Satellite Times

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Volume 2, Number 1
September/October 1995

A Look Inside The Air Force's SPACE COMMAND

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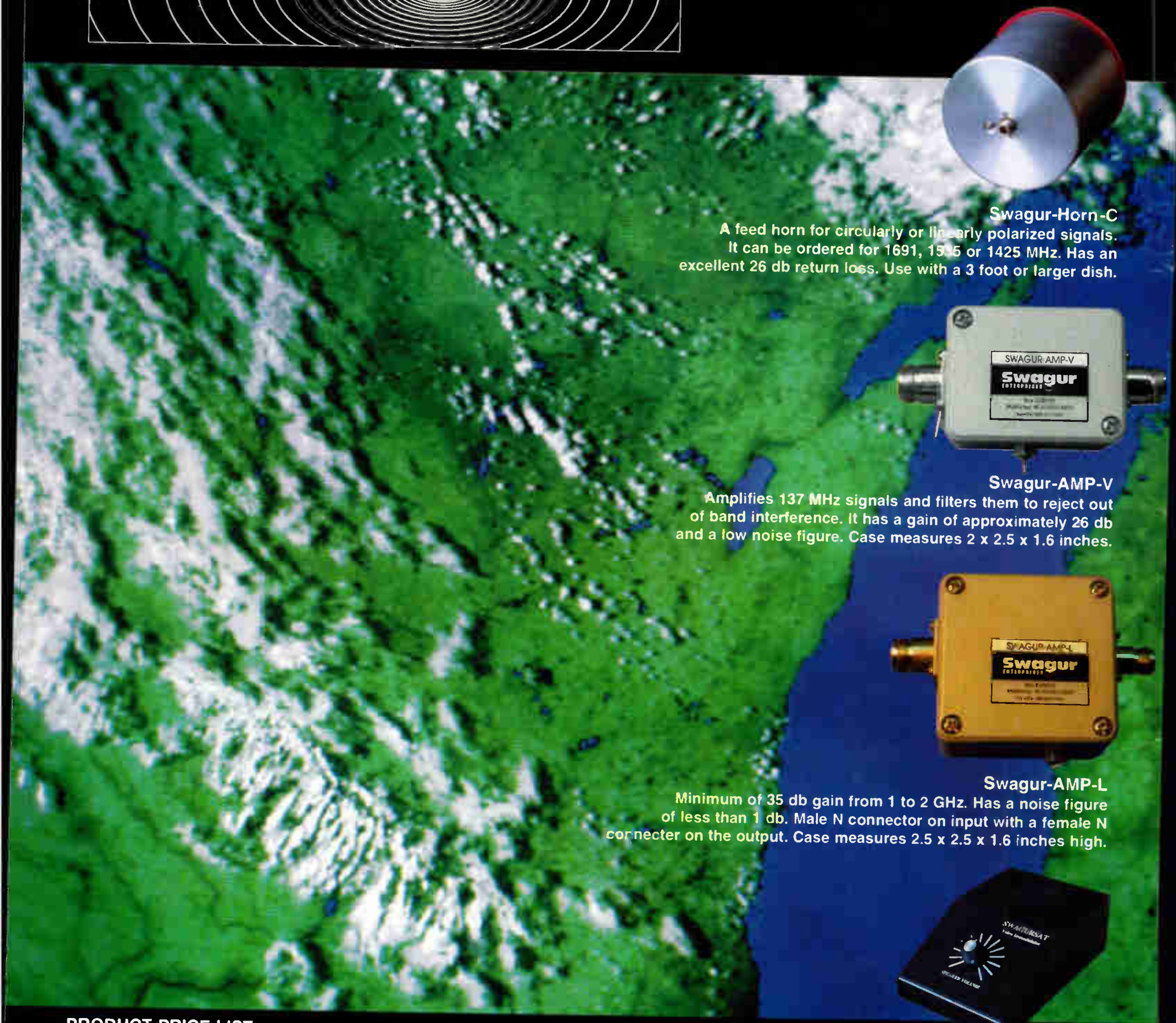

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Satellite Times

✣ FIRST ANNIVERSARY ISSUE ✣

Cover Story

ST *editor Larry Van Horn and* MT *editor Rachel Baughn take a look around the inside of the golf ball at the Colorado Satellite Tracking Station in Colorado Springs, Colorado. The huge dish above the editor's heads moves at 15 degrees per second as it communicates with DoD payloads. (Cover photo by Harry Baughn)*

Guardians of the High Frontier

By Larry Van Horn

Located 11 miles east of Colorado Springs, Falcon Air Force Base is one of America's most secretive military installations. *ST* takes you for a tour of the U.S. Air Force Space Command's Space Warfare Center. Story starts on page 10.

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September/October 1995

A Look Back at the Corona Program

The look back at the Corona Spy Satellite program on page 18 is a very interesting story. In this month's *Satellite Sleuth*, columnist Theo Pappan describes first-hand what it was like to work on the super-secret Corona program starting on page 24.

DEPARTMENTS

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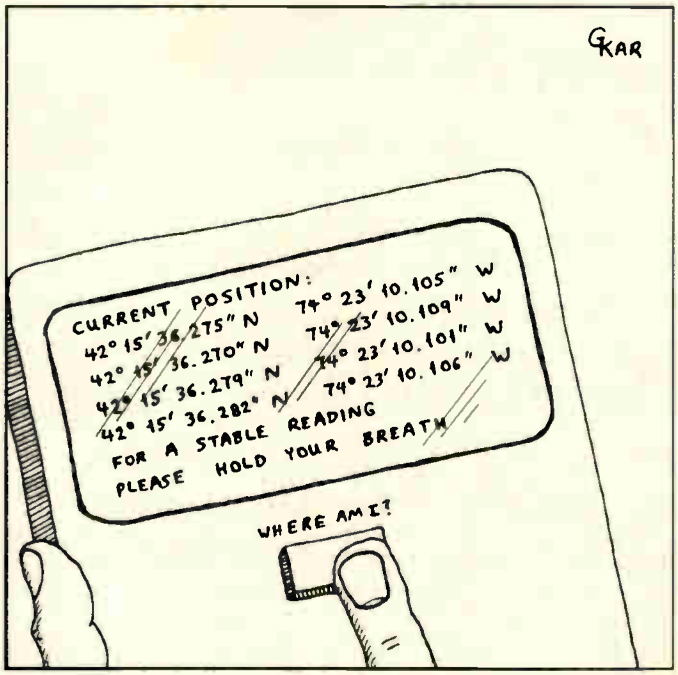
By Larry Van Horn
Managing Editor

ST on the Road

Things are finally starting to slow down as this column is being written after a very busy two months for the staff of *Satellite Times*.

Rachel Baughn (the editor of our sister publication *Monitoring Times*), her husband Harry and your *ST* editor journeyed to the land of Pikes Peak to tour the Space Warfare Center at Falcon Air Force Base and NORAD in Cheyenne Mountain. To say the least, it was an eye opening experience and one I won't soon forget. Our cover story this month will take you behind the scenes at one of this country's most secure military installations. You'll see how the controllers at Falcon control 110 satellites in orbit all around the world.



SUPER GPS (CIRCA 2005 A.D.)

The tour of NORAD and Cheyenne Mountain was just as impressive. We will have the complete story of that visit in the November issue of *Monitoring Times*. If you aren't a subscriber to *MT* call in your subscription right now. You won't want to miss the story of our visit to "The Mountain."

I would like to take this opportunity to publicly thank the staffs of the Space Warfare Center and NORAD for their time and assistance during our visits to their installations. We especially appreciate the efforts of Major Don Planalp at U.S. Space Command and 2nd Lt. Susan Idziak at Falcon public affairs and their staffs. The hospitality extended to us by the fine folks at Colorado Springs was first class.

Our second story in this issue is the conclusion of a four-part series on the military UHF communications satellites. *ST* regular, Phillip Chien, takes an in-depth look at the Navy's newest communications satellites. And, for the very first time, *ST* reveals the frequency bandplans being used by the UFO constellation of satellites, an *ST* exclusive.

An Executive Order, signed by President Clinton on February 23, 1995, authorized the declassification of satellite photographs collected by the U.S. intelligence community during the 1960's. Vice President Gore held a press conference in Washington, DC, on February 24 to announce the signing of the Executive Order. The press conference included a prepared speech by Admiral William O. Studeman, Acting Director of the Central Intelligence Agency, explaining the history of the early satellites in U.S. intelligence. *ST* presents that history in our story *Corona, Tracking America's First Spy Satellite Program.*

If you are interested in obtaining some of these KH-4 images, the photos will become declassified and available for purchase by the public around August of 1996. This allows government agencies enough time to create the working negatives and integrate the photo collection into their existing product ordering and distribution systems.

When the declassified images become available to the public, an Internet catalog and image browse capability for the entire collection will be accessible, at no charge, on the U.S. Geological Survey's Global Land Information System (GLIS). To try the GLIS online catalog and browse capability for Landsat MSS, Landsat TM, and NOAA AVHRR satellite image, load your web browser and click on http://edcwww.cr.usgs.gov/glis/glis.html.

Also in this issue we have an *ST* Satellite Profile on the DoD DSP satellite constellation and much, much more. So it's time to turn the page and see what's been happening as we start our second year of *Satellite Times*. ST

Comments to the editor of *Satellite Times* can now be addressed via the Internet at the following e-mail address: steditor@grove.net.

Satellite Monitor

By Wayne Mishler, KG5BI

Jupiter Probe gives its life for science

A six-year flight that included a couple of passes around Earth, a swing past Venus, and a close encounter with an asteroid were all just warm-ups for the spacecraft Galileo. The performance of its life began on July 13.

On that date, the Hughes exploratory spaceship launched a sensor-laden probe on a 150-day voyage to Jupiter. Its sensors are to gather and transmit back to Galileo eye-opening data on the temperature, pressure, and chemical composition of Jupiter's atmosphere. The probe then is expected to be crushed in the atmosphere it was sent to read.

Although the probe is only 123 centimeters (49.2 inches) in diameter and 87 centimeters (34.8 inches) long, it weighs a hefty 340 kilograms (748 pounds). It has an outer heat shield built by Hughes Aircraft Co. Inside the heat shield is the descent module, also built by Hughes, which contains six instruments, the main parachute, data and command processors, communications equipment, power electronics, and a lithium-sulfur dioxide battery. The battery will power the probe's electronics throughout the mission.

The probe will be traveling 171 thousand kilometers per hour (106,000 mph) when it pierces Jupiter's atmosphere. "At that speed, you could fly from Los Angeles to New York in 90 seconds," says Bernie Dagarin, Hughes program manager.

When it slams into the atmosphere, the probe will slow to Mach 1 in less than two minutes, subjecting its payload to forces of up to 300 times Earth's gravity.

Once the probe completes its fiery entry, it will operate in a gaseous environment with internal temperatures rising from 15 degrees below zero to 60 degrees above zero, Celsius. As the probe descends toward Jupiter, the atmospheric pressure around it will grow to perhaps 20 times that of the Earth within an hour. Eventually the atmospheric pressure will crush the vehicle and its contents.

So say the scientists who planned this historic mission. But, on the positive side, if all goes as planned, the probe's brief career will tell us more than we've ever known about Jupiter.

North Korean light mystery resolved...but is it solved?

Satellite Times reported in its January/February 95 issue a mysterious blackout that left North Korea in pitch darkness for an unknown length of time last fall.

Meteorologist Hank Brandii produced weather satellite pictures taken from an elevation of 726 kilometers (450 miles) on two separate cloudless nights, September 3 and 26, 1994, showing North Korea in darkness both nights while South Korea and surrounding islands and ships glowed as usual.

Hank recently sent us another satellite photograph taken on April 28, 1995, from about the same location, showing that the North Korean lights were back on again.

The blackout mystery apparently has been resolved, but not necessarily solved in the minds of weather satellite sleuths.

Hank conjectures that the blackout could have resulted from the lack of economic development in North Korea, or that the nation could have been on a war footing during that period, or that the blackout could have been ordered by the government in mourning the death of its revered leader, Kim Il Sung.

A more ominous possibility could be that the North Koreans ordered the blackout to prevent aerial inspection of their nuclear facilities at night.

The mystery continues.

Historic military satellite launched by Europe

The first military observation satellite ever to be developed jointly by France, Italy and Spain went into orbit at 1623 UTC on Friday, July 7, 1995, Arianespace has announced.

"This is an extremely important event for the European space industry, eagerly awaited by many people for a long time. It marks access to space for our armed forces," says Arianespace Chairman and CEO Charles Bigot.

The satellite, Helios 1A, was launched aboard an Ariane 40 rocket from the Space Center in Kourou, French Guiana. After a flight lasting just 18-minutes, 19-seconds, it was accurately injected into a quasi-polar, sun-synchronous orbit.

Helios 1A is the first satellite to be launched in the defense observation program conducted by France, Italy and Spain.

Testing of Delta Clipper resumes after explosion damage

In a recent test flight, The McDonnell Douglas Delta Clipper experimental launch vehicle (DC-X) rose more than a thousand meters (3,300 feet) above the U. S. Army White Sands Missile Range, moved laterally 106 meters (350 feet) until it hovered over its landing pad, then descended and touched down on the pad 123.6 seconds after liftoff.

In a subsequent test, the Delta Clipper demonstrated its re-entry capabilities by performing a critical rotation maneuver which a vertical-landing rocket must execute after re-entering the Earth's atmosphere.

After climbing to 2,500 meters (8,250 feet) at a maximum ascent rate of 73 meters per second (241 feet per second), the rocket rotated its base toward Earth. It then landed base first, using its four Pratt & Whitney RL-10 engines as brakes.

Testing of the 12.8-meter tall Delta Clipper has resumed after being halted by an explosion a year ago.

Plans call for up to three more flight tests this year. The single-stage, vertical-takeoff, vertical-landing vehicle will be put through rigorous flight maneuvers to prove that it can blast off, carry a payload into orbit, return to earth, and land under its own power as it was engineered to do.

The tests will contribute more data about the flight environment and characteristics of single-stage vehicles. They will also provide data on Delta Clipper's ability to be serviced and re-launched in quick turnaround operations.

During a test last June, a cloud of fuel vapors outside the Delta Clipper were accidentally ignited by ground support equipment during takeoff. The resulting explosion ripped the vehicle's shell, but it managed to make a successful emergency landing on the desert floor.

McDonnell Douglas developed the craft for the Ballistic Missile Defense Organization with support from the Air Force Phillips Laboratory at Kirtland Air Force Base in New Mexico. In tests preceding the explosion, engineers demonstrated its subsonic maneuverability and airplane-like performance.

Following this years tests, McDonnell plans to integrate advanced components into the vehicle in cooperation with NASA. The upgraded version will be called DC-XA. Tests are to resume in 1996.

Aerospace giants select X-33 configuration

arianespace inc.

McDonnell Douglas and Boeing have chosen a vertical takeoff, vertical landing configuration for the X-33 spaceship they are developing jointly with NASA for America's space program.

The X-33 is to be capable of relatively low-cost, airline-like space operations.

"Our team took a hard look at the technologies and critical issues associated with the various configuration options," says Paul Klevatt, X-33 program manager.

"The team concluded that (vertical takeoff and landing) is the right option to aggressively advance technology for an operational reusable launch vehicle."

Earlier this year, as reported by *Satellite Times*, NASA awarded the McDonnell Douglas and Boeing firms one of three agreements for Phase I of the X-33 program. This 13-month phase could lead to the selection by NASA of a single team in 1996 to design, manufacture, and flight test a demonstration vehicle. A joint government and industry decision on whether or not to proceed with production of such a vehicle is expected in 1999.

The Keck you say?!

One measure of a telescope is its ability to "gather light." That is, to see in the dark. One such telescope on Mauna Kea in Hawaii is raising eyebrows among astronomers because its light-gathering ability is so keen that it enables the human eye to see and study the components of light from objects lying at the fingertips of our farthest reaches yet into the cosmos.

It is called the Keck telescope, and the August edition of Scientific American magazine reports that the dazzling view resulting from its 10-meter (33 feet) mirror is stirring the emotions, the curiosity, and possibly the imaginations of astronomers searching for evidence of the "big bang."

Images from Keck are different than those from the much-publicized Hubble Space Telescope, orbiting above earth's murky atmosphere. Hubble gives us sharp pictures of objects in space. But objects visible to the human eye may account for only about 20 percent of the matter that exists in the cosmos, according to astronomers. Keck, because of its sensitivity to light, exposes secrets of the intensities of light spectra. This enables astronomers to "see" such things as clouds of gases and other invisible matter in space. These are valuable clues to the origin of our universe, clues which previously may have been overlooked.

One man, S. George Djorgovski of the California Institute of Technology, has spent much of his life searching for such clues. He recently discovered the faintest galaxies ever seen. But the evidence he needs to explain the origin of those galaxies eludes him.

"The universe is very, very strange. Nobody knows how (galaxy formation) is going on. Perhaps infant galaxies are cloaked in dust that obscures them, or perhaps astronomers need to use a different approach to look for them. We're overdue for some nice discovery," the Scientific American quoted Djorgovski as saying.

He hopes that Keck will virtually shed light on the matter.

Civilian satellites to star in military communications?

The Pentagon would like for commercial satellites to handle its low-security missions by the end of this century, according to the U.S. Defense Department.

A study predicts that the military's communications needs will grow to five times its present load between now and 2010.

"The Pentagon will never, ever be able to afford to buy enough (dedicated) government satellites to handle a load that large," says one high-ranking military official.

While the defense department sees a continuing need for secure satellite systems such as Milstar, commercial technology will probably be used for military missions when protection against jamming is not required, the study suggests.

Digital satellite...the way it ought to be

Nationally syndicated talk show host Rush Limbaugh is speaking out for digital satellite programming.

USSB (United States Satellite Broadcasting) is now advertising on Limbaugh's daily radio show. The 60-second spots, read by Limbaugh himself, are intended to drive prospective DSS customers into retail stores, and to raise awareness of both USSB and DIRECTV programming.

"With 4.8 million adults tuning in every quarter hour, Limbaugh's audience is a perfect target for the DSS message," says Mary Pat Ryan, USSB senior vice president for marketing.

"Mr. Limbaugh's personal enthusiasm for DSS makes advertising on his show a winner for us all."

The USSB line-up of top networks includes Comedy Central, Nickelodeon/Nick at Nite, All News Channel, VH1, MTV and Lifetime, in addition to numerous movie channels.

