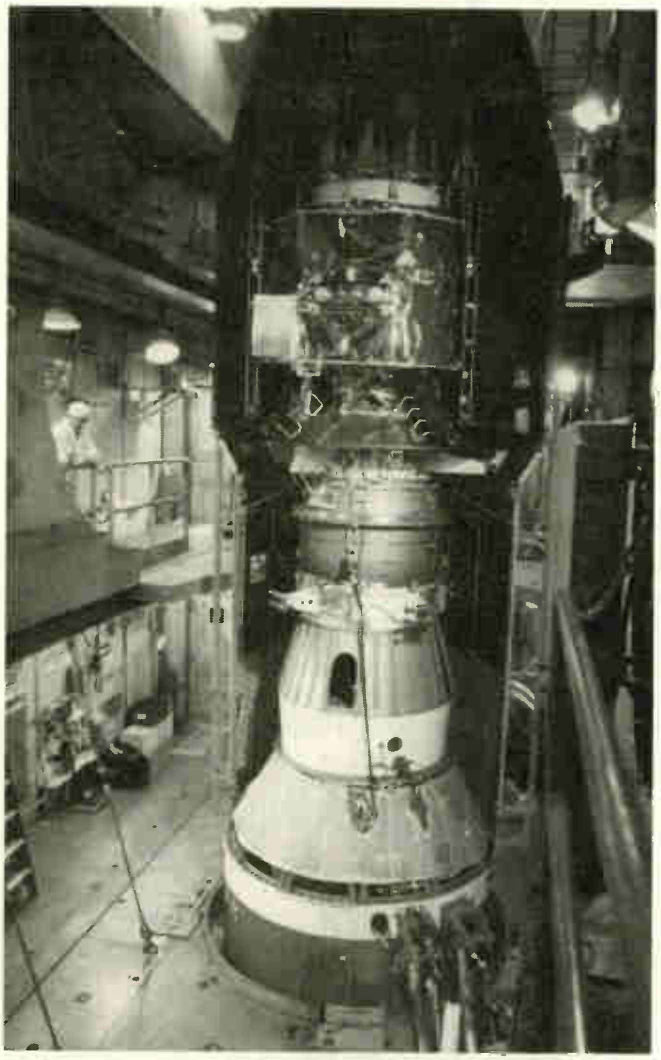
That age old question has been asked by mankind for generations. Since the early days when man first walked the Earth, he has always looked toward the stars with wonder and amazement, and he has always wanted to know were on Earth he was. With the launch of the U.S. Air Force Global Positioning System (GPS) satellites, mankind now uses space to answer that age old question of "Were on the Earth am I?"

What is the GPS satellite system?

The $10 billion Global Positioning System includes 21 satellites and three spares in 20,180 km. (10,900 nautical mile) circular orbits and a dedicated ground control center at Falcon Air Force Base, Colorado (See *Satellite Times* September/October 1995, page 10, *The Guardians of the High Frontier* by Larry Van Horn).

The first Block I GPS spacecraft was launched on February 22, 1978 on an Atlas H launch vehicle from Vandenberg Air Force Base in California. It was in service for seven years before it was retired. All together eleven Block I GPS spacecraft were launched from 1978 through 1985, although one was lost in a launch failure. The Block I 10 spacecraft is still active — eleven years after its launch. The Block I spacecraft, built by Rockwell International, have five year planned lifetimes and use three Rubidium and one Cesium atomic clocks for their time standards. At launch they weigh 525 kg (1,157 lbs.)

Rockwell International also built the 1,667 kg. (3,675 lb.) Block II and Block IIA GPS satellites. A total of 24 Block II spacecraft were ordered, 24 to fill an entire constellation and four spares. They have an planned lifetime of 7.5 years and include two Rubidium and two Cesium atomic clocks.



Delta GPS-25, Navstar II-12 installation of the fairing at complex 17B at Cape Canaveral Air Station. (U.S. Air Force photo)

Originally the Block II spacecraft were supposed to be launched from the shuttle, starting in 1987. After the Challenger accident the decision was made to launch the GPS satellites with the Delta II launch vehicles. The first second generation satellite was launched on February 14, 1989 on a Delta 6925 launch vehicle. The first Block IIA spacecraft, the tenth of the Block II series, was launched on November 26, 1990 with a Delta 7925 launch vehicle. The 7925 Delta features more powerful graphite cased solid boosters and a more efficient first stage main engine optimized for high altitude operation. From a peak of a launch every couple of months, the GPS launch rate went down to just one per year as all of the slots in the constellation were filled. On March 10, 1994, Block II-24 was launched, with the GPS constellation finally reaching full operational capability.