USSB and DIRECTV make available more than 175 channels of television through DSS. Their service includes a 46-centimeter (18 inch) satellite dish, digital home receiver and remote control, sold by RCA and Sony dealers nationwide.

The cost of their packages ranges from \$7.95 to \$34.95 per month.

Doc talk

Doctors in a remote hospital are consulting with colleagues in Mexico City via satellite in a six-month pilot program originated jointly by Hughes Electronics Corporation and the Mexican government.

"Doctors can consult with each other and medical information can be transmitted over long distances," says Pete Cortes, Hughes project manager. "Patients get immediate diagnoses without the discomfort of being transferred to another hospital. Families are spared the stress and expense of going out of town to be with their loved ones. And the hospitals save on travel costs."

It's all being done through the Hughes Tele-Imaging system, a fully integrated hardware and software system developed by Hughes Business Communications.

Hughes has announced plans to market this system to other medical facilities and to mining firms which often need to confer visually with experts in distant locations.

Mickey Mouse may go abroad

The Walt Disney Company has applied to the telecommunications authority of Singapore to set up an earth station in that country to receive the Disney Channel, *Satellite Times* has learned.

If successful, Disney movies will be beamed across the Asia-Pacific region to viewers in Taiwan, and Disney will become the fifth company licensed under Singapore's liberalized policy on satellite links.

Radio operators names and call signs will fly with satellite

The Radio Amateur Satellite Corporation (AMSAT) has begun a program enabling amateur radio operators to have their names and call signs placed aboard the Ariane 501 rocket prior to its launch on May 29, 1996.

For a donation of 150 or more British pounds to the AMSAT-UK Phase 3-D Fund, donors can have their names and call signs photo-etched into a small aluminum plate that will ride into space aboard the satellite.

Prior to launch, the plate will be photographed, and a copy of the photo, with certificate or plaque, will be sent to the donor as a momento of their support of the project.

Anyone who would like to make a donation should send inquiries to Ron Broadbent, MBE, VP RSGB, G3AAJ; 94 Herongate Road, Wanstead Park; London, E12 5EQ, England.

His telephone number is +44 181 989 6741. You can fax him at +44 181 989 3430.

He is also available on CompuServe: 100024,614, and on the Internet: R.Broadbent@EE.SURREY.AC.UK.

Challenger Center continues crew's mission

The Challenger Center for Space Science Education is continuing the Challenger crew's educational mission.

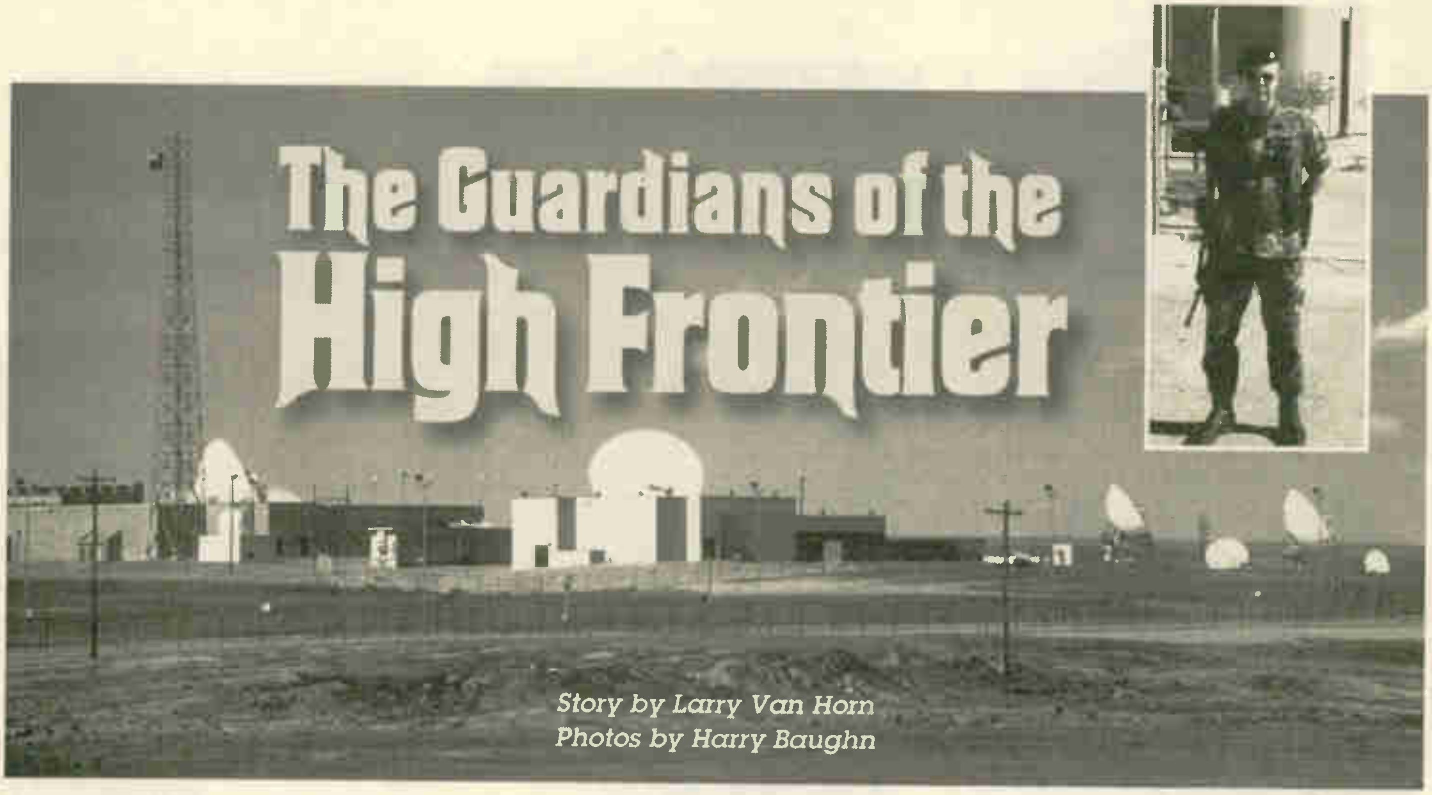
Founded by the families of the space shuttle Challenger 51-L astronauts, the non-profit center has become an international force in innovative education. During the 1995-96 school year, more than a quarter-million students and teachers are expected to participate in the program.

To raise funds for this important mission, the center is selling educational books for all ages on space and aerospace topics for a 20% discount of the cover price. A portion of each purchase will go toward funding the center's mission.

The center has published a mail order catalog of 60 of their most popular books.

For additional information, you can call them at 703-683-9740 or 1-800-98-STARS, or write to them at 1029 North Royal Street, Suite 300, Alexandria, VA 22314. ST

Sources: Arianespace Inc., Challenger Center for Space Education, EchoStar Communications Corporation, Hughes Space and Communications Company, Industrial Opportunities Inc., McDonnell Douglas, Radio Amateur Satellite Corporation (AMSAT), Satellite Meteorologist Hank Brandii, Scientific American Magazine, U. S. Department of Defense, United States Satellite Broadcasting.



The Guardians of the High Frontier

Story by Larry Van Horn
Photos by Harry Baughn

A Look Inside the U.S. Air Force Space Command

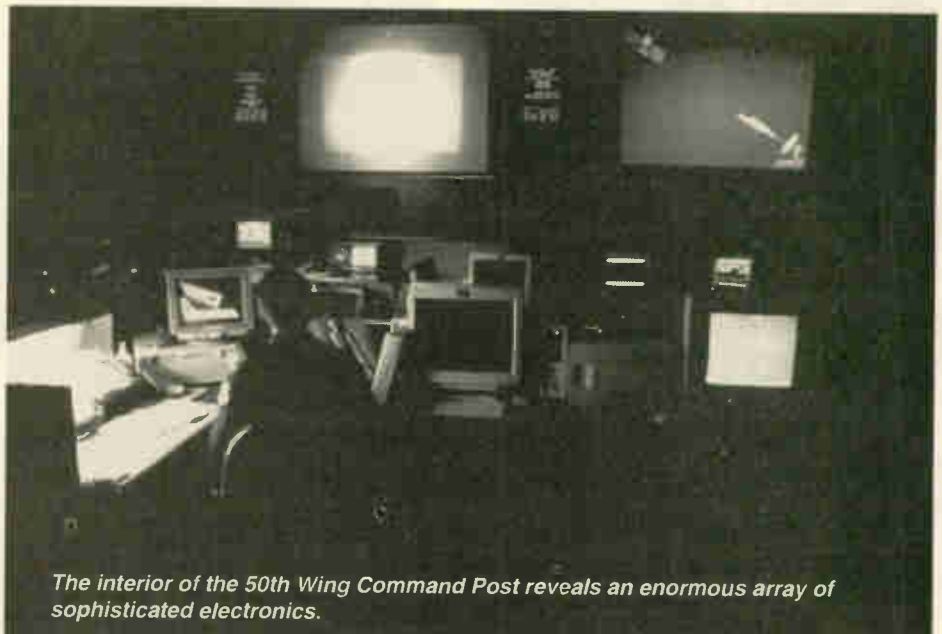
It's only 11 miles east of Peterson Air Force Base in Colorado Springs, Colo., but to get there it seemed like we had been traveling for an eternity. Maybe this perceived delay was due to my being anxious to get a tour of a facility not many civilians get inside.

Sitting in the back seat of our rental car and looking out the back window, I could see Pikes Peak and civilization disappear as we drove over another foothill heading east toward our destination. Urban Colorado Springs had given way to fields of beautiful yellow wildflowers nestled in a sea of green grass along the roadside.

"This place really is in the sticks," I commented to Harry Baughn, *ST* staff photographer, as he drove down a rural two-lane highway. Rachel Baughn, editor of *Monitoring Times*, nodded in agreement.

Finally we topped a hill and out in the middle of nowhere we saw our target. The modern buildings, dish antennas, and one giant white golf ball that we had traveled so far to see was spread out right in front of us. We had arrived at our destination—the U.S. Air Force Space Command's Space Warfare Center. The editors of *Monitoring Times* and *Satellite Times* magazines had traveled across the country to

Today's combat operations are significantly enhanced by U.S. space superiority; tomorrow's will be nearly impossible without it. Getting space into the cockpit, into shipboard command centers and into the foxhole is now within the state of the art.



The interior of the 50th Wing Command Post reveals an enormous array of sophisticated electronics.

tour the Air Force's newest base at Falcon and the home of the 50th Space Wing.

My first impression upon our arrival at what the Air Force calls the vehicle entrapment gate, was the enormous degree of security that envelops this 3,840 acre facility. Barbed wire, armed security guards, TV security cameras, and a high tech, personnel processing facility (called the entry control facility or ECF) only underscored the importance of the buildings we were about to enter.

Inside the ECF an employee at Falcon steps into one of several glass cages where he or she, runs a picture card with magnetic strip on the back through a machine, and punches in a personal ID number. If it all checks out, and the scales you were standing on don't indicate the presence of a second person, you get to go to work. Personnel at Falcon said it used to be worse when they use to have to do the retina optical scans as well in order to clear the ECF.

After a short stay at the ECF our tour guide for the day — 2nd Lt. Susan Idziak, deputy chief of Falcon public affairs, whisked us away to our first stop at the 50th Space Wing Command Post.

Satellite operations are conducted from the Jack Swigert Space Operations Facility (SOC). The facility was dedicated in June 1986 in memory of Jack Swigert who was born and raised in Denver, Colo. Swigert was an astronaut and command pilot on the Apollo 13 mission. Upon leaving NASA he ran for Congress from Colorado, and was elected, but died one week prior to accepting office in December 1982. He was 51 years old.

Even inside the SOC, security is the first thing you notice. Cipher locks and alarms are on every door which allow you 15 seconds to get through an open door before armed security personnel with dogs scramble to your location to check you out real close and personal.

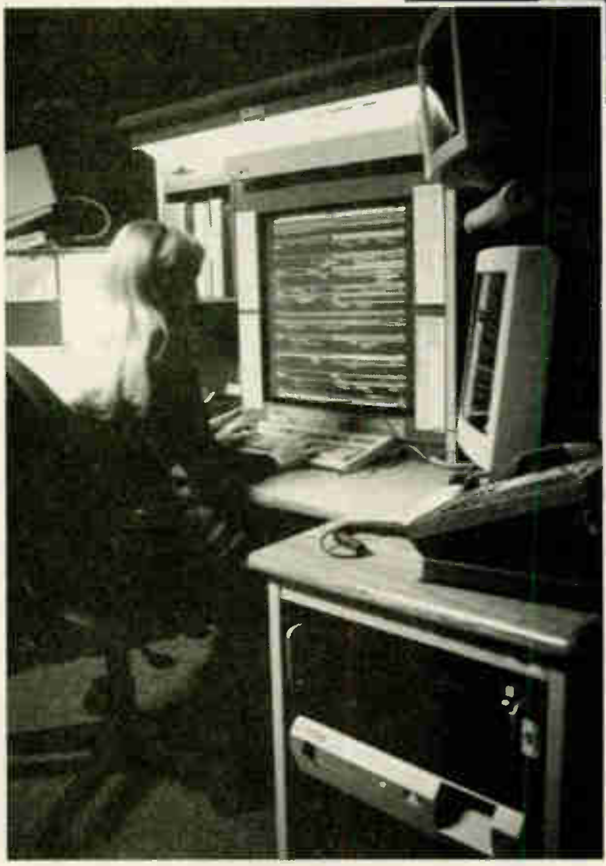
Once inside the wing command post you start to get a sense of the sheer magnitude of the job the people at Falcon do. Sitting in the wing commander's chair, I looked through a glass window into a control room full of computer terminals and large video displays on the wall.

Electronic clocks tick off the local and Zulu time, display the Julian date, and the officer in charge on duty. A status board to the right of the main video screen reminded me we were in Defcon 5 (peacetime), our threat condition was normal (no threat of armed attack), and road conditions were green (no snow or ice). The people behind the computer terminals were busy performing the primary mission of the 50th Space Wing — controlling our nation's military satellites.

Our briefer for this portion of the tour — Lt. Col. Michael Mantz, commander of the 4th Space Operations Squadron (SOPS) — proceeded to tell us what goes on behind the secure walls of the SOC.

The Air Force Space Command (AFSPC) is a major command and component of the U.S. Space Command for space forces and U.S. Strategic Command for ICBM forces. AFSPC is located at Peterson Air Force Base (also in Colorado Springs). The mission of AFSPC is to conduct Air Force operations by providing forces with:

- Military Space Systems—weather, communications, navigational, and missile warning satellites—already on the scene anywhere conflict may occur.
- Ground-based radars and missile warning satellites to provide ballistic missile warning for North America.
- National launch centers and ranges to provide military, civil, and commercial access to space.
- Worldwide surveillance radars to provide the nation and the world continuous



Above, a satellite operator in the Pike remote tracking station watches an ARTS terminal during a contact with a DoD satellite.

At left, a computer operator in the 22 SOPS schedules another contact with a DoD satellite for the AFSCN.

Take 110 satellites, mix in dozens of users and nine tracking stations, then you shake out the AFSCN contact schedule for the next 24 hours. Colonel Mitch Fry explains how it is done.

information on the location of satellites and space debris in orbit.

- The nation's durable and time proven deterrent against nuclear attack — the ICBM force.

As a component of the U.S. Space Command, the AFSPC's primary focus is to increase the utility of space systems for the U.S. and allied fighting forces. Desert Shield and Desert Storm provided the first real proving ground for space. Today's focus is to develop even more efficient and faster avenues for bringing space support to the warfighters. As we learned during the brief, the Space Warfare Center and 50th Space Wing at Falcon form the nucleus of that assistance to the warfighters.

Inside the 50th Space Wing

The 50th Space Wing mission, under the command of Col. Simon P. Worden, is to command and control operational Department of Defense satellites and to manage the worldwide Air Force Satellite Control Network (AFSCN). In addition to the space operations centers at Falcon, the wing operates remote tracking stations and other command and control facilities around the world. These facilities monitor satellites during launch, put the satellites in their proper orbits following launch, operate the satellites while they are in orbit, and fix satellite anomalies when they occur. The wing provides support for the operation of over 110 military satellites valued at over ten billion dollars.

The next stop on our tour was to one of the ten space operations centers under the 50th Space Wing — the 2nd Space Operations Squadron (SOPS), commanded by Lt. Col. Roger Hunter. This squadron is responsible for the day-to-day command and control of the Navstar GPS satellite constellation. This unit operates and maintains the Master Control Station and a dedicated network of monitor stations and ground antennas that control and monitor the satellites of this vital national asset.

Following a brief overview of the Navstar program, Colonel Hunter escorted us to the "operations floor." Behind the glass we saw one of the five crews, which consist of three officer and four enlisted personnel, processing data from a network of monitor stations that were being used to update these satellites' navigation messages. These updates are sent from Falcon through ground antennas to the GPS satellites. These same ground antennas are used by the controllers in 2nd SOPS to transmit commands to the GPS spacecraft and receive state-of-health information (telemetry).

There are six other squadrons under the 50th Space Wing that perform various functions for the payloads as indicated below.

The 1st SOPS is responsible for launch and early orbit operations, as well as anomaly resolution for the DSP and Navstar programs. This unit conducts the day-to-day operations for DSP early warning constellation of satellites.

3rd SOPS conducts day-to-day operations for the Defense Satellite Communications System (DSCS III) and the Navy's Fleet Satellite Communications System (FLTSAT). It also conducts both launch and on-orbit operations for the Navy's UHF Follow-On satellites.

Like the 1st and 3rd SOPS, the 4th SOPS is located at Falcon and is responsible for day-to-day satellite command and control, communications management, and ground segment maintenance for the Milstar satellite program — a joint service communications satellite system.

The 5th SOPS is located at Onizuka Air Station, Calif., and is responsible for day-to-day operations for the DSCS II constellation, the residual DSCS III satellites and NATO III communications satellites. The squadron has prime launch responsibility for DSCS II, NATO IV/Skynet IV, and the Inertial Upper Stage (IUS) for the space shuttle. They are the prime backup node for GPS launches, NATO IV/Skynet IV, and DSP on-orbit operations. In addition, this squadron provides backup telemetry and commanding support to the Space Shuttle Control Center, various NASA programs, the Atlas, Titan and Delta booster rockets.

6th SOPS is located at Offutt Air Force Base, Neb., and is responsible for day-to-day command and control of the Defense Meteorological Satellite Program (DMSP). Detachment 1, 6th SOPS, located at Fairchild Air Force Base, Wash., collects real-time data from the DMSP satellites and relays the data to Offutt AFB and the satellite users. It is also capable of conducting emergency command and control of the satellites.

An Air Force Reserve unit at Falcon is the last of the command and control squadrons attached to 50th Space Wing. 7th SOPS reserve members augment active duty units during launch operations, national emergencies, and low manning periods. The members provide command and control support for the DSP, Navstar, GPS, Milstar, and DSCS satellite programs.

All of the SOPS share a common resource to perform their mission and that is the AFSCN. The 750th Space Group, a component of the 50th Space Wing, is located at Onizuka. This group is responsible for operations, maintenance, and logistical support for the common user resource of the AFSCN in support of the DoD-assigned space mission. Two of the group's subordinate units, the 21st and 22 SOPS, schedule the usage of the tracking stations for the various SOPS at Onizuka, Offutt, and Falcon. This enables the SOPS to make contact through the tracking stations to communicate with the satellites for which they are responsible.

22 SOPS Writes the Schedule

Lt. Col. Mitchell Fry commands the 22 SOPS which is responsible for the scheduling and control of the AFSCN resources and the Colorado Tracking Station (Pike). Colonel Fry showed us the Resource Schedule Branch which prepares and publishes a monthly summary of satellite supports, plus a weekly and daily schedule for all users and maintains the status of all AFSCN common user resources. The AFSCN averages about 400 contacts a day with the various DoD space platforms.

For many years scheduling for the AFSCN was done manually using a large, graphics-based paper chart which was used to prepare the tasking orders for the nine stations of the AFSCN for a 24-hour period. Due to budget cuts, computers were introduced in November 1992 which has eased the loss of personnel and streamlined a very complicated process.

The 21st SOPS has an identical twin at Onizuka (22nd SOPS). These centers are linked together by a computer network, fixed-based antennas, and highly sophisticated communications equipment. Using military and commercial satellite connectivity, these two squadrons work in tandem and provide end users and controllers alike the ability to use the military hardware that DoD has placed in space.

A Look Inside the Golf Ball

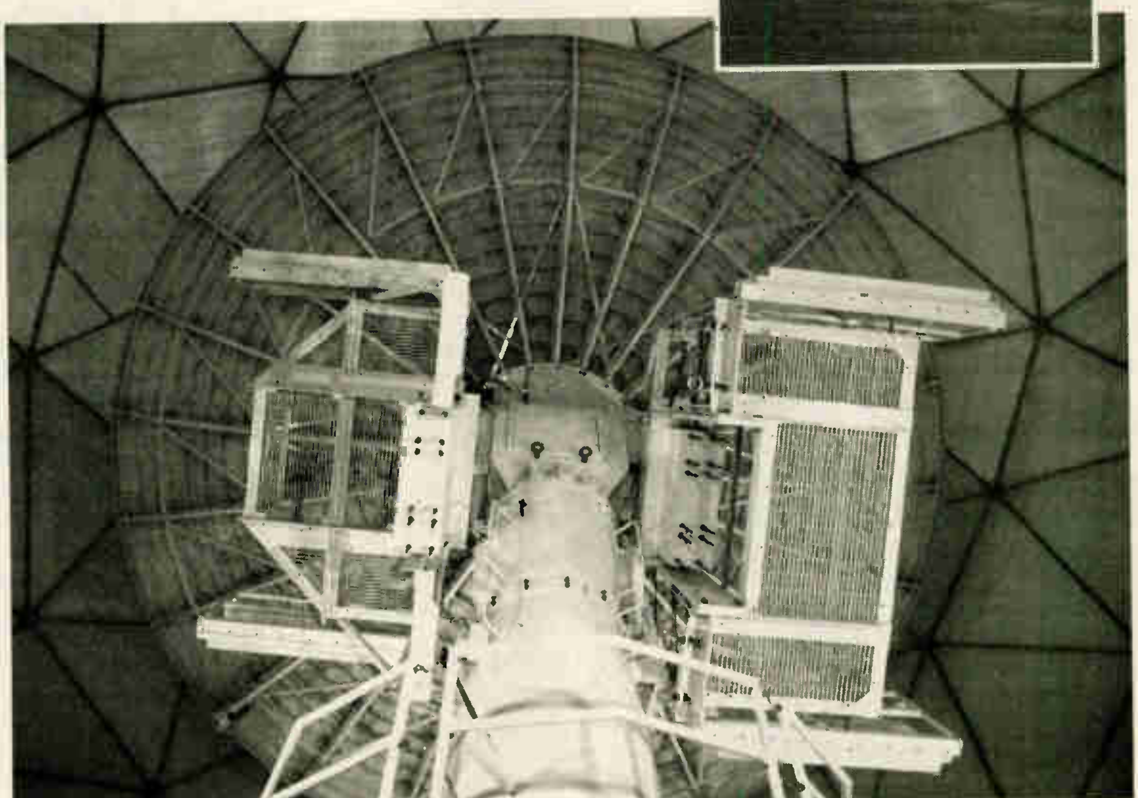
After a quick tour in the scheduling center, we jumped into an Air Force van for the quick ride across the base to Pike, as the Colorado Tracking Station is known. Pike is responsible for providing on-orbit tracking, telemetry, command, and mission data retrieval services to support NASA's space shuttle, NATO, and DoD satellite operations. This is also one of the sites equipped to support the Global Positioning System (GPS) for its navigation upload messages.

The station, part of a global network of nine AFSCN common user sites, was the first stand-alone, new generation, Automated Tracking Station (ARTS) to be installed. ARTS has really streamlined tracking and commanding satellites. One satellite contact used to involve 90 racks of equipment and 15 operators. Now that is down to 18 racks of equipment and two operators. The purpose of the ARTS system was to increase the AFSCN sites' reliability, reduce life cycle costs, add to the network capacity, and improve inter-netting and inter-operability with the DMSP and GPS dedicated systems.

With 110 payloads in orbit, a common communications system was required to be able talk to all of the satellites. The Space Ground Link Subsystem (SGLS) was the answer to this problem. SGLS operates with a single uplink and up to two downlinks. The uplink carries commands and ranging to the satellite. The downlinks involve tracking functions and transfer of telemetry. All the uplink and downlink frequencies are in the 2.0 to 2.3 GHz S-band region.

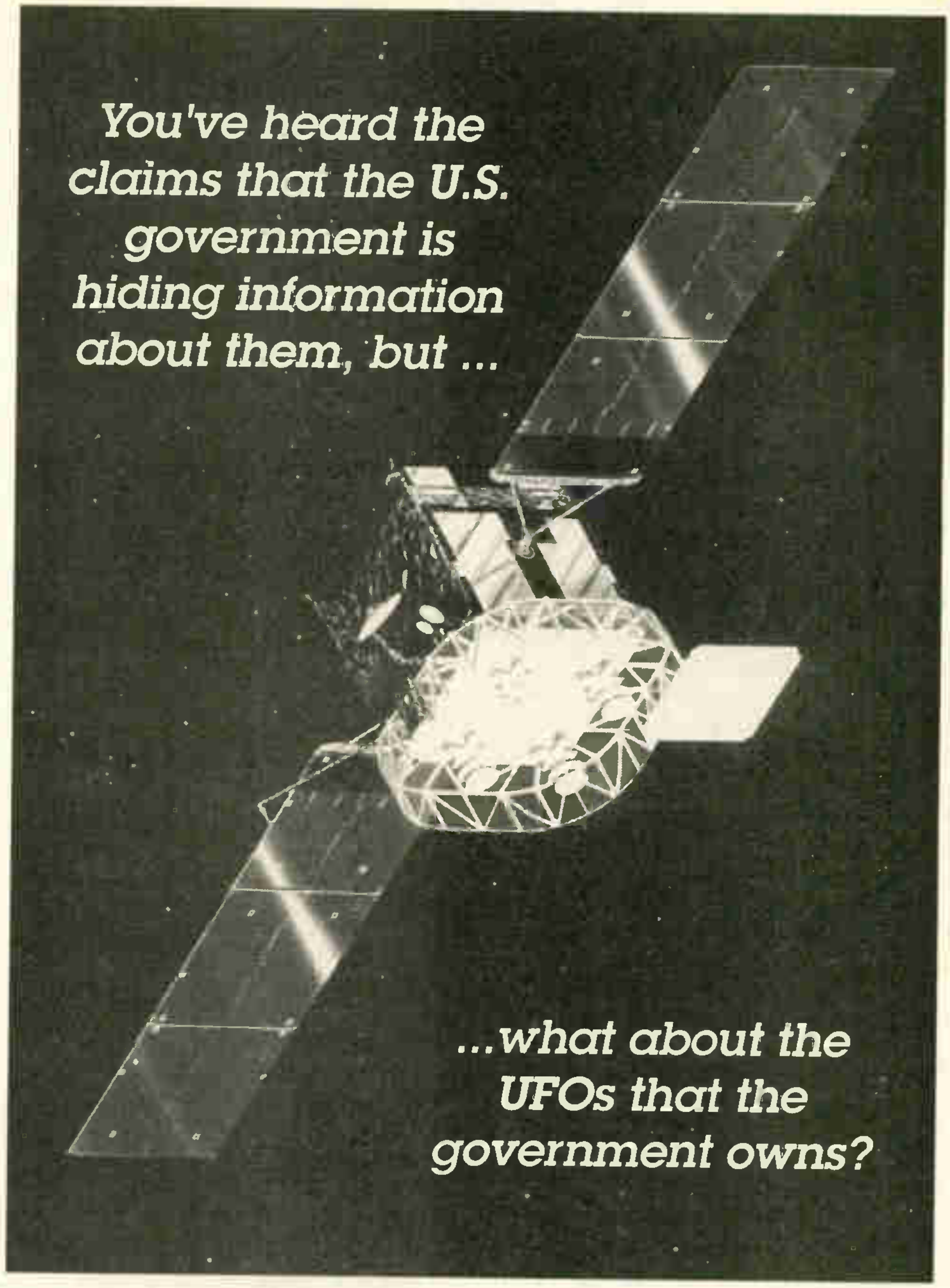
As all good things must our tour ended and we reluctantly had to take our leave of Falcon. It was a fun day, one I will never forget. As we drove back toward Colorado Springs, I looked out the front window at snow-capped Pikes Peak and couldn't help but think, "The people at the 50th truly are the Guardians of the High Frontier."

ST



At right and below are outside and inside views of the impressive Pike AFSCN tracking station (inside view also shown on the front cover of this month's ST.

UFOs



By Philip Chien, Earth News

The Navy has its own UFO program. No it's got nothing to do with flight saucers or non-terrestrial intelligence. UFO stands for UHF Follow-On, the current generation of dedicated Navy communications satellites which are replacing the aging Fltsatcom and Lesat spacecraft.

In 1989, the Navy contracted with Hughes Aircraft to build the first UFO spacecraft, with options for additional spacecraft. Hughes is responsible for building the satellites, procuring launch services, and on-orbit checkout. In an extremely unusual procurement decision the Navy decided not to contract with the Air Force or NASA for launch vehicles, as it had done for previous spacecraft. Instead the Navy chose to go the commercial route, with the satellite manufacturer procuring the launch vehicles commercially. Hughes had a commercial launch service competition and chose General Dynamics (now Lockheed Martin) and its Atlas launch vehicle over Martin Marietta's Titan III.

The Navy doesn't actually take title to the spacecraft until its finished its orbital checkout and is ready to enter service. As a UFO spacecraft enters service it replaces an existing Fltsatcom or Leasat platform. By 1997 the constellation of eight operational spacecraft plus one spare should be completed. Originally the contract for nine spacecraft, delivered on orbit came to $1.6 Billion. A tenth satellite was ordered by the Navy in January 1994 for a cost not to exceed $197 Million. The spacecraft have nominal lifetimes of 10 years, but carry enough propellants for 14 years of operation.

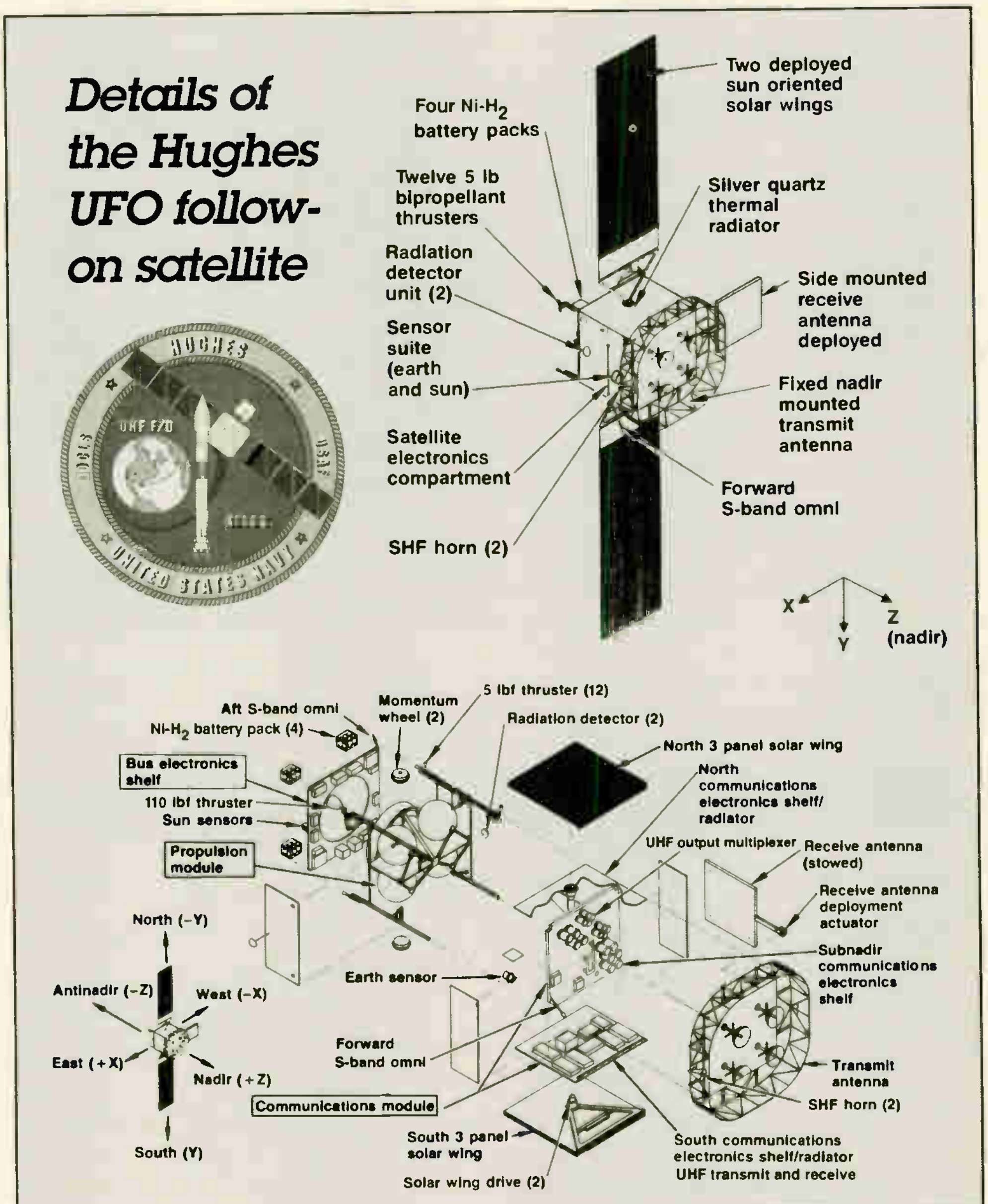
The UFO series consists of a military communications payload on a commercial HS-601 spacecraft bus. The first three spacecraft featured 11 solid state UHF amplifiers and 39 UHF channels with a total 555 kHz bandwidth. The band plan consists of 21 narrow band channels at 5 kHz each, 17 relay channels at 25 kHz, and one fleet broadcast channel at 25 kHz. The early UFO spacecraft were launched on Atlas I launch vehicles. The later spacecraft, the EHF series, add an additional 11 Extremely High Frequency transponders including a 5° steerable spot beam to the communications package. With the additional weight of the EHF payload the larger Atlas II launch vehicle is used.

The original spacecraft weigh 2,807 kgs. (6,189 lbs.) at spacecraft separation. This is well above the normal capacity of an Atlas I launch vehicle for a geosynchronous transfer orbit mission, so the Atlas only places the spacecraft into a 16,850 x 287 km. (9,098 x 155 nm) transfer orbit. The spacecraft uses its own onboard 444 Newton (100 lbf) thruster to raise the orbit up to geosynchronous altitude, with four intermediate burns. The thruster is also used to decrease the inclination from the launch site's 28.5 degree inclination to an equatorial orbit. The transfer orbit profile, using both the launch vehicle and onboard spacecraft supplies to reach its operational orbit, is more efficient than to have the launch vehicle go all the way. The EHF series weighs 3020 kgs. (6660 lbs.) at separation from its Atlas II launch vehicle and uses a similar set of burns to reach geostationary orbit.

Each satellite measures more than 20 meters (60 ft.) from tip-to-tip of its solar arrays. The arrays generate 2500 watts on the early spacecraft, and 2800 watts on the EHF series. The UFO spacecraft are based on Hughes's HS-601 bus, which is also used by Galaxy IV and VII, DirecTV, Optus B1, Panamsat 2 through 4, Astra, MSAT, and other commercial spacecraft. The HS-601 is an 3.35 meter (11 ft.) cube, including the spacecraft's propulsion systems, computer, power systems, and other support components. The separately built communications platform is customized for each particular communications application. Consequently, the HS-601 has been used for C-and K-band television transmissions, L-band mobile communications, and high-power direct broadcast applications in addition to the UFO series's UHF and EHF transponders.