Since all of the launches were successful and there were no premature spacecraft failures, four spares remained to replace spacecraft as they reached the end of their operating lives. As *ST* goes to press, Block II-25 is scheduled for launch on March 27, 1996, and the other three spacecraft will be launched as required. It's anticipated that most of the remaining Block IIA satellites will be launched before the end of 1996.

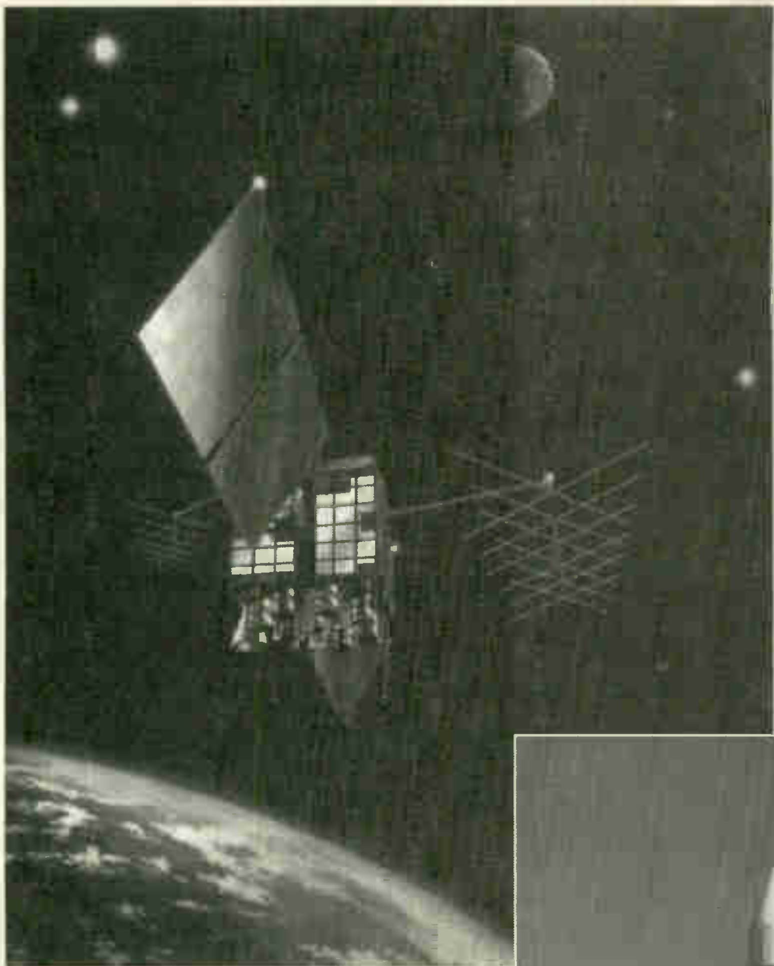
The first of the Block IIR spacecraft is in its final preparations for launch. The Block IIR are built by Lockheed Martin Astrospace. They have an anticipated lifetime of 10 years and will weigh 2032 kg (4480 lbs.) at launch. The Block IIR spacecraft will continue to use the Delta 7925 launch vehicle. All together 21 spacecraft are being built in the series, which should take GPS program through the year 2006.

Besides the GPS satellite's primary function as a navigation spacecraft they're also used to monitor international nuclear test ban treaties. The first U.S. nuclear detectors were the Vela (Spanish for "Watchman") spacecraft which were placed in extremely high orbits. One of the Velas detected something which may have been a clandestine South African nuclear test, however, it was determined to be almost certainly some unusual anomaly — like a hit by a micrometeoroid. The Defense Support Program (DSP) spacecraft also include nuclear detectors that watch for nuclear blasts from their geosynchronous vantage point.

But the largest number of nuclear detectors are aboard the GPS spacecraft. With 24 spacecraft covering literally the entire world every single nuclear explosion can be detected from space. Any country which chooses to violate the various nuclear test ban treaties, or any terrorist organization which intends to test its own homebrew nuclear device would be quickly caught in the act.

The GPS satellites, also know as Navstar satellites, must be precisely tracked to keep the system accurate. Several world-wide radar stations track the satellites and send that data to the GPS control center. Mainframe computers calculate the orbits for each satellite and decide if they've drifted beyond allowable margins. If a satellite drifts out of place a small thruster on the satellite can be used to put the satellite back in position. If the satellite's atomic clocks drift, critical circuitry fails, or if it runs out of fuel, it's shut off and retired. The system is extremely labor intensive and requires an army of personnel to maintain the constellation. One of the key features of the Block IIR spacecraft is the capability to operate for as long as six months without any updates to its ephemeris.