The UFO program started with an unauspicious start—the first launch resulted in a failure, although a rather unique failure in that the spacecraft did reach orbit, but not its intended one. AC-74 was a standard Atlas I launch vehicle, consisting of an Atlas first stage and Centaur upper stage. The Atlas was derived from the 1950s-era ICBM, and early versions launched the Mercury astronauts in to orbit, and early planetary and communications spacecraft. Atlases had a long heritage of success, with over 500 successful satellite launches. Unfortunately AC-74 had a jinxed Atlas stage. A stem screw used to control the first stage's 'throttle' was incorrectly tightened, resulting in the Atlas feeding only 66% of the required propellants to its MA-5 engines. Without enough kerosene and liquid oxygen the engines didn't produce enough thrust, causing the stage to use more propellant than planned, and ending up without enough altitude or velocity. The Centaur upper stage's inertial measurement unit realized that it did not have enough velocity, but burned as much of its propellants as possible, to get as high an orbit as possible. Since it started its burn at a much lower than anticipated velocity it was not able to put the spacecraft into its planned orbit, ending up in an orbit with an apogee of 9,198 km. (4,967 nm), instead of the planned altitude of 16,849 km. (9,098 nm). It was a rather unique case — the failure of a launch vehicle's first stage still resulting in a spacecraft, in good shape, in space.

It was quickly apparent that the spacecraft's onboard propellants could not raise the spacecraft to geosynchronous altitude and reduce the inclination to an acceptable value for normal mis-

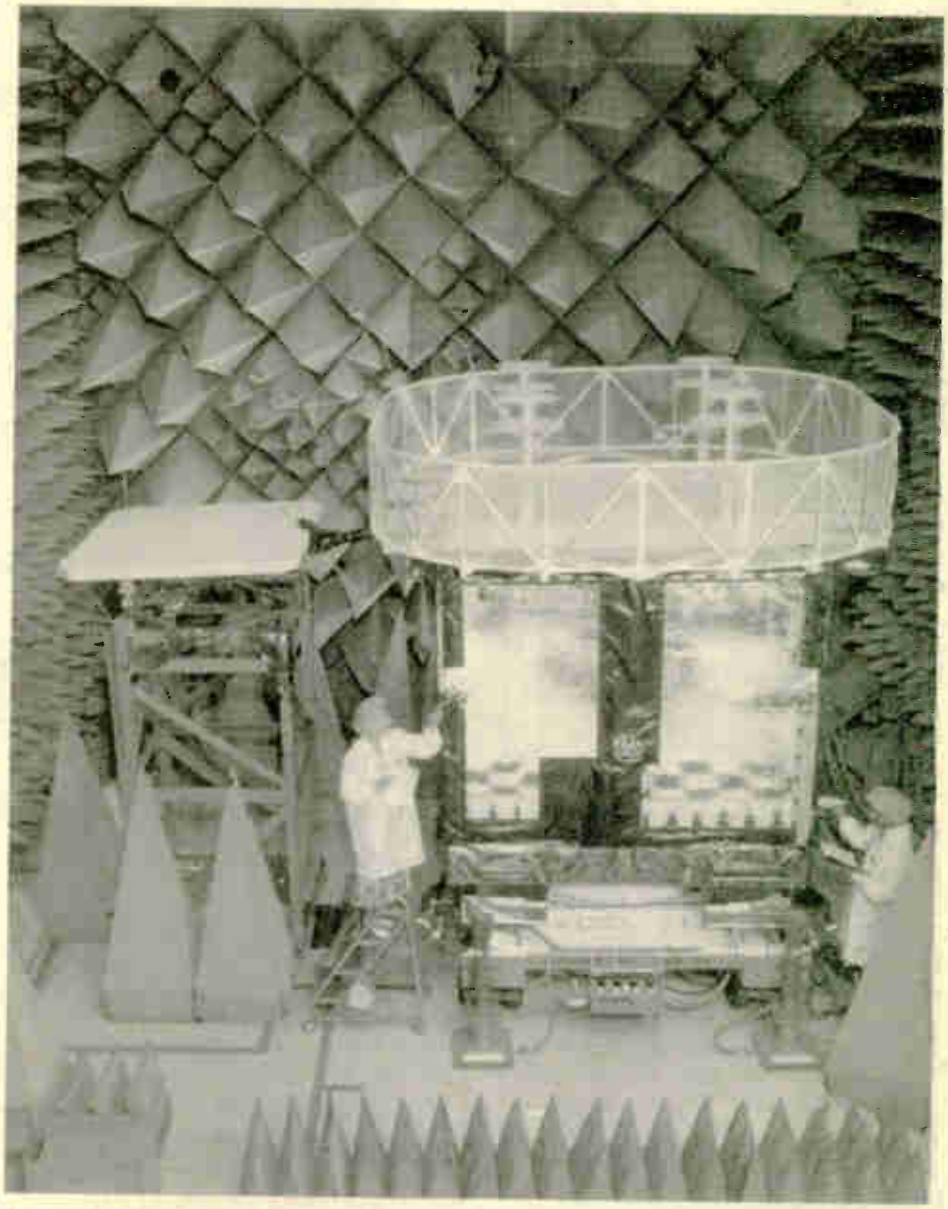


Details of the Hughes UFO follow-on satellite

sion operations. And the spacecraft was not designed to be recovered by the space shuttle. Even if a shuttle retrieval was possible it was certainly not practical — a replacement spacecraft would be less expensive than the cost of a shuttle retrieval mission! Hughes, hoping that some limited use could be found, raised the spacecraft to geosynchronous altitude even though there wasn't enough propellant onboard to reduce its inclination to an acceptable value. The Navy and Hughes tried to evaluate possible uses for the spacecraft in its distorted orbit, but eventually determined that it wasn't worth the extra effort.

Eventually Hughes decided to use the spacecraft for engineering tests, including risky ones which would never be performed on a useful spacecraft. After the tests UFO-1 was raised out of geosynchronous orbit to ensure that it would not interfere with other spacecraft. The last UFO-1 command was sent on July 12, 1995. Without commands coming from the ground the spacecraft started to drift, and couldn't point its solar arrays at the sun. Without power or thermal control the spacecraft quickly froze. That spacecraft is still up there, but turned off and just an expensive piece of space junk. Hughes's insurance carriers paid back the cost of building the satellite and launch services, and the Navy never took control of the satellite. It's now in an orbit with an altitude of 36,000 km. (19,438 nm) and 28.5 degree inclination, drifting westward each day. So while the UFO-1 spacecraft has an international designator of 1993-15A and a NORAD catalog number of 22563, it never received an USA military designation.

Even with that unauspicious beginning the UFO program has been extremely



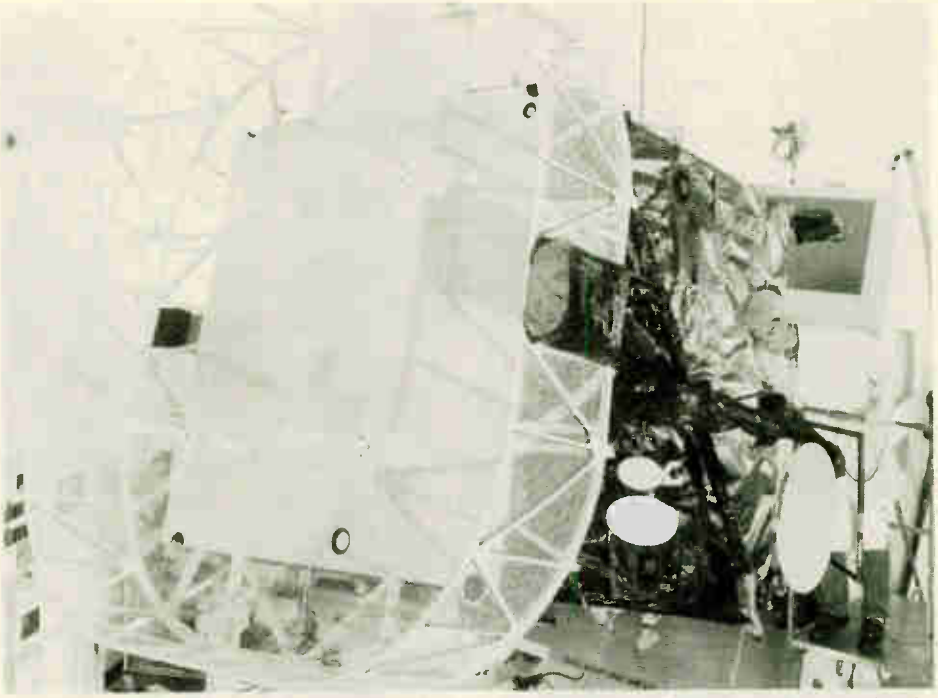
Antenna array and electronics section of the UHF Follow-own satellite are being tested in an anechoic chamber at Hughes Space and Communications Comapny in El Segundo, California.

TABLE 1: ***UFO Payload Launches and Scheduled Launches***

NORAD	Intl Desig	Name	USA	Location (W)	Ocean	Replaces:	Mass	ELV	Year	Date	Pad
22563	1993-15A	UHF follow on #1		N/A			2871	Atlas I AC-74	1993 1Q	Mar-25	36B
22787	1993-56A	UHF follow on #2	USA 95	-72.0	Indian		2871	Atlas I AC-75	1993 3Q	Sep-3	36B
23132	1994-35A	UHF follow on #3	USA 104	15.0	Atlantic		2853	Atlas I AC-76	1994 2Q	Jun-24	36B
23467	1995-3A	EHF 4	USA 108	177.0	Pacific	Lea 2	3027	Atlas II AC-112	1995 1Q	Jan-28	36A
23589	1995-27A	EHF 5	USA 111	-72.5	Indian	Lea 5	3027	Atlas II AC-116	1995 2Q	May-31	36A
	1995	EHF 6		105.0	Conus	Lea 3	3027	Atlas II AC-119	1995 4Q	Oct-25	36A
	1996	EHF 7		-172.0	Pacific	Fltsat 4	3027	Atlas II AC-	1996 3Q	Aug-19	36B
	1997	EHF 8		100.0	Conus	Fltsat 7	3027	Atlas II AC-	1997 1Q	Feb	36B
	1997	EHF 9		23.0	Atlantic	Fltsat 8	3027	Atlas II AC-	1997 3Q	Aug	36B
		EHF 10		Spare	TBD	TBD	3027	Atlas II AC-	1997 4Q	?	36B

successful. UFO-2 was launched on September 3, 1993 aboard AC-75 and was turned over to the Navy on December 2, 1994. UFO-3 was launched on June 24, 1994 on AC-76 and turned over to the Navy on September 22, 1994. EHF-4, the first spacecraft with the EHF platform, was launched aboard AC-112, an Atlas II launch vehicle, on January 28, 1995, and turned over to the Navy on March 16, 1995. The most recent spacecraft, EHF-5, was launched on May 31, 1995, and scheduled to be turned over to the Navy in late July or early August. EHF-6 is scheduled for launch in October 1995, with EHF-7 spacecraft scheduled for launch in mid 1996 and the remaining three spacecraft in 1997. As each UFO enters service an aging Fltsatcom or Leasat spacecraft can be retired.

The cold war is over, but high quality communications remains a priority for all of the armed services. The UFO series replaces two types of aging communications satellites and will support the Navy's communications requirements into the 21st century. ST



A technician examines an antenna that is part of the extremely high frequency payload on the UHF Follow-On F5 spacecraft, under construction in the Hughes Space and Communications Company satellite facility.

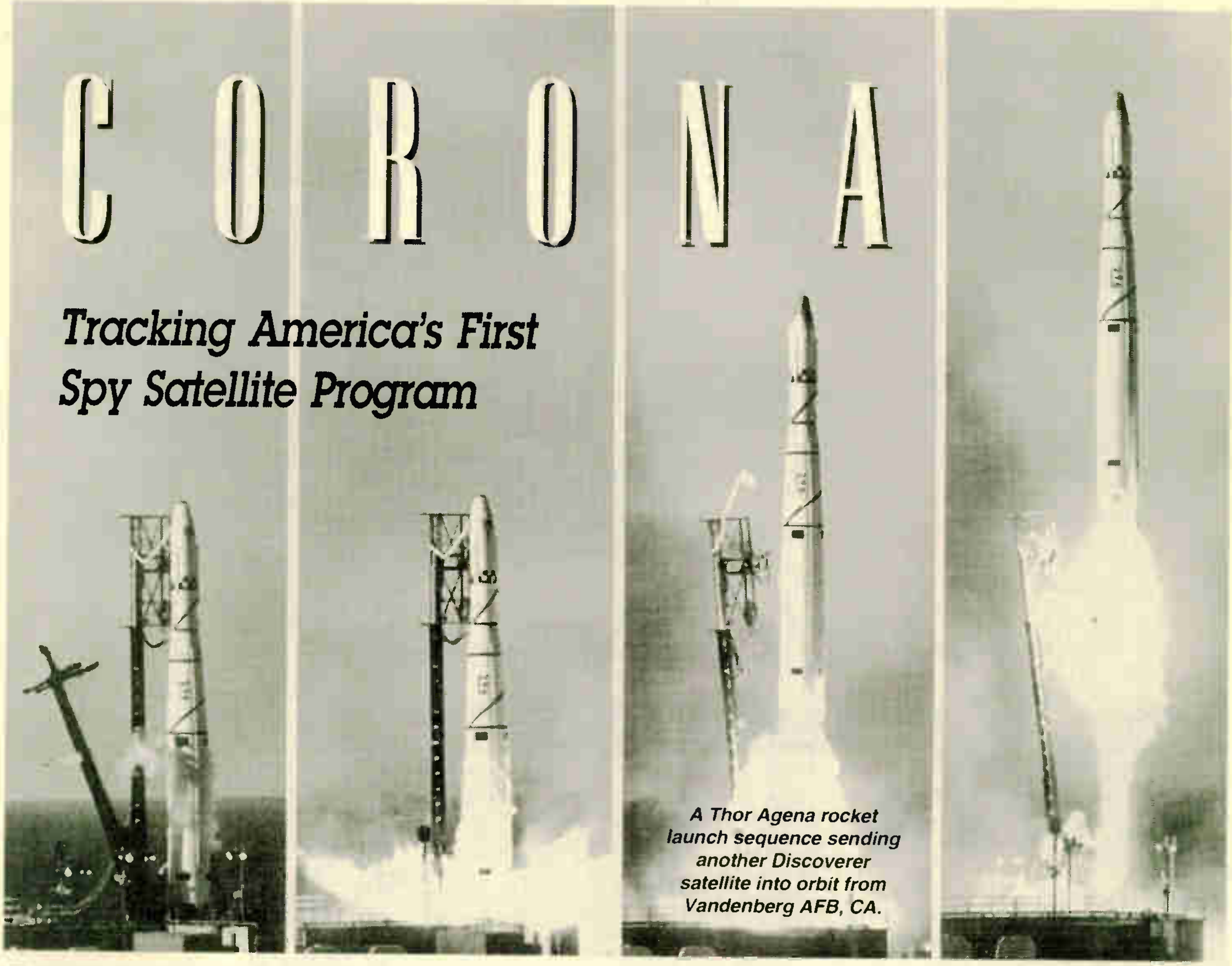
TABLE 2: ***UFO Communications Downlink Frequencies***

Channel No./Bandwidth	November	Oscar	Papa	Quebec
Channel 1 (25 kHz)	250.350	250.450	250.550	250.650
Channel 2 (25 kHz)	251.850	251.950	252.050	252.150
Channel 3 (25 kHz)	253.550	253.650	253.750	253.850
Channel 4 (25 kHz)	255.250	255.350	255.450	255.550
Channel 5 (25 kHz)	256.850	256.950	257.050	257.150
Channel 6 (25 kHz)	258.350	258.450	258.550	258.650
Channel 7 (25 kHz)	265.250	265.350	265.450	265.550
Channel 8 (25 kHz)	266.750	266.850	266.950	267.050
Channel 9 (25 kHz)	268.150	268.250	268.350	268.450
Channel 10 (25 kHz)	269.650	269.750	269.850	269.950
Channel 11 (25 kHz)	260.375	260.575	260.425	260.625
Channel 12 (25 kHz)	260.475	260.675	260.525	260.725
Channel 13 (25 kHz)	261.575	262.075	261.625	262.125
Channel 14 (25 kHz)	261.675	262.175	261.725	262.225
Channel 15 (25 kHz)	261.775	262.275	261.825	262.325
Channel 16 (25 kHz)	261.875	262.375	261.925	262.425
Channel 17 (25 kHz)	263.575	263.775	263.625	263.825
Channel 18 (25 kHz)	263.675	263.875	263.725	263.925
Channel 19 (5 kHz)	243.915	243.995	244.075	244.155
Channel 20 (5 kHz)	243.925	244.005	244.085	244.165
Channel 21 (5 kHz)	243.935	244.015	244.095	244.175
Channel 22 (5 kHz)	243.945	244.025	244.105	244.185
Channel 23 (5 kHz)	243.955	244.035	244.115	244.195
Channel 24 (5 kHz)	243.965	244.045	244.125	244.205
Channel 25 (5 kHz)	243.975	244.055	244.135	244.215
Channel 26 (5 kHz)	243.985	244.065	244.075	244.225
Channel 27 (5 kHz)	248.845	248.975	249.105	249.235
Channel 28 (5 kHz)	248.855	248.985	249.115	249.245
Channel 29 (5 kHz)	248.865	248.995	249.125	249.255
Channel 30 (5 kHz)	248.875	249.005	249.135	249.265
Channel 31 (5 kHz)	248.885	249.015	249.145	249.275
Channel 32 (5 kHz)	248.895	249.025	249.155	249.285
Channel 33 (5 kHz)	248.905	249.035	249.165	249.295
Channel 34 (5 kHz)	248.915	249.045	249.175	249.305
Channel 35 (5 kHz)	248.925	248.055	249.185	249.315
Channel 36 (5 kHz)	248.935	248.065	249.195	249.325
Channel 37 (5 kHz)	248.945	248.075	249.205	249.335
Channel 38 (5 kHz)	248.955	248.085	249.215	249.345
Channel 39 (5 kHz)	248.965	248.095	249.225	249.355
Channel 40 (5 kHz)	248.975	248.105	249.235	249.365

Note: Channel 1 is the U.S. Navy multichannel fleet broadcast channel. Channel 2-18 are fleet relay channels. Channel 19-40 are narrowband AFSATCOM channels.

CORONA

Tracking America's First Spy Satellite Program



A Thor Agena rocket launch sequence sending another Discoverer satellite into orbit from Vandenberg AFB, CA.

It was shrouded in secrecy for more than 25 years. Only a handful of people knew the whole story. It's a story that that has all the elements of a best selling techno-thriller. Now thanks to an executive order by President Bill Clinton, America can take its first official look at the black world of photo intelligence. This is the story of Corona.

Corona was a classified effort within the Air Force's Weapon System 117L (WS-117L), awarded to Lockheed in 1956. As the program from which all space reconnaissance evolved, WS-117L is best understood in relation to earlier programs.

In the early years of the Eisenhower administration, concern gave way to alarm as intelligence sources revealed several Soviet technical accomplishments that for the first time put American soil at risk of a nuclear surprise attack, including: test of a hydrogen bomb in 1953; operation in 1955 of the Bison bomber; and hints of a ballistic missile program. As Soviet expansionism increased, Soviet homeland activities became increasingly secretive, eliminating the reassurance a nation normally obtained from knowing, day-to-day, what another nation was doing.

Rejection of a 1955 initiative to exchange military installation blueprints with regular aerial photographs of each site led Eisenhower to conclude that "Khrushchev's own purpose was evident—at all costs to keep the USSR a closed society." Such an intention was a call to action. "When the Soviets rejected Open Skies . . . I conceded that more intelligence about their war-making capabilities was a necessity."

Following the rebuff, Eisenhower, on December 27, 1955, authorized a project of camera-carrying balloons called Genetrix. Flying at altitudes of up to 27.3 km (90,000 feet), the balloons drifted across the Soviet land mass, photographing areas of interest, then were recovered in mid-air over the Pacific ocean. Flights began on January 22, 1956, and were continued until February 24 with 516 releases. The operation was discontinued because of vigorous Soviet objection. Intelligence gathering resumed as the U2 aircraft began operation on July 4, 1956, though sparingly and discreetly until May 1, 1960, when Francis Gary Powers was shot down during a flight from Pakistan to Norway. When the President decided to cancel additional aircraft overflights, the U.S. was, once again, "blind."

In 1957, the USSR took the lead in the space race with an August flight of an intercontinental ballistic missile, causing dismay since the U.S. had suffered five highly publicized missile test flights that year, all failures. Immediately after the Soviet success, the expression "missile gap" came into use. The scope of national anxiety was reflected in Eisenhower's statement that "there was rarely a day when I failed to give earnest study to reports of our progress and to estimates of Soviet capabilities."

The USSR placed the first satellite, Sputnik, in orbit on October 4, 1957. One month later, Sputnik II was launched, with a live dog as passenger. The U.S. responded by launching the Navy's Vanguard satellite in early December, which in full television view of the American public, malfunctioned and was destroyed by fire on the launching pad. Amid the turmoil, U.S. Defense Secretary Neil H. McElroy authorized the acceleration of WS-117L to proceed "at the maximum rate consistent with good management."

The need for WS-117 was outlined in 1954 by Air Force General Operational Requirement No. 80. A government board in March 1956 recommended selection of Lockheed's proposal and a letter contract issued on October 29 made Lockheed the prime contractor for WS-117L. On January 1, 1957, Lockheed established its first Space Systems organization in Palo Alto, California, which was later moved to Sunnyvale.

Presidential Go-ahead

The late 1950s were driven by a space reconnaissance imperative. To protect this development, Air Force WS-117L program manager Col. Frederic C.E. Oder presented the system as an Air Force scientific satellite project known as Discoverer. As a precursor to later spacecraft designs, Discoverer fell under overall cognizance of the Central Intelligence Agency (CIA), with the Air Force's Western Development Division, commanded by Major General Bernard A. Schriever, retaining technical management responsibilities.

Conversion of WS-117L into a scientific satellite program was briefed to President Eisenhower at the White House in February 1958. Owing to the extreme sensitivity of the subject, details were furnished orally. It was explained that Corona would orbit the earth three times, taking pictures as it passed over the Sino-Soviet bloc, and then would de-orbit the film capsule. It was of utmost importance to protect this project as the satellite cameras would only be able to discern objects 1.5 to 3 meters (50 to 100 feet) on a side. This being the case, it would be easy for the Soviets, if they learned about the project, to build dummies that could fool the satellite cameras; therefore, it was of paramount importance to keep them from learning it.

The President indicated the CIA should have exclusive control of the intelligence phases of the operation. He said only a handful of people should know about it. In a follow-up meeting Eisenhower said "emphatically that he believed the project should be centered in the new Defense space agency, doing what CIA wanted them to do."

Following this meeting, the program was revised to include a Thor-Hustler upper stage (later known as the Lockheed-designed Agena satellite vehicle). White House endorsement of the effort, coupled with acceptance by the CIA of the approach, enabled Corona to press forward.

Discoverer XIII capsule was ferried to Moffett Field from Hawaii where it was displayed at the then-named Lockheed Missiles and Space Division before continuing its trip to Washington, D.C. Pictured left to right are Lt. Gen. Bernard Schriever, chief of air force research and development; Gen. Thomas White, air force chief of staff, and Col. Charles Mathison, vice commander of the 6594th Test Wing of Santa Clara, California. (Photo courtesy of Lockheed-Martin)

Additional factors leading to CIA involvement were its ability to contract with industry for expeditious procurement; the ability to maintain effective security; and

the desire of the CIA to orient the program toward the collection of priority intelligence.

Corona Program Details

In 1959, WS-117L was renamed Sentry. This effort was then divided into three sub-programs: Discoverer, Midas and Sentry. Soon after, the program Sentry was renamed Samos. By 1960, Sentry encompassed: Discoverer (Corona) for film recovery visual reconnaissance; Samos Projects 101A (E2) and 101B (E5) for, respectively, readout high magnification visual surveillance and film recovery high magnification visual reconnaissance; Samos Program 201 (E6) for film recovery high magnification visual reconnaissance; and Midas, an infrared sensor that was the precursor to today's Defense Support Program (DSP) program to detect missile launch and bomber movement.

Samos was terminated (Projects 101 in 1961 and Program 201 in 1962) as Corona achieved increasing success. Yet throughout its early years, Samos was reported extensively as the key spy satellite that keeps "this Nation informed of vital military installations and build-ups behind the Iron Curtain." So replete was the confusion that Discoverer was viewed as a mask for Samos capsule retrieval, serving to reinforce thinking that a space reconnaissance system meant large organizations with broad, discernible activities—the antithesis of the Corona program.

To assemble Corona into operationally-ready satellites, a work area was leased on April 1, 1958 in Menlo Park, California. Within Lockheed, few questions arose since Corona was compartmented: most workers engaged in a single, segmented phase of the vehicle-assembly process; as of 1963, well into regular Corona operation, only four people in Lockheed were briefed to the entire Corona program. Corona was moved to Lockheed's Sunnyvale, California, plant in 1969.

Spacecraft System Details

Lockheed served as technical adviser and integrator of all Corona equipment other than the Thor booster, developed the orbiting Agena upper stage, and integrated and led the test, launching and on-orbit control operations.

Agena, a space vehicle produced on an assembly line, was the heart of Corona and other military and NASA satellite systems. Mated to a rocket booster, Agena consisted of a three-axis gyro guidance and control system with correction inputs from horizon sensors that enabled precise cold-gas valve firings; an electrical system with six one-hour batteries; a telemetry, command and tracking system; a recovery system of a thermally protected reentry capsule with a retro-rocket, cold-gas spin-stabilized attitude control system, power supply, telemetry link and acquisition beacon, sequence timer and parachute; and a propulsion system utilizing a Bell rocket engine delivering 7,200 kg (16,000 pounds) thrust for orbit injection.

President Dwight D. Eisenhower inspects an American flag that was returned from Earth orbit in a capsule ejected from Discoverer XIII. (Photo courtesy of Lockheed-Martin)

A vertical-looking, reciprocating, 70-degree panoramic Itek camera exposed the Eastman Kodak film by scanning at right angles to the line of flight. Integrated into the three-axis stabilized Agena, Corona's first camera used a 60.96 cm (24-inch) focal-length, f/5.0 Tessar lens with image-motion compensation. Resolution in the early years was in the range of 1.05 to 1.2 meters (35 to 40 feet). The imagery was by air catch following ejection in orbit by a sequence timer of the General Electric reentry capsule containing the film. Water recovery was used a backup.

By 1972, Corona delivered resolutions of .18 to .3 meters (six to 10 feet), routinely, as camera payloads matured. Early capsules carried 4.5 to 7.2 kg (10 to 16 pounds) of film; toward the end of the program they carried 80 pounds (16,000 feet). In the 1970s, flights could remain on orbit for 19 days, provide accurate attitude, position, and mapping information, and return coverage of 8,400,000 nm^2.

Agena became so successful that it was invoked in 1961 as a standard on other government programs. Last flown in 1987, Agena's world record 362 launches was achieved with an overall success rate exceeding 90 percent and a peak launch rate of 41 launches in one year.

Corona Gets Off the Ground

Launches 0-38 were called Discoverer, with the first attempt on January 21, 1959 — one year after program go-ahead. The flight was aborted by premature ignition of ullage rockets on Agena, after which President Eisenhower conferred with Richard M. Bissell personally. Discoverer I, launched on February 28, established an orbit with an apogee of 968 km (605 miles) and perigee of 158.4 km (99 miles). Though no capsule was carried, it was deemed a success, and constitutes Lockheed's first satellite in space.

Following its April 13 launching, Discoverer II ejected its capsule halfway around the earth from the planned recovery zone. At the time, Air Force Lt. Col. Charles "Moose" Mathison (who was not Corona cleared), served as Vice Commander of the 6594 Test Wing which operated the control facilities for Air Force satellite programs. Mathison flew to the impact area to make a ground and air search, and though no capsule was found, Corona managers had little worry: the capsule carried mechanical mice, electronic devices to record biomedical effects data.

Discoverers III and IV, launched on June 3 and June 25, failed to reach orbit velocities because of inadequate Agena thrust. Eisenhower began asking the Director of Central Intelligence, Allan W. Dulles, for explanations. After Discoverers V and VI failed in August, flights were grounded for exhaustive tests which found technical weaknesses in the reentry subsystem being exposed to temperatures lower than for what it was designed, and problems in electrical power, telemetered information, tracking, separation sequence and capsule stability. An independent report on September 8 urged the program be halted for further study, and led to conclusions that Lockheed had been overconfident and that the Agena and capsule section were not instrumented adequately. In response, Lockheed increased satellite battery output and instrumented the recovery capsule more elaborately.

The next two Discoverer flights, on November 7 and 20, experienced subsystem and camera malfunctions. After two months of corrective engineering, Discoverer IX and X suffered booster complications on February 4 and February 19, 1960. Discoverer X was destroyed during its climbout, showering Vandenberg with debris.

By March, discussions resurfaced of canceling Corona as discouragement grew. Air Force Corona Program Director Col. Paul Worthman reminded people that problems were inevitable in a rushed and pioneering program. Bissell overturned the cancellation drive, deciding the activity should press on with renewed vigor.

On April 15, Discoverer XI went into orbit and the recovery system malfunctioned again, unfortunate, as it was the first perfect camera operation due to Eastman Kodak's change from acetate-base to polyester-base film. But the failure triggered a personal message from Air Force Vice Chief of Staff, General Curtis LeMay, to Lockheed, urging "extraordinary corrective actions" and the personal attention of top Lockheed management to the elimination of defects in the system. Lockheed conducted further tests in environmental chambers plus diagnostic flights in which the capsule would be instrumented specifically for recovery system telemetry. Discoverer XII climbed very briefly from the launch pad on June 29, with an erratic horizon sensor causing a nose-down position during separation of the Agena from the Thor booster.

Two circumstances in mid-1960 made the situation more tense. President Eisenhower canceled U-2 operations following the May 1 U-2 shootdown, putting the onus on satellites for reconnaissance. The second was the approaching maiden flight of the Samos readout reconnaissance satellite, a system attractive to a growing chorus frustrated with complicated Corona recovery attempts.

During this time, it was theorized that the hot-gas spin rockets on the recovery vehicle were not igniting simultaneously and, instead of spinning the capsule like a football in flight, were causing it to cartwheel and to enter unintended orbits, rather than return to earth. Lockheed designed a cold-gas spin-stabilized rocket system that was retrofitted into the vehicles. The use of these rockets was a major contributor to future NASA and military space capsule and object recovery.

Because of heavy pressure for success, the launching of Discoverer XIII on August 10 took on great importance. The satellite was inserted into orbit, with the recovery vehicle ejecting on revolution 17. Capsule separation, retrofire and reentry were nearly perfect, with the predicted impact point very close to plan. Communication confusion between the air recovery teams caused the capsule to splash down in the sea, where it was retrieved by helicopter and deposited on the deck of the Haiti Victory recovery ship on August 12. "Capsule recovered undamaged," was the terse message across cryptographic lines to Washington, D.C.

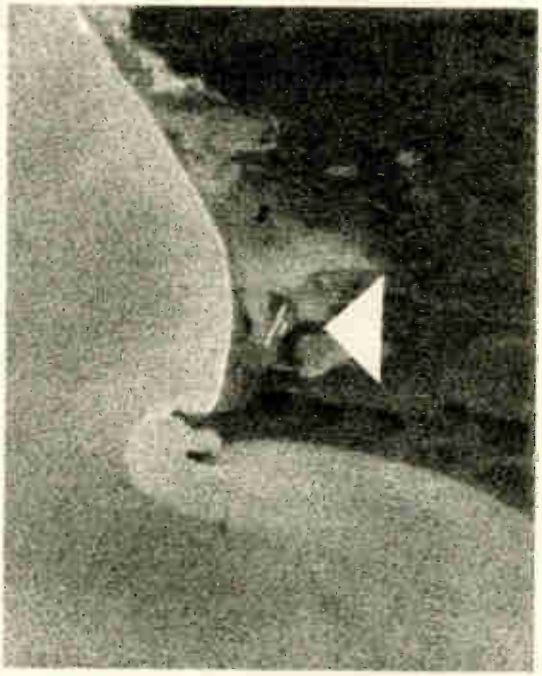
Lucky 13 First Corona Success

A plan laid down 18 months earlier called for the surreptitious exchange of the capsule for a dummy, shortly after return to California, with shipment of the real capsule to the East Coast. These necessary precautions would preclude examination of the real capsule's film-entry aperture.

Although Discoverer XIII had no camera, the first recovery was planned as a full dress rehearsal for the handling of a real Corona capsule. Unknown to all involved though, "Moose" Mathison (not briefed on Corona), had a different plan.

Mathison believed that the first Discoverer success would offer an opportunity for media exposure of Air Force space programs and attention on the fine work being done by his friend General Schriever (who now headed Air Force Systems Command and also led the Air Force Corona effort). On August 12, Mathison landed by helicopter on the flight deck of the Haiti Victory and assumed charge.

After arranging to have the Commander of the Pacific Air Force meet him at the dock for press photos, Mathison transferred the capsule to a C-130 aircraft and began a flight to Sunnyvale, California. While airborne, he passed the time by breaking into the capsule, which he found to be almost empty. He sent a message to General Ritland and the president of Lockheed in Sunnyvale to meet him for another photo shoot.



This August 18, 1960, photograph is the first intelligence target imaged from the first Corona mission. It shows a military airfield (arrow) near Mys Schmidta on the Chukchi Sea in far-northeastern Russia. (Photo courtesy of the EROS Center)

The next day, Mathison and the capsule landed at Andrews Air Force Base for more photographs, this time with General Schriever and the Chief of the Staff of the Air Force. A White House ceremony was set for August 15.

Thus a capsule which was to have been returned discreetly to Sunnyvale, made noisy progress to the White House, where President Eisenhower hailed it as "historic." It continued to attract attention for months after Mathison released it, being displayed throughout the country, and finally coming to rest in the Smithsonian Institution where a plaque has read:

> "The Discoverer program was initiated to develop satellite reconnaissance capability. Early missions in the Discoverer series were plagued with failures. It was not until the launch of Discoverer XIII in 1960 that the program achieved its first success. The Discoverer XIII reentry vehicle was the first spacecraft to be returned and recovered from orbit. Discoverer satellites later photographed Soviet ballistic missile launch sites, enabling better determination of the actual number of such missiles."

Mathison's efforts single-handedly documented the innocent nature of a U.S. space capsule, as it contained nothing noxious—no bomb, no camera, no leaflets—just one American flag. After the successful flight of Discoverer XIV on August 18, and recovery in mid-air of its capsule, the first Corona film was quietly couriered under a more effective system.

Reaction to the film was unbridled jubilation. Photo interpreters called it "terrific, stupendous," and "we are flabbergasted." Imagery of more than 1,650,000 nm^2 (square nautical miles) of Soviet territory had been acquired. Resolution was estimated at 55 lines per millimeter, with ground objects ranging upwards from 1.05 meters (35-foot) dimensions identifiable.

After President Eisenhower saw the photography from this flight, he let it be known that he wanted everything about the "take" kept secret, to avoid affronting the Soviets. As this comment passed down the chain of command, his cautionary words were translated and amplified into "Destroy the capsule." So the capsule was literally beaten to pieces and disposed of.

Corona Intelligence Accomplishments

On the basis of photography from Discoverer XIV, the missile gap theory of 1959-60 was debunked (owing to Corona's exceptional sensitivity, however, this information was shared on a very strict basis). In an election year (1960) the missile gap became a grave political issue.

After 13 years, the Corona program ended with a launch on May 25, 1972. Recently released National Intelligence Estimates reveal that Corona:

- Imaged all Soviet medium-range, intermediate-range and ICBM complexes
- Imaged each Soviet submarine class from deployment to operational bases
- Provided inventories of Soviet bombers and fighters
- Revealed the presence of Soviet missiles in Egypt protecting the Suez Canal
- Identified Soviet nuclear assistance to the People's Republic of China
- Monitored the SALT I treaty
- Uncovered the Soviet ABM program and sites (Galosh, Hen House, etc.)
- Identified Soviet atomic weapon storage installations
- Identified People's Republic of China missile launching sites
- Determined precise locations of Soviet air defense missile batteries
- Observed construction and deployment of the Soviet ocean surface fleet
- Identified Soviet command and control installations and networks
- Provided mapping for Strategic Air Command targeting and bomber routes
- Identified the Plesetsk Missile Test Range, north of Moscow

The government's declassification of Corona provides scientists, educators and historians with powerful tools in understanding environmental and historical occurrences. Lockheed Martin endorses this information being made public.

"It is, after all, the collective citizenry for whom our employees in defense programs offer years of silent dedication and consummate skill in service to the Nation," said Lockheed Martin Chairman and CEO Daniel M. Tellep. "Corona is the first chance to honor those visionary pioneers, whose legacy we continue in our programs today." ST

Satellite Times would like to thank the employees of Lockheed-Martin and in particular, Jim Graham in the Public Information Office for their assistance preparing this story on America's first spy satellite program - Corona.