The Block IIR spacecraft will take GPS in to the next century, but Air Force and industry officials are looking even further in to the future. Already preliminary designs and specifications exist for the GPS Block III spacecraft, which will eventually become the world's source for high precision navigation signals from space. ST



Above: Artist rendition of the GPS-11R spacecraft in ordit. (Lockheed Martin Astrospace photo)

Right: A Delta II launch vehicle sits poised on complex 17A at Cape Canaveral Air Force Station, Florida, ready to carry the 24th Navstar GPS satellite into orbit. (U.S. Air Force photo)

SPACE INTEREST GROUPS

ST's Space Interest Groups list those local, national and worldwide groups you can join that promote space, astronomy, and space activities. Groups are selected for inclusion in this column by the staff of *Satellite Times* and run as editorial space permits.

Space Group Profile: National Space Society

The National Space Society (NSS) is an educational nonprofit 501(c)3, membership organization dedicated to the creation of a spacefaring civilization. NSS has more than 25,000 members and 75 chapters across the United States and throughout the world.

The following are highlights of the Society's activities and programs:

Ad Astra "to the stars" magazine is the primary membership benefit and the official publication of NSS. This non-technical, bimonthly magazine reports to the general public on a broad range of space-related topics, including domestic and international space policy and programs, commercialization, colonization, transportation, extraterrestrial resources, planetary science, education, and space advocacy.

NSS Chapters are sponsors of regional meetings, educational symposia, and the annual International Space Development Conference. These grassroots organizations are located in more than 75 cities in the U.S. and around the world. They serve as local organizers for space education and political activism, and frequently provide speakers and demonstrations for schools, civic organizations, and other forums on the merits of space science, exploration and education. Each year, a local chapter serves as host the annual International Space Development Conference (ISDC).

National Educational Activities include partnerships with National Science Teachers Association, American Institute of Aeronautics and Astronautics, Challenger Center, Young Astronauts, Spaceweek National Headquarters, Boy Scouts of America, Girl Scouts USA, and others.

On-going projects with these organizations include model rocket launches, teacher training workshops, student seminars. simulated space missions, public technology demonstrations, and scouting merit badge sponsorship.

The International Space Development Conference is the Society's annual meeting. More than 750 space activists convene to attend lectures, deliver papers, and plan strategies for developing space.

The National Space Society's 15th Annual International Space Development Conference (ISDC'96) will be held at the Grand Hyatt New York, 42nd St. and Park Ave., New York City, NY from Thursday., May 23 to Monday., May 27, 1996 (Memorial Day Weekend). It will be hosted by the Space Frontier Society of New York City

The International Space Development Conference is five days of spaceflight panels, workshops, exhibits, and more — all open to the public. At this multi-track space conference, you'll rub elbows with hundreds of astronauts, visionaries, entrepreneurs, activists, and educators.

A separate but parallel event, the 1996 New York Space Expo will include a special speaker track featuring astronauts and space visionaries, a space collectibles show, an exhibits hall, and a space art show. Space Expo is included in the full ISDC registration price.

For more information about ISDC'96 send e-mail to the following:

Speaker/program inquiries
Greg Zsidisin, ISDC'96 Chair, SFS/NYC President
71055.2110@compuserve.com

Registration inquiries
Linda DeLaurentis, SFS/NYC Secretary, Past President
74651.615@compuserve.com

General inquiries on the Space Frontier Society of NYC:
nssnyc@aol.com

ISDC Public Support for Space is a major goal of the Society. NSS leaders and members are frequently cited in newspaper articles and editorials and often appear on radio and television news and talk shows.The goal is to raise the attentiveness of the public, and especially the space-interested public, in the space-related activities of government, industry, and academia.

Public Policy Education is provided to our members via a network of telephone, electronic on-line services, newsletters, and direct mail. Member benefits also include private shuttle launch tours, a computer bulletin board service and a recorded telephone hotline.

NSS leadership is provided by an all-volunteer board of directors who govern the Society; Boards of Governors and Advisors provide additional expertise and visibility. Education, publication, technical and policy committees offer guidance.

Membership in the NSS is $20 Student/Senior Citizen (Student is 21 or younger), $35 Individual Member, and $50 for a Contributor Member

For more information on the National Space Society contact the NSS offices on Capitol Hill at 922 Pennsylvania Ave., SE, Washington, DC 20003.

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Satellite Times is a proud sponsor of the National Space Society's 15th Annual International Space Development Conference (ISDC'96).