THE SATELLITE

SLEUTH

By Dr. Theo Pappan
C.N.E.S.S.

LEO Photo Intelligence Satellites (a longnecker look)

The pizza was running low and the last of a Sam Adams neared the bottom of the longnecker. "And so while Kennedy put off signing it we worked all day, every day to get three pairs of birds to The Cape. They were launched and Khrushchev couldn't set off a 10 kiloton device without us knowing when and where."

I dumped the paper pizza plate into the trash and sat back to enjoy the last of the golden brew. "Those were the good old days... Yep." I sighed. Thomas Mishler (famous rediscover of Prospero X3) had primed me with a Deep Dish Pizza and a bottle of Samuel Adams's fine brew and dragged another story out of me. He knew how I hated to talk about "the olden days," but he also knew how I lost control and spoke of them when pizza and good beer were mixed internally.

A U.S. Air Force JC-130A modified with polse, lines and winches extending from the rear cargo door captures a capsule ejected from a Discoverer satellite. the same aircraft were used to retrieve Corona film capsules.

"Yes", he agreed. "I wish I had been around in those days and been able to hear some of this stuff. It must have been fun to listen in on the early days of the space program." "You still can." I offered.

He placed his empty bottle on the table and shook his head, "What are you talking about, all that has gone by. The U.S. and Russia, and even ESA (European Space Agency) have gone to real-time electronic surveillance systems using super high frequencies and encrypted downlinks directed through geosynchronous spacecraft like TDRS and Luch and Helios. We can't intercept those transmissions." He continued shaking his head with a downtrodden look.

"Not everybody" I said. "What?" he exclaimed looking up. "I said not everybody is using super high frequency (SHF) encrypted links. Someone is still putting out signals from a low earth orbit (LEO) photo intelligence (PhotoInt) satellite in the very high frequency (VHF) band that we can copy."

I kicked back the footrest of my lounge chair and got comfortable. His face took on a puzzled look. "Who?", he leaned forward conspiratorially, "Who is it, Who is it?" I drained the last few drops of fine hops nectar from the dark bottle and placed it on the table. "It's a long story and you know how telling these tales dries my throat." He paused not a moment, but like a flash and turned to his briefcase next to his chair. From the dank and cold interior he pulled out one last Messrs. Adams. He knew it would be wise to bring an extra for such a contingency (and I knew he knew). With both of us re-heartened, I began the story.

The Beginning

When Dr. Werner Von Braun and his associates came to the US (as a conscious choice over the former USSR) the testing of the V2s that followed after them at White Sands and the success that they enjoyed caused the Army to begin thinking of a use for them other than artillery rockets. In the past, gathering current tactical intelligence of the enemy's military activities consisted of flying a high performance fighter that had been stripped down and equipped with the latest aerial camera. Flown as fast as possible over enemy territory by a pilot who liked being shot at, the film recorded whatever was beneath the speeding aircraft when the pilot flipped the switch to operate the camera's shutter. If he was being shot at while he was passing over the areas he was supposed to photograph, sometimes the pictures didn't come out real good. We lost a lot of good men who tried to hold it straight and level when a real hard zag would have saved them.

We tried putting cameras under big balloons and opening the shutter with timers. The problem was that trying to guess where the balloon would be blown by the winds after so many hours and set the timer accordingly, usually brought back pictures of cloud tops or unknown forests. We assumed that the balloons that were shot down or broke and fell into enemy territory also had useless images in them. No pilots got killed, but not even *National Geographic* magazine would buy the pictures.

When the scientists told the military that it would be possible to put a camera on a rocket and launch it into space in an orbit that would take it over interesting places in other lands and that the film could be brought back and dumped right into our waiting laps, the generals got interested. When they were told that this spacecraft would be flying so high over enemy ground 200+ km (120+ mi.) that it could not be shot down, the generals got real interested. And when someone said that maybe we could say it was in "outer-space" and not in their "air-space" at all and there was nothing anyone could do about it, the generals got very interested.

The makers of aerial photo cameras were sounded out on taking pictures from 100-200 km (60-120 mi.) instead of the 1-10 km (1-6 mi.) our photo-reconnaissance planes had been working at. They had been learning how to make their cameras and lenses better throughout the war (WWII) under open-ended government contracts so they said "Can do!".

Film manufacturers were approached about making better and thinner film as we would have to take a lot more pictures over many days in space rather than the limited number shot in a few minutes as we had been. They had been making better and faster film during these same years so they said "Can Do!".

The scientists that were in charge of the rockets were asked if they could fly this camera and film over interesting spots on the

When the scientists told the military that it would be possible to put a camera on a rocket and launch it into space in an orbit that would take it over interesting places in other lands and that the film could be brought back and dumped right into our waiting laps, the generals got interested.

Earth and keep it pointed at the ground. They chuckled because they knew orbital mechanics and said "Can Do!".

Somebody asked somebody else if they could make this all work together and bring back the film pack into our waiting arms. They said "Easy-as-pie. Can Do!" We are still looking for those people. It wasn't that easy after all.

It became clear that we would have to build a large booster to put all of this into orbit. The military, as it turned out was already working on bigger boosters to launch our atomic and nuclear warheads. They would be called Short Range Ballistic Missiles (SRBMs), Intermediate Range Ballistic Missiles (IRBMs), Intercontinental Ballistic Missiles (ICBMs) and later Submarine Launched Ballistic Missiles (SLBMs).

While the Soviets spent their efforts building a large booster to carry the massive nuclear warhead they got from us, the U.S. spent their time and money making the warhead smaller to fit on more easily developed and cheaper rockets. We developed the Atlas, Thor and Titan and the USSR developed colossal behemoths. The press invented "The Missile Gap". There never was any gap. We could throw our atom bombs just as far as the Russians could throw theirs.

Everything came together about 1959. The Thor IRBM was powerful enough to do the boosting and something called an Agena upper stage had been built to carry the camera and film payload and perform the all important point-it-at-the-ground functions. The Agena had some advanced and most helpful abilities. It could turn it's rocket engine off and then back on again. By being able to re-start itself in space the spacecraft payload (now a part of the Agena) could be re-positioned in orbit slightly to place the ground track over a target of opportunity within the camera's field of view.

The cameras had been improved, the film made faster and thinner, and the lenses more powerful. The only thing that had not been made "better" was the spacecraft "bus". The bus was the thing that held everything else and made it all work together. That was because it was all new. Nothing had really existed before that could be made "better" except for those balloon controllers. (See Figure 1)

With everything having been done that we could think of, the rocket and the payload were shipped north from Los Aangeles to Vandenberg Air Force Base where people like Jerry Antcliff launched them from a pad near the Pacific into the night sky. In those "Early Days" the boosters, upper stages and even the nosecones were a common sight as they were hauled on flat-bed trailers down the city streets of Inglewood and up the public highways north to Vandenberg.

Now for a Trivia Lovers test: What was the name of that place before it was called Vandenberg AFB? Hint: it was an army base.

Others like Andy Courage manned a monitoring station in Alaska listening for telemetry from the spacecraft and ready to send up the latest commands to continue the mission.

The first few didn't exactly work "right out of the box" as we had hoped. Number one was launched just before midnight on Saturday Feb 28, 1959. The Catalog number was lucky 13. It tumbled and could not maintain radio contact. We tried again on the 13th of April (lucky 13 again). This one made it into orbit at about 240 x 345 km (144 x 207 mi.) inclined 90.4 degrees but "someone" at the Alaskan Command and Control station sent an ill-coded command and the film capsule came down in the wrong place.

Rumor has it, that it came down near Spitzbergen, Norway and was likely picked up by a nearby Russian team. Great! Our first recoverable film capsule dropped from space and it went right into the hands of the Russians. For an interesting and fictional (?) account of this fiasco check out the movie *Ice Station Zebra* from your local video store. For those of us down in LA that had worked on these satellite systems, the job was over when the birds were shipped north and we seldom heard anything more about them.

I found that I couldn't just let these things go after I had worked so closely on them for months or even years. I knew the classified command and control/satellite telemetry frequencies and wondered if I could construct a ground station from commercial components and receive the downlink telemetry. Hearing them and how they sounded would tell me how well our birds were doing in space.

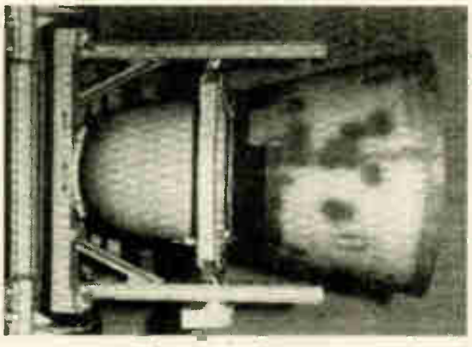
It didn't take much. I used a Regency monitor radio that received between 130 and 180 MHz, a two meter ham beam antenna, some RG-8 coax, a few connectors and I was ready. I knew what direction the spacecraft would approach from (it would be either be from the southeast or the northwest depending on time of day), so I would point the antenna in the appropriate direction a little bit above the horizon and go inside and listen.

It took a few tries to finally hear something as I had to wait for a new launch to be sure of catching a fresh bird with good batteries sending out a strong signal. With some very basic calculations of simply adding orbital period to the last pass time in hours and minutes and moving the northbound Equator crossing west so many degrees each orbit, it was easy to keep track of things. Later if work schedules or the orbital plane precluded hearing anything for a few days, it would take a lot of listening to re-discover a signal again and start again with accurate timings for a new set of manual predictions.

We didn't have portable electronic computers in those days and had to just do the additions and multiplication's by hand. A Freiden reed calculator at work might sometimes be pressed into service during a lunch break to compute passes for an entire week. It usually took the entire hour to do them. Although the Freiden could do multiplication and division with great accuracy and fairly quickly, when done it merely presented you with the answer on several columns of numbered reeds turned toward you. You had to write all the results down. Those of you who remember this may also recall the selected calculations that when performed on a Freiden would produce certain rhythms or "songs".

I was soon keeping the others at work advised of the operational condition of the spacecraft we had built. "I heard G-9643 again last night. It was right on schedule." We referred to the spacecraft by their contract or job numbers, as the true mission name was

FIGURE 1



Encountering this very small thing dangling from a very small parachute somewhere over the very big Pacific after it "maybe" had been ejected at exactly-the-right-time at an altitude of 300 km (180 mi.) halfway around the globe required all the good karma the crew of the recovery aircraft could collectively amass.

always classified. Sometimes even "Guess what, I heard old G-8864 last weekend. Kind of weak but still operating and it's been over three months since it went up." The "secrecy" surrounding these satellites was always a hodgepodge patchwork of hide this, but publish photos about it.

"You can't talk about it," but you then could read all about it in the *Chemical Rubber News.* The program that was to be our first photo-reconnaissance system in space was at first open, then closed, then "deny and mis-inform" and then "talk about it, but say it's something else".

See Table 1 for a listing of the early Discoverer/Corona PhotoInt flights. You will notice things like there were no other successful space launches in the 44 days between the launch of catalog numbers 13 and 14. You may also notice a pattern in the launches if you look closely.

While the Discoverer program did involve biomedical experiments and other non-reconnaissance related activities, its primary function was to serve as a cover for Project Corona. Its central concerns were the "testing of techniques for recovery of a capsule (i.e. film pack) ejected from an orbiting satellite" and other techniques related to reconnaissance satellite development. Everything now publicly said about the program was in some way true, but the "whole truth" of the photo intelligence nature of its mission was no longer referred to.

Launches were announced in advance as part of the "Open Cover Story" policy that Discoverer was purely scientific. Even people that were outside "the program" laughed at the announcements of this new "clean" program that used the same booster/launch site/orbits that the old "now-you-see-it-now-you-don't" program use to use.

The Hard Work Continues.

Starting with flight number two, a film canister was ejected with tracking gear and a parachute so that it could be snatched in mid-air by a C-119 or C-130 equipped with a loop that could (the operative word here is could) snag the object by the shroud lines somewhere between the parachute and payload between 15,000 feet and the Pacific Ocean. It was a "piece of cake" all the way from the drawing board right up to the point of actually doing it. Encountering this very small thing dangling from a very small parachute somewhere over the very big Pacific after it "maybe" had been ejected at exactly-the-right-time at an altitude of 300 km (180 mi.) halfway around the globe required all the good karma the crew of the recovery aircraft could collectively amass. If they saw it (and sometimes they didn't) and if they could make a pass at it before it disappeared into the cloud deck below, and if the pilot could match his large clumsy airplane with this very-very small thing without dive-bombing it and tearing apart the rigging from too high a speed... Well, after a lot of practice they got pretty good at catching something dropped far above and ahead of them on test runs. But then that was only a test.

The Payoff

On a hot Wednesday the 10th of August 1960, Discoverer 13 (this time it was a lucky 13) was launched on a Thor-Agena out of Vandenberg and all went so well that 17 orbits later the capsule was ejected and the parachute floated down right in front of an oft-frustrated recovery crew and... they missed it! Later, the U.S. Navy fished it out of the salt water and it began a top-priority helicopter and cargo plane ride to the west coast where it was welcomed home and then either (A) gutted and the shell and a small flag flown on to be presented to then-president Eisenhower in front of a hastily called press photo-opportunity and subsequently placed in the Smithsonian; or (B) autopsied to bits while a prototype from my boss's desk was sent on the above journey.

All I know for sure is that the capsule in the pictures with Eisenhower was the "cleanest" and most "empty" package I had ever seen. (See Corona article this issue-editor)

Oh well, it was 529 days since the first launch, but at last the "can-do/easy-as-pie" system had finally worked. Now if we could keep the Soviets from catching their own pictures, we could have some very good information. (See Figure 5)

I put away the now empty Sam Adams and the room was quiet. "So who still transmits from recoverable PhotoInts on VHF," Tom leaned forward inquiringly. "Hm-m-m?" I murmured. "You said you were going to tell me who still transmits from PhotoInt satellites." he continued impatiently. And so I did, but we are out of time (space) this issue. I'll have get to that next time. We'll get into a mysterious space program and come up with some idea of where and when to listen. And more importantly, what to listen for.

Meanwhile for the trivia buffs the answer to our quiz is Vandenberg AFB. It was known as Cooke Field back during WWII.

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TABLE 1

Early Discoverer Photo Intelligence Program Launches (Table courtesy of CNESS)

Intl Designator	Catalog #	Date Launched
1959 Beta 1	13	Feb 28, 1959
1959 Gamma 1	14	Apr 13, 1959
1959 Epsilon 1	18	Aug 13, 1959
1959 Zeta 1	19	Aug 19, 1959
1959 Kappa 1	24	Nov 7, 1959
1959 Lambda	25	Nov 20, 1959
1960 Delta 1	32	Apr 15, 1960
1960 Theta 1	48	Aug 10, 1960
1960 Kappa 1	54	Aug 18, 1960
1960 Mu 1	57	Sep 13, 1960
1960 Omicron 1	61	Nov 12, 1960
1960 Sigma 1	67	Dec 7, 1960
1960 Tau 1	68	Dec 20, 1960
1961 Epsilon 1	83	Feb 17, 1961
1961 Zeta 1	84	Feb 18, 1961
1961 Lambda 1	100	Apr 8, 1961
1961 Xi 1	108	Jun 16, 1961
1961 Pi 1	160	Jul 7, 1961
1961 Psi 1	181	Aug 30, 1961
1961 Omega 1	182	Sep 12, 1961
1961 Alpha Beta 1	186	Sep 17, 1961
1961 Alpha Gamma 1	189	Oct 13, 1961
1961 Alpha Epsilon 1	197	Nov 5, 1961
1961 Alpha Zeta 1	201	Nov 15, 1961
1961 Alpha Kappa 1	213	Dec 12, 1961
1962 Epsilon 1	247	Feb 27, 1962

DOMESTIC

TVRO

By Dr. Frank Baylin & John McCormac

Link Analysis in a Digital World

The process of sizing receive dishes for reception of analog signals is well known among satellite professionals. However, the digital revolution is upon us. Can we use a smaller dish to receive QPSK modulated, compressed digital video signals? What is the process of digital link analysis compared to analog broadcasts? The final answer is surprisingly simple although the route to achieve it requires some understanding and depends to a certain extent upon the particular broadcast system in use.

The performance quality of a satellite reception system depends upon how well the uplink-to-TVRO link has been designed. Many factors in this process such as the power level uplinked to the satellite or the type of modulation technique or transponder power used are out of the control of all but uplink engineers. However, the size and quality of the receive dish as well as the noise temperature of the LNB strongly affect the quality of the audio, video or data signal received.

Sizing receive dishes and choosing LNB noise temperature/noise figure is relatively straightforward. This method can be applied whether the underlying signal is FM analogue or MPEG-2 compressed digital video broadcast. There is no difference. However, the value of the carrier-to-noise ratio, the C/N, required to achieve the same result differs between analogue and digital systems. Digital systems require lower input C/N ratios to achieve high quality pictures and sound.

In this article I first briefly explore the process of link analysis and then examine the methods used to calculate the threshold C/N of a digital receiver. A more detailed treatment will be forthcoming in a new book from Baylin Publications to be announced this fall.

The Process of Link Analysis

This first step in designing either a digital or an analog satellite receive system is to make sure that an acceptable C/N is available to the satellite receiver, name a C/N at least at or above threshold. This will result in an acceptable quality television picture. Analog receivers typically have thresholds of 8 dB or slightly better.

The downlink C/N ratio can be determined using the link equation. The components of this equation include the EIRP, the signal power aimed towards any geographic location as found from a footprint map, the gain of the receive dish and the system noise temperature. Link analysis accounts for the weakening of earthbound microwaves as they spread out in space, the gain of the receive dish as it captures and concentrates these signals, and the effect of noise, in a large part determined by receive dish and LNB characteristics.

In words the link equation states that the C/N at the input to a satellite receiver equals signal power leaving the satellite (the EIRP) less free space path and atmospheric losses plus receive system G/T less dish pointing errors. In a more condensed form, in which the above words, excluding pointing losses, are expressed in algebra, the link equation expressed in decibels becomes:

$$C/N = EIRP - PL + G/T_{sys} - 10 \log B + 228.6$$

T_{sys} is the noise temperature of the dish, low noise amplifier and all other system components. B is the demodulator bandwidth expressed in Hertz. As either noise temperature or bandwidth is increased, more noise enters the system, so 10 log B is subtracted to show its effect on the C/N ratio. The constant, 228.6, stems from Boltzman's constant. If the EIRP, path loss and bandwidth are known, the G/T_{sys} required to obtain a desired C/N can be calculated by addition and subtraction.

The EIRP of a particular satellite can be determined for any geographic location from a published footprint map (as found, for example, in the *1995 World Satellite Yearly*). Free space path loss expresses how the power of the downlinked signal is attenuated in traveling from a satellite to a receive dish. There are two effects at work. First, the signal spreads out and is weakened on its earthbound journey. Free space path loss is a function of the distance

Sizing receive dishes and choosing LNB noise temperature/noise figure is relatively straightforward. This method can be applied whether the underlying signal is FM analogue or MPEG-2 compressed digital video broadcast. There is no difference. However, the value of the carrier-to-noise ratio, the C/N, required to achieve the same result differs between analogue and digital systems.

between a satellite and the receive site and signal frequency. The second, much less predictable, cause of path loss is absorption of a signal by the earth's atmosphere. At Ku-band frequencies by far the greatest reduction in power is caused by water vapor and rain; this attenuation is approximately 9 to 10 times greater at Ku-band than at C-band for a given amount of water in the downlink path. The higher the water vapor content or rainfall, the greater is this reduction in power level. A torrential downpour can cause a power loss of 10 dB or more and complete picture wipe-out in a system not designed with an adequate margin.

A typical value for path loss at 12.75 GHz on a clear day for a satellite directly overhead as viewed from the equator is -205.6 dB, equivalent to a reduction in signal power by a factor of over 3.63 x 10^{-20}! For a 4 GHz C-band link it is about -195.6 dB.

For example, using the link equation, we find that at a site that receives 34 dBw of downlink power, where path loss from the satellite is -195.6 dB and where bandwidth is 27 MHz we find that $C/N = G/T_{sys} - 7.31$. To achieve a C/N of 12 dB, G/T_{sys} must be 17.3 dB.

G/T_{sys} is shorthand for $G - 10 \log T_{sys}$ where gain is expressed in decibels and noise temperature in degrees Kelvin. The G/T_{sys} is the "figure of merit" of a dish/feed/LNB combination. The bottom line G/T_{sys} defines the combination of minimum dish diameter and LNB noise temperature required so that input C/N is just at receiver threshold.

Digital Design

Digital satellite receivers that process MPEG-2 DVB signals, like their analogue counterparts, have a threshold C/N ratio. Below this point the picture, sound or data cannot be reconstructed. The difference is that this threshold can be much lower than that for an analog transmission since various forward error correction techniques are employed and the bit stream rate for each compressed digital program can be varied within limits.

The C/N requirement of a digital receiver can be calculated from a parameter known as the E_b/N_o, the program information rate and the noise bandwidth of the channel. C/N is given by:

E_b/N_o + 10 log(Info Rate) - 10 log (Demod Noise Bandwidth)

The parameter E_b/N_o, the ratio of the energy per bit to the noise power in one Hertz of bandwidth, is defined by the MPEG-2 DVB standard. MPEG is a set of parameters and constraints that mandate the compression scheme employed, the data stream packet structure and the final bit error rate required at the satellite receiver to recreate the original analog signals with acceptable fidelity.

Determining the information rate is an iterative process. The first step is to assess the gross information rate that can be transmitted via a communication channel. This relatively sophisticated calculation depends upon available transponder bandwidth, the type of modulation employed and the digital system in use. QPSK is used on MPEG-2 digital satellite links. Ballpark gross information rates of 40 Mbits/second can be relayed in a 27 MHz transponder. This data stream must carry all error correction as well as synchronizing, addressing, program and other information.

Next the net information rate must be determined. The MPEG packet is composed of 188 bytes of channel information plus an extra 16-bytes checksum for a total of 204 bytes. This extra 16 bytes, the "Reed Solomon" error correction coding, also known as the outer code rate, is built into the MPEG-2 structure and considered "channel encoding" information. The 188-byte MPEG packet itself has a 4-byte header consisting of sync, program identifier, scrambling and other information. So just 184 of the original 204 bytes is available to actually carry video, audio and data program information. As a result the information rate is reduced from the gross rate by a factor of 184/204.

Another reduction in the number of bytes available to carry program information occurs with the use of Viterbi forward error correction. This combined with the Reed Solomon error correction is essential since nearly 1 in every 100 bits received by a TVRO is corrupted during the voyage to and from a satellite. This bit error rate of slightly better than 1 in 100 is much too high for reconstruction of the original signal. The MPEG-2 DVB standard mandates a "quasi-error-free" BER of 1 in 10^{-11}. In order to accomplish this stringent requirement as much as 50% of the bits must transmit Viterbi error correction information.

A variety of Viterbi FEC ratios including 1/2, 2/3, 3/4, 5/6 and 7/8 are common. A rate of 2/3 means that 2/3 of the bytes are used to carry program information while the remaining 1/3 is used for error correction bits. The FEC ratio, dish size, the information rate required per program and the number of programs to be carried over the channel are all inter-related. Thus, for example, if a broadcaster wishes to use a 30' receive dish and an information rate of 3.9 Mbits/second per program has to be relayed to reproduce a quality signal, a lower FEC ratio means that fewer bytes are available for each program and thus fewer programs can be transmitted via one transponder. However, if the FEC ratio is set too high a larger dish might be required to capture enough signal to maintain an acceptable bit error rate.

Thus, for example, if a Viterbi FEC rate of 1/2 had been selected the net program information rate should be 1/2 of 184/204 of 40 Mbits/second equal to 18.84 Mbits/second. Assuming that the MPEG-2 noise bandwidth is 24 MHz, the net and the E_b/N_o is 5.5 dB the threshold C/N is given by:

C/N + 5.5 + 10 log 18.84 - 10 log 24 = 4.3 dB ST

Dr. Frank Baylin, president of Baylin Publications, has served the industry as author and consultant since the early 1980s. He has authored and co-authored more than ten books as well as software and a video. He has recently published two new books "Miniature Satellite Dishes - The Digital Television Revolution" available for $20 plus $4 s/h and the "1995/96 World Satellite Yearly" available for $90 plus $4 s/h. Interested readers can also obtain a free catalog from his company by writing Baylin Publications at 1905 Mariposa, Boulder, CO 80302 or by calling 800-483-2423.

INTERNATIONAL
TVRO

By George Wood
(SMOIIN/KA6BIN)

Satellites Making Inroads with SWL's

EDXC '95

REBILD, DENMARK · JUNE 2-5 1995

June 2-5, 1995 saw the 29th annual conference of the European DX Council (EDXC), in Rebild, Denmark. What, you may ask, does a convention billed by the organizers as "The shortwave gathering of the 90's" have to do with satellite broadcasting?

Actually, quite a bit. A few years ago, when shortwave stations discovered they were really "international broadcasters", and starting using satellites, there was hostility within the Shortwave Listeners (SWL)/Distant Listener or DX community, which was quite obvious at the annual EDXC meetings (at several other SWL gatherings as well—*Larry*). But things have been slowly changing, and this year's EDXC seemed to mark a watershed for the acceptance of satellites by the hardcore shortwave DX community.

The most obvious sign of this was at the regular panel where representatives from each station gave short presentations about current conditions and future plans. This year there were 15 chairs on the stage, which may be an EDXC record. The stations were organized in alphabetical order, and after such stations as Radio Austria International, Radio Budapest, Radio Netherlands, Radio Romania International, Radio Sweden, and Radio Vlaandern International had spoken, the final speaker was Karl Miosga of the World Radio Network, the London-based organization that broadcasts each and every one of those stations, and many more, on satellite to Europe and North America!

This the was the first time Karl has attended an EDXC conference, although he was at last year's *Monitoring Times* convention in Atlanta and a number of similar gatherings. When I asked him how he had been treated by the DXers, he replied:

> "I've had a good time. I've attended a couple of these events, and the first ones were the most difficult. I was given a very hard time. To begin with, I think many DXers were a afraid that satellite was going to come along and replace shortwave. We know that's not the case now."

What's happened is a general recognition that while satellites may be a good way to reach listeners in the industrialized countries, it will be awhile before listeners in the Third World will give up their shortwave receivers for dishes. This was underlined by another prominent participant at EDXC 95, Victor Goonetilleke from the Union of Asian DXers in Sri Lanka. On a number of occasions during the conference Victor called on broadcasters not to abandon Third World listeners for the bright lights of satellites and cyberspace.

Actually, it was generally accepted that the move to satellites has had some advantages for shortwave hobbyists. The much sought-after tropical stations in the lower frequency bands will be with us for many years to come. Plus, DXers are realizing that as more and more larger stations leave some of their shortwave frequencies for satellite channels, congestion on the shortwave bands is easing up.

"Over the last two or three years, " Karl Miosga says, "I think there's been a change. I think that those DXers who had an idea that satellite is eroding the hobby have actually come around to the idea that it isn't, and is actually a benefit."

When I gave my presentation of Radio Sweden, a few moments before Karl Miosga, after describing our latest round of cutbacks, including a planned reduction in the use of electricity-burning short and medium wave transmitters, especially to Europe, I wanted to just point at Karl and say — "there's the future, what WRN does, Radio Sweden will be doing!"

Karl Miosga of the World Radio Network

A few years ago, when shortwave stations discovered they were really "international broadcasters", and starting using satellites, there was hostility within the Shortwave Listeners (SWL)/Distant Listener or DX community, which was quite obvious at the annual EDXC meetings. But things have been slowly changing.

The Future at WRN

So what does the future hold for international radio broadcasting on satellite? WRN has a number of projects in the pipeline.

What's already on the air is WRN's third channel to Europe, joining the English language Network One on Astra and the relay of Vatican Radio on Eutelsat II-F1. The new relay carries programming from the Canadian Broadcasting Corporation and Radio Canada International, on the European Business News transponder on the new Hot Bird satellite (which shares 16º East with Eutelsat II-F1), audio 7.20 MHz.

WRN has had to put several other projects on hold. America One, the second English language channel to Europe, carrying the programming from National Public Radio and Public Radio International currently on Network One, plus many more programs from the two American public service broadcasters, was blocked by the cutbacks in the Corporation for Public Broadcasting budget by the new Republican Congress. But after some delays, in late June NPR, PRI, and the Corporation for Public Broadcasting reached agreement on the financing. America One should be on the air any day now, uplinked from Munich.

Not only will this greatly increase the amount of NPR/PRI programs available in Europe, it will also free up important primetime slots on Network One for European broadcasters on the WRN waiting list.

But WRN's new German service to Europe is still stalled, waiting for a few more stations to sign up.

"We've got to reach a critical mass of broadcasters on the network", says Karl Miosga, "but we hope to start by the end of the year."

WRN is also planning to start a second channel to North America, in addition to the current Galaxy 5 package. The new channel would carry programs in the international broadcasters' home languages, Dutch from Radio Netherlands, Swedish from Radio Sweden, etc.

"This idea for a new non-English multi-lingual channel came out of the *Monitoring Times* convention in Atlanta last October", Karl Miosga told me. "Some of the DXers there said wouldn't it be a good idea if you actually had a multi-lingual service? We've got a second subcarrier on 6.2 MHz on our Galaxy 5 transponder, and we hope very much to have that going soon."

If the American channel works, there are plans for a similar channel in Europe.

WRN may also be joining the audio services on DirecTV, now that the DBS-3 satellite has been launched.

When Asiasat-2 launches later this year, Deutsche Welle is planning a digital service on the new satellite. WRN hopes to have their own subcarrier. But as the service is digital, home listeners will most likely be unable to tune in.

"We hope to use it as a distribution method, with local rebroadcasting", says Karl Miosga, adding that Asiasat will also be a stepping stone to Australia: "The Galaxy consortium who are launching a pay-per-view TV service with high-powered transmissions and small dishes, have offered to redistribute WRN within Australia."

Back to Europe

Besides WRN's Canadian relay, there's been considerable new radio activity at 13º East on both the EBN transponder on Hot Bird and the BBC World transponder on Eutelsat II-F1. The BBC is planning to launch a series of digital MPEG-2 services on both transponders. When MPEG-2 is introduced, the output on EBN's transponder will reportedly be:

7.38 MHz English in stereo MPEG
7.56 MHz Foreign 1 and 2 each in mono MPEG
7.74 MHz Foreign 1 PAL (analog)
7.92 MHz Foreign 2 PAL
8.10 MHz Foreign 3 PAL

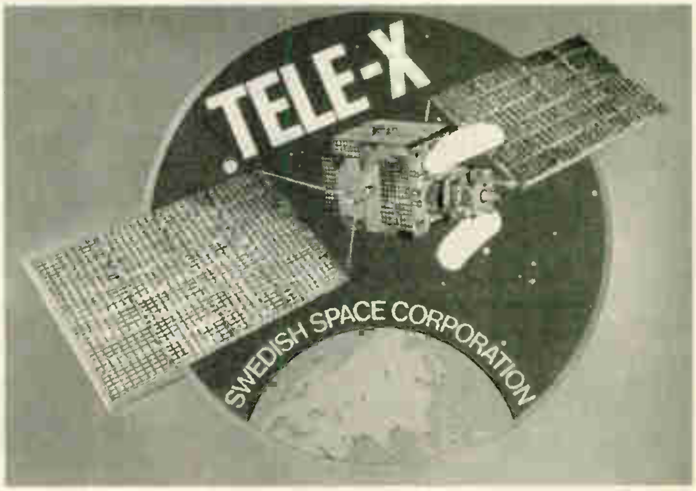
The output on BBC World will be:

7.38 MHz English mono PAL
7.56 MHz Foreign 1 PAL
7.74 MHz Foreign 2 PAL
7.92 MHz Foreign 3 PAL
8.10 MHz English stereo in MPEG-2

Initially, most of the channels were analog, and the BBC World line-up was the same as the BBC radio channels on UK Gold (including relays of BBC domestic radio channels).

Several new stations have begun operating via WRN, including Radio Austria International, which Wolf Harranth told EDXC 95 is actually bound by its charter to broadcast only on shortwave. Austrian Radio is trying to get the charter changed to make the satellite relays legal. Radio Budapest is another new WRN broadcaster.

Going in the other direction, for some time now, Radio Netherlands has been part of the WRN package. Now, Radio Netherlands has added its own multi-lingual service on Astra transponder 64 (RTL-5) on 7.74 MHz, which means even more opportunities to hear Jonathan Marks' excellent "Media Network" program on Thursdays.



Several new stations have begun operating via WRN, including Radio Austria International, which Wolf Harranth told EDXC 95 is actually bound by its charter to broadcast only on shortwave. Austrian Radio is trying to get the charter changed to make the satellite relays legal. Radio Budapest is another new WRN broadcaster.

If you can access the World Wide Web, look for Radio Netherlands' new Web site at:

http://www.rnw.nl/rnw/en/ernwhome.html

Radio Sweden has moved its multi-lingual channel from Sky Movies Gold to another Astra transponder, number 33, home of the German TV station ZDF. Radio Sweden has been reaching the Sky uplink using the Swedish Tele-X DBS satellite, but now Sky is moving to a new uplink station outside Tele-X's primary coverage zone. There's also been some dissatisfaction with using a scrambled channel. Even if the Videocrypt coding doesn't affect the audio subcarriers, the scrambled picture may make it harder for would-be listeners to find the transponder.

Moving over to television, there are changes afoot at Sky Movies Gold, on Astra transponder 26. When a previous Sky Comedy Channel on that transponder failed to attract viewers, a couple of years ago, British Sky Broadcasting turned it into an oldies film outlet, available only to subscribers to both of Sky's movie channels. But recently Sky Gold has been broadening its output by adding children's and travel programs in the morning, followed by soap operas before the usual movie fare begins in the early evening. There's speculation that BSkyB may be planning to change Sky Movies Gold into a new entertainment channel called Sky Two, as a complement to the existing Sky One.

Sky One has broken tradition, and for the first time in several years is not broadcasting Star Trek weekdays. Having recycled the original "Star Trek", "Star Trek: The Next Generation", and "Deep Space Nine" programs over and over again twice a day Mondays to Fridays for a number of years, all that is over. The only Trek left on Sky is the current season of "Deep Space Nine" carried on Sundays only. That's scheduled to be replaced by "Voyager" this Fall.

Fortunately for Trekkers in northern Europe, Sweden's TV 5 Nordic (also known as "Femman") has been carrying original Trek weekday afternoons (but now even that has come to an end) and "Next Generation" Tuesday evenings. While the Tele-X DBS may not be available in all of Europe, it does reach many northern areas.

TV 5 is also now broadcasting "ABC World News Tonight" with Peter Jennings. Initially this was live, Monday to Friday at 00:30 hrs European Time and Sundays at midnight. Now the live broadcast has been dropped, but a pre-taped version of the program is now Scandinavian breakfast TV at 8:30 AM local time.

While TV 5 says they have chosen the ABC program because it is the best American news program, a more important consideration is probably because TV 5's owner SBS is in turn owned by ABC.

It isn't mentioned in many listings, but NBC Super Channel is now apparently the only European broadcaster carrying live American baseball games, Saturday mornings at 2:00 am Central European Time, with edited repeats the following afternoon. The old channel Screensport used to carry both American baseball and football, but when it merged with Eurosport, both sports disappeared from the schedule. American football has found a following in Europe, with both games from the NFL and the new European-based World League carried on various stations in different countries. But baseball has been hard to find.

(Turner Broadcasting has missed an opportunity to broadcast Braves games on the combined Cartoon Network/TNT transponder on Astra. But according to reports, there's a plan to give each service it's own transponder, so there may be room for the Braves yet.)

NBC Super Channel is reported to be splitting up the current simulcast on its Astra and Eutelsat II-F1 transponders this Fall, with an entertainment-only format on Astra transponder 50, and mainly business programs on Eutelsat. The current line-up has much programming from CNBC and the European "Money Wheel" program during the middle of the day. This will stay on Eutelsat.

European TVRO monitors were saddened when MTV Europe began scrambling on July 3rd (although some parents may have heaved a sigh of relief). The signal on Astra transponder 15 is in Videocrypt (like the other Sky Multichannels), while the Eutelsat

Artist's conception of the Swedish Tele-X DBS satellite.

There's a new war for global business channels starting between NBC, Dow Jones, and CNN. In the last few months Dow Jones has launched both European Business News and Asia Business News. CNN is reported to be countering by starting a financial news service, which in North America would share the CNNI transponder.

II-F1 signal is in Videocrypt 2, the low-profile system that is supposed to be marketed to European countries outside the British Isles. VH-1 Germany on Hot Bird is also now scrambled in Videocrypt 2.

The German rivals to Viacom's MTV/VH-1 channels are Viva 1 and Viva 2. The latter has ceased transmission from Eutelsat II-F1 on 11.146 GHz. It continues in clear PAL on 10.972 GHz on the same satellite.

Arab Radio and Television, ART, is now using Eutelsat II-F3, 11.095 GHz, audio 6.6 MHz. Owned by a Saudi prince, ART continues to transmit on four channels on Arabsat 1D.

TM3 is a new German channel which was to launch on Hot Bird on 11.343 GHz on August 28, in clear PAL. There are digital MPEG-2 tests on Hot Bird 11.283 GHz. The Sci-Fi Channel is due to launch there on October 5, using MPEG-2.

On July 1, several channels on Spain's Hispasat DBS dropped scrambling and are now in the clear, financed by advertising: Canal Clasio, Teledeporte, Telesat 5, Antena3/TeleNoticias, and Cinemania 2.

In Scandinavian satellite news, a major broadcaster is leaving Astra. Bertil Sundberg reports in the magazine "Paa TV", owned by the Kinnevik media empire, that Kinnevik is closing down its TV3 (in Swedish, Danish, and Norwegian) and TV1000 channels on Astra in October. That frees up 4 valuable Astra transponders for other broadcasters on the waiting list.

Kinnevik has been using the Sirius satellite at 5º East to relay many of its stations, and Intelsat 702 and TV-Sat 2 at 1º West for others. With MTV scrambling on other satellites, Scandinavians are being urged to subscribe to the package on the Thor satellite, which is co-located with Intelsat 702 and TV-Sat. Besides MTV, this includes CNN, Discovery, Children's Channel, and Eurosport Nordic.

Now Swedish Telecom and the Swedish Space Corporation have ordered a new Sirius 2 satellite, which is to be put into orbit in 1997, presumably alongside Sirius 1, and probably replacing the aging Tele-X. They've reached agreement with General Electric Americom for the 32 transponder satellite. Half the transponders will be retained by GE to transmit video and entertainment programming through-out Europe. The Swedish interests will use their 16 transponders for satellite broadcasts and data transmissions to the Nordic region.

Kinnevik's competitor, FilmNet, is launching a new sports channel to Scandinavia. SuperSport will be starting this Winter, featuring English and German soccer, and World Cup skiing competitions, as well as boxing and tennis.

Asian Update

There's a new war for global business channels starting between NBC, Dow Jones, and CNN. In the last few months Dow Jones has launched both European Business News and Asia Business News. CNN is reported to be countering by starting a financial news service, which in North America would share the CNNI transponder.

NBC launched its Asian counterpart, CNBC Asia, on June 20. It broadcasts via the Palapa B2P satellite, as well as PAS-2. Dow Jones moved to counter the CNBC launch a week earlier, when Dow Jones and TCI increased their stakes in Asia Business News to 44.5 percent each, buying out TV New Zealand's share of the channel.

Another Asian media battlefield is youth programming. Almost exactly one year after being dumped by Rupert Murdoch from his Star-TV package on Asiasat-1, MTV has returned to Asian skies. MTV Mandarin started on Indonesia's Palapa B2P satellite (113º East) on April 21, followed on May 5 by the return of the English language MTV Asia. The new channel, operated in co-operation with Polygram in the Netherlands, is scrambled in B-MAC, and reaches viewers in Indonesia, Thailand, the Philippines, Singapore, and Hong Kong. MTV Mandarian is primarily aimed at Taiwan.

Star-TV, which replaced MTV with its own music video outlets called Channel V, has countered by launching yet another language version. The new Channel V Asia supplements the Indian and Chinese versions of Channel V that were already broadcasting. The first Star offering not on Asiasat-1, the new service broadcasts to viewers in Taiwan, the Philippines, and Indonesia via Palapa B2P.

Asiasat-2 is scheduled to be launched by a Chinese Long March rocket this summer. It carries 24 C-band transponders, and 9 in the Ku-band. Star and other broadcasters (like Deutsche Welle) are waiting for the new satellite to start many new digital services across Asia. The international video news bureau Worldwide Television News has announced it has leased 9 MHz of a C-band transponder on Asiasat-2,

India's staid public broadcaster Doordarshan, shaken by the sudden appearance of satellite-borne competitors over the past few years, has now struck back with a plan to take its own programming to the rest of the world. Doordarshan International began broadcasts on March 14th. The channel has signed an agreement with PanAmSat for three transponders on the PAS-4 satellite. This is to be placed at 72º East, which in theory should give Doordarshan coverage from Western Europe to Eastern Australia. (Unfortunately footprint maps are one thing, actual-on-the-ground reception is something else. Even as far east as Stockholm, 72º East is out of reach for ordinary TVRO monitors.)

The Doordarshan signal is supposed to be downlinked in Paris for a relay via PAS-1 (45º West) over the Atlantic to North America.

That's for this time. Thanks to James Robinson, Michael Murray, Curt Swinehart, Vicente Aguilo, and "Tele-Satellit" for contributions. If you can send e-mail over the Internet, my address is: wood@stab.sr.se

And don't forget unofficial MediaScan page on the World Wide Web at:

http://www.abc.se/~m8914/media.html ST

ON THE AIR

By Steve Handler

Satellite TV: Yes America, You Have A Choice!

So your sitting there relaxing in the old easy chair watching a local TV channel when you see a commercial selling the concept of TV reception via satellites. Here lately, you have probably seen quite a few of these commercials on TV. There are ads for the new small RCA and Sony DSS™ dishes. Primestar has also bought a lot of air time promoting their satellite service. Even the older C-band, big dish dealers are starting to promote their products on the airwaves.

With so many options to choose from, you probably start thinking. "I would like to get in on this new satellite craze, but I really don't understand the advantages or disadvantages of each of these systems. Should I get a big, expensive C-band TVRO system? How about purchasing one of those new 18-inch Digital Satellite Systems™ (DSS) from Sony or RCA. Maybe leasing a Primestar™ satellite system is the answer. And then their is programming that has to be purchased. So many options, what does a person do?"

I am sure those questions have crossed your mind and really there is no one right answer for everyone on which system you should choose. The answer is going to depend on your individual needs, desires and resources as to which application will serve you best.

This column will present a very simplified view of some of these satellite TV options. Before you decide which would be best for you, I strongly suggest that you contact local dealers for each of the systems and meet with them to further educate yourself about each type of satellite TV system. Dealers usually have demo models available in their showrooms for you to view and operate. Since C-band and DSS systems require a considerable investment of money, and the Primestar system a more modest investment of money, I would strongly suggest that you visit your local dealers showroom.

When I purchased my C-band system, I visited several local dealers and spent many hours speaking to each dealer learning about the dishes, LNB/LNAs and IRDs. I also inquired about service and maintenance for the system. I also tried a number of IRDs until I settled on one that was affordable and had the features that I desired.

C-band TVRO Systems

C-band satellite systems for TVRO (television receive only) have been around the longest. The name C-band comes from the U.S. military. Back in the old days, the higher frequencies were used almost exclusively by military radar systems. The military divided the higher frequencies into bands and labeled each of them with letters to aid in identification. The 3700-4200 MHz spectrum where the majority of satellite programming is downlinked is part of the military's old C-band radar spectrum, hence the term C-band TVRO.

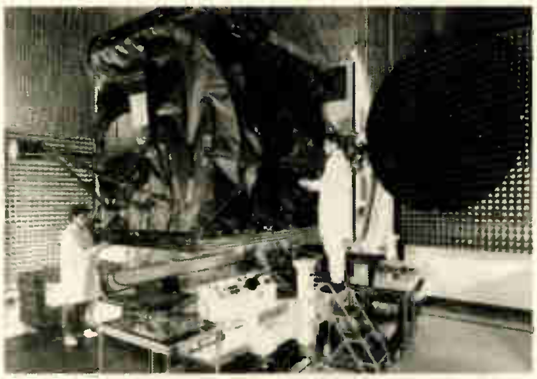
The hardware portion of a C-band system consists of several components. The most visible component in the system is the satellite dish (this is the antenna which captures the broadcast signal). C-band dishes typically range in size from 240 to 360 cm (8- to 12-feet) in diameter. The size of the dish you will need varies and depends on your location within the United States and Canada. This brings up another important reason to see your local dealer, the site survey. A site survey will let you know what type system you need and where it needs to be placed. Site surveys are very important and should only be done by competent personnel.

Mounted on your dish is a feedhorn and an amplifier (known as a LNA or LNB) which collects the satellite signal reflected by your dish. Another important component, the actuator arm, acts like a rotor and moves the dish to the satellite you have selected. From the dish there is a cable, which is buried underground, that carries the signal into your house and also sends signals to your dish feedhorn, actuator arm and LNA/LNB. This cable connects to a receiving device known as an IRD or integrated receiver descrambler. The IRD processes the signal received by the dish and delivers that signal to your television. It also contains a module that unscrambles those scrambled broadcasts which have been paid for by the viewer. Some satellite receivers are sold without a descrambler module and can be purchased at a lower cost. However, they do not have the ability to receive any scrambled broadcasts.

So what does a new C-band system cost? Prices do vary and typically range between $2000 and $3000 including installation depending on your choice of dish, feedhorn, amplifier, actuator, cable and IRD.

DSS Receiving Equipment

The new kid on the block is the Digital Satellite System or DSS. The DSS system uses the small 18-inch dish may be aesthetically more pleasing to the user and his neighbors. One major advantage of the DSS system over a C-band system is the initial acquisition and installation cost is less. Dealers in my area have been selling the standard RCA DS1120RW (feeds one TV set only) receiving system for about $695 and the advanced RCA DS2430RW system for $899. This includes the receiver, LNB, cable, remote and the antenna. A do-it-yourself installation kit runs about $70 or you can arrange for installation through the dealer at a cost that I have been quoted that ranges from $150 to $200. Remember that in many cases the cost of equipment and installation for DSS, as well as C-band, may be negotiable. It



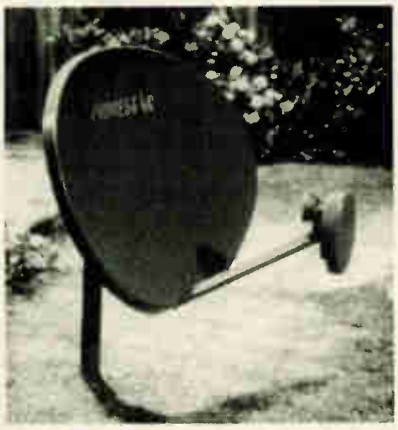
DBS-3, a model HS-601 satellite made by Hughes Space and Communications was launched into orbit in June of this year and joints DBS-1 and DBS-2 used for DSS programming. (Photo courtesy of DIRECTV, Inc)

For those people that are either unable or unwilling to ante up the cost of a DSS or C-band system, the Primestar system's initial cost is lower. For an installation fee of about $299 a Primestar distributor will install the system. This includes the dish, Primestar 300D receiver, cable, and 23-button remote control.

does not hurt to try to negotiate a better price from your equipment provider.

Primestar Satellite Equipment

For those people that are either unable or unwilling to ante up the cost of a DSS or C-band system, the Primestar system's initial cost is lower. For an installation fee of about $299 a Primestar distributor will install the system. This includes the dish, Primestar 300D receiver, cable, and 23-button remote control. The Primestar distributor owns the equipment. You, in effect, leasing it on a monthly basis as part of whatever programming package you choose. In the long run this will be more costly to the user, however the amount that you have to invest up front to obtain satellite reception is the lowest of the three alternatives I have discussed.



A Primestar satellite receiving dish is about the size of an open umbrella. (Photo courtesy of Primestar)

A Primestar representative I spoke to indicated that the dish is about the size of a standard open umbrella, 91-101cm (36-40 inch) in diameter. It weights 100 pounds and I was told that it can be mounted on a post, a wall or the roof. In March of this year Primestar announced that new subscribers would be provided with an elliptically shaped receiving antenna to enhance the technical quality and aesthetic appearance of their system. A free local site inspection by the Primestar distributor is available to assess whether your location is suitable for the dish and where the dish can be mounted.

Some Pros & Cons on Equipment

Now a word of advice — if your VCR still flashes 12 o'clock, you may wish to consider a satellite system that is simple to use. Primestar and DSS require less technological skill to operate than a C-band system. Primestar has one additional advantage — one-stop shopping. You call your local Primestar distributor for everything — installation, programming, and service. Your ongoing maintenance and service is handled through your local Primestar distributor as part of your monthly fee. With C-band or DSS once the warranty expires, the entire cost of repair and maintenance of the system is yours.

All of the systems use a remote control for programming access. On a C-band remote you will perform one additional step the other do not require, entering the satellite you want to view. Once you select your satellite the dish then rotates to that satellite and stops. Then you need to enter the channel number on that satellite (Numbered 1 through 24) that has the programming you wish to watch.

The DSS and Primestar remote controls do not require you to select a satellite. They are more like the typical remote controls used with either a cable TV converter box or a regular television receiving off the air broadcasts. You simply enter the channel number you wish to watch.

A C-band system uses an actuator to move the dish. These actuators are subject to wear and tear and possible breakdown. Actuators are not needed with either Primestar or DSS systems. They each use a single fixed mount dish that does not rotate.

One other thing. A mouse is useful with your computer but not so with a satellite dish. My brother-in-law had to repair his cable that were severed by a hungry mouse. Regardless of the system you use protect the cable between the dish and the receiver.

A Variety of Programming Available

What types of programming is available on C-band? Each issue of *Satellite Times* contains a list in the Satellite Services Guide of all of the C-band channels. This list is printed in a grid form and shows all the satellites available for viewing in the United States and Canada. The transponder guide includes the name of the programmer using each of the satellite channels (also known as a transponders). The list also indicates whether the channel is scrambled or in the clear. Most of the scrambled channels are available by subscribing through an authorized programmer and paying a fee for the reception of that channels programming.

Neither Primestar nor DSS currently has the number of channels that are available to a C-band viewer. If a C-band dish owner does not wish to subscribe to paid programming, there are still quite a few free channels which can be viewed. On both Primestar and the DSS system, to receive programming you are required to pay a monthly fee that varies depending on the package you elect.

New Sony DSS system.

Another advantage for C-band dish owners is they can view un-edited news feeds, from networks, affiliates and other satellite news gatherers. These feeds are typically not broadcast on any fixed schedule, but rather as events occur. In addition, television programming syndicators also use some C-band channels to broadcast their programs to their television station affiliates. Viewing these feeds may let the C-band dish owner see his or her favorite program before it airs at its regular time on network television or cable.

Programming for DSS is supplied by two companies, DIRECTV, a unit of General Motors Hughes Electronics Corporation, and United States Satellite Broadcasting, a subsidiary of Hubbard Broadcasting. Each of these program providers carry different programming.

One of DIRECTV's more comprehensive packages is the *Total Choice* available for

Neither Primestar nor DSS currently has the number of channels that are available to a C-band viewer. If a C-band dish owner does not wish to subscribe to paid programming, there are still quite a few free channels which can be viewed. On both Primestar and the DSS system, to receive programming you are required to pay a monthly fee that varies depending on the package you elect.

$29.95 per month. It includes 33 channels of entertainment programming, seven Encore movie channels, 29 Music Choice (CD quality audio channels), and several local/regional sports networks.

Also, all of their programming packages include *Direct Ticket*‡ with access to up to 63 more channels of movies, sports and live special events on a pay-per-view basis. As a *Total Choice* subscriber you get two free pay-per-view credits each month you subscribe to the service. *Direct Ticket* movies are priced at $2.99 each. For those viewers not served by local broadcast network affiliates, DIRECTV also offers *Prime Time 24* for $3.95 a month which includes affiliates from ABC (New York), CBS (Raleigh), NBC (Atlanta), FOX (Chicago) and PBS (Denver). DIRECTV offers other programming packages and a la carte options. For current pricing and programming information you can contact them at 1 (800) DIRECTV (347-3288).

United States Satellite Broadcasting, more commonly known as USSB), offers a basic programming package that included Nickelodeon, Comedy Central, MTV, VH-1, Lifetime and the All News Channel at a monthly cost of $7.95. They also offered a *One Plus* package which includes all the basic channels plus a choice of one of the following premium movie channels: Showtime/Flix (4 channels total), or HBO (5 channels total), or Cinemax (3 channels total), or The Movie Channel (2 channels total) for $10.95. For current prices, other programming packages and options you can contact USSB direct at 1 (800) 204-8772 .

At this point, Primestar does not have the channel capacity that the DSS systems have. Consequently, you will not receive as many channels on the Primestar system than the folks with DSS. I was quoted a monthly charge of $31.95 for 33 video and 6 audio channels.

In addition to the *Basic Value Package*, several other optional packages were available. *The Works* option (subject to geographic availability) was available for $5.95 a month, which includes network affiliates from ABC (Miami), NBC (Boston), CBS (Washington DC), FOX (San Francisco) and PBS (Philadelphia). A *Variety* package was available for $3.95 a month and included A&E, CMT, Sci-Fi Channel, The Weather Channel, Turner Classic Movie Channel and CNN International. HBO and Cinemax were available as add-on options at $9.95 a month for either, or $15.95 per month for both. A combined price for the "Basic Value Package", "The Works", "Variety" and HBO and Showtime was quoted at $54.95 a month. You can contact Primestar at 1 (800) PRIMESTAR to inquire about their programming packages, current cost and channel availability.

How do programming costs compare between C-band, Primestar and DSS? I do not believe that the question of cost has a simple answer. It is very hard to make an exact comparison. On C-band you are able to receive a number of stations for free without payment of any monthly fee. Not so with Primestar or DSS. However, the initial cost of a C-band system is significantly more expensive then either DSS and Primestar. I believe that to purchase a typical C-band system and have it professionally installed may cost between two and three times as much as a typical single TV DSS system. The same C-band system may cost more than 6 times the cost of the installation fee charged by Primestar. Although I was unable to duplicate the DIRECTV *Total Choice* package on C-band due to the lack of availability