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The new Sony Digital Satellite System rises head and shoulders above competing systems, offering technological innovations that make it easier and faster to set up and use—at a price you can afford!

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- Dish can be locked onto the satellite by using Sony's exclusive Signal Seeker® LED indicator, allowing a single person to install system.
- Provides better and easier use of menu screens.
- Sony's Express Navigator® offers simplified point and click menu selection.
- Rust-proof aluminum dish, not plastic or steel like others.
- Sony's remote control also operates Sony and other major brands of TVs and cable boxes.
- Sony has exclusive multi-event programmable timer (with AD1 receiver only).
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DSA03	UHF Remote Control (RM-4130)	$Call

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SPACE GLOSSARY

NAVSTAR GPS Related Acronyms and Abbreviations (Courtesy of the U.S. Coast Guard Navigation Center)

AE	Antenna Electronics
A/D	Analog to Digital
AFB	Air Force Base
AFI	Automatic Fault Indication
AFS	Air Force Station
AHRS	Attitude and Heading Reference System
AIMS	Airspace Traffic Control Radar Beacon System IFF Mark XII System
A/J	Anti-Jamming
AOC	Auxilliary Output Chip
A-S	Anti-Spoofing
ASIC	Application Specific Integrated Circuit
ATE	Automatic Test Equipment
BCD	Binary Code Decimal
BIH	Bureau International de L'Heure
BIPM	International Bureau of Weights and Measures
BIT	Built-In-Test
BPSK	Bi Phase Shift Keying
C/A-code	Coarse/Acquisition-Code
CADC	Central Air Data Computer
CDMA	Code Division Multiplex Access
CDU	Control Display Unit
CEP	Circular Error Probable
CMOS	Complementary Metal Oxide Semiconductor
C/No	Carrier to Noise Ratio
CRPA	Controlled Radiation Pattern Antenna
CSOC	Consolidated Space Operations Center
CW	Continuous Wave
DAC	Digital to Analog Converter
dB	Decibel (X = 10 Log X dB) 10
DGPS	Differential GPS
D-Level	Depot Level
DLM	Data Loader Module
DLR	Data Loader Receptable
DLS	Data Loader System
DMA	Defense Mapping Agency
DoD	Department of Defense
DOP	Dilution of Precision
dRMS	Distance Root Mean Square
DRS	Dead Reckoning System
DT&E	Development Test and Evaluation
ECEF	Earth-Centered-Earth-Fixed
ECP	Engineering Change Proposal
EDM	Electronic Distance Measurement
EFIS	Electronic Flight Instrument System
EM	Electro Magnetic
EMCON	Emission Control
ESGN	Electrically Suspended Gyro Navigator
FAA	Federal Aviation Administration
FMS	Foreign Military Sales
FOM	Figure Of Merit
FRPA	Fixed Radiation Pattern Antenna
FRPA-GP	FRPA Ground Plane
GaAs	Gallium Arsenide
GDOP	Geometric Dilution of Precision
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
HOW	Hand Over Word
HSI	Horizontal Situation Indicator
HV	Host Vehicle
HQ USAF	Headquarters US Air Force
ICD	Interface Control Document
ICS	Initial Control System
IF	Intermediate Frequency
IFF	Identification Friend or Foe
I-Level	Intermediate Level
ILS	Instrument Landing System
INS	Inertial Navigation System
ION	Institute of Navigation
IOT&E	Initial Operational Test and Evaluation
IP	Instrumentation Port
ITS	Intermediate Level Test Set
JPO	Joint Program Office
J/S	Jamming to Signal Ration
JTIDS	Joint Tactical Information Distribution System
L1	GPS primary frequency, 1575.42 MHz
L2	GPS secondary frequency, 1227.6 MHz
LEP	Linear Error Probable
LRIP	Low Rate Initial Production
LRU	Line Replaceable Unit
LO	Local Oscillator
mB	Millibar
MCS	Master Control Station
MCT	Mean Corrective Maintenance Time
MHz	Megahertz
MLV	Medium Launch Vehicle
MmaxCT	Maximum Corrective Maintenance Time
MOU	Memorandum of Understanding
M/S	Metres per Second
MSL	Mean Sea Level
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
N/A	Not Applicable
NAV-msg	Navigation Message
NOSC	Naval Ocean Systems Center
NRL	Naval Research Labratory
NS	Nanosecond
NSA	National Security Agency
NTDS	Navy Tactical Data System
NTS	Navigation Technology Satellite
OBS	Omni Bearing Select
OCS	Operational Control System
O-Level	Organization Level
OTHT	Over The Horizon Targeting
PC	Personal Computer
P-Code	Precise Code
PDOP	Position Dilution of Precision
PLSS	Precision Location Strike System
P I	Pre Planned Product Improvement
PPM	Parts Per Million
PPS	Precise Positioning Service
PPS-SM	PPS Security Module
PRN	Pseudo Random Noise
PTTI	Precise Time and Time Interval
PVT	Position Velocity and Time
RAM	Reliability and Maintainability
RCVR	Receiver
RF	Radio Frequency
RMS	Root Mean Square
RNAV	Area Navigation
RSS	Root Sum Square
RT	Remote Terminal
RTCA	Radio Technical Commission for Aeronautics
RTCM	Ratio Technical Commission for Maritime Services
S/A	Selective Availability
SAMSO	Space and Missile Systems Organization
SBB	Smart Buffer Box
SC	Special Committee
SEP	Spherical Error Probable
SI	International System of Units
SIL	System Integration Labratory
SINS	Shipborne INS
SPS	Standard Positioning Service
SRU	Shop Replacable Unit
STDCDU	Standard CDU
TACAN	Tactical Air Navigation
TAI	International Atomic Time
TBD	To Be Determined
TDOP	Time Dilution of Precision
TFOM	Time Figure Of Merit
TTFF	Time to First Fix
UE	User Equipment
UERE	User Equivalent Range Error
UHF	Ultra High Frequency
USA	United States of America
USNO	US Naval Observatory
UT	Universal Time
UTC	Universal Time Coordinated
VDOP	Vertical Dilution of Precision
VHSIC	Very High Speed Integrated Circuit
VLSIC	Very Large Scale Integrated Circuit
VOR	Very High Frequency (VHF) Omnidirectional Range
WGS-84	World Geodetic System - 1984
YPG	Yuma Proving Ground
1 PPM	1 Pulse Per Minute
1 PPS	1 Pulse Per Second

UPLINK

By Bob Grove, Publisher
E-mail address: st@grove.net

PCS Progress at the Speed of Light

Last week I had a delightful phone conversation with an old friend, Al Gross, well-known communications luminary and inventor of the walkie-talkie, CB service, pager, mine detector, and just about everything else that beeps and squawks. Our discussion centered around just where the industry was headed, and the frantic PCS race was the main topic.

The more I learned from Al, who is deeply involved with the impending low-earth orbiting (LEO) constellation platforms, the more I realized how little I know about PCS and that exploding market. It was an uneasy feeling; after all, who should know more about an industry than a publisher speaking to that industry?

But I don't feel guilty. As I talk with other leaders in the field, I am aware that they don't know all that much about it, either. I get the impression that few—if any—actually have the grasp of what's going on. It's all happening so fast, and most of us are still hanging on for dear life, afraid to let go of what we know, and afraid to grab onto what we don't know.

We all know what "PCS" stand for...or do we? Coming from the radio side of the house, I think it stands for Personal Communications *Service*, while our editor, Larry Van Horn, says it is more appropriately Personal Communications *Satellites*. If we can't even agree on what the initials stand for, how can we begin to define the technology?

We are flooded with news releases from entrepreneurial organizations announcing products and services, hoping to get their pieces of the pie. But does *anyone*—even Al—envision just how wide this new horizon is? It is more than pocket phones, portable faxes, LANs, telecommuting, and the virtual office. It is our entire concept of informational interchange at the government, public, professional, recreational, and even private levels. And it's worldwide.

It is as sophisticated as the Dick Tracy video watch or Star Trek communicator, and as simple as a toy walkie-talkie. It brings us into the board rooms of major corporations, allows a church in St. Louis to communicate with a mission in Zaire, affords security and response to a disabled motorist late at night on a lonely road, facilitates a frustrated businessman in a traffic jam conduct his appointment by long distance, invites an executive basking on a Florida beach to attend a conference in Paris, and lets mom call the kids home from the playground for dinner.

Let's do our increasingly technocratic society a favor and define their future for them. How about sitting back, letting your creative juices flow and your imagination soar, and coming up with what you think is a comprehensive list of devices and services which should be included under "PCS." To make the job easier, limit your list to wireless concepts even though many of them will undoubtedly interface somewhere with physical lines. Avoid similar listings (digital and voice pagers don't count as two!).

Send your entries to me at *ST* headquarters no later than March 30, 1996, so we can get the results in the next issue. We'll choose the list which in our judgement, has the largest number of valid, unique applications. The winning entrant will receive a complimentary one-year's extension to their *ST* subscription, and we'll share this list with all our readers so the industry will know what's in store for them as well.

Technological evolution is, indeed, caught up in a global whirlwind...or should that be *world*wind? ST

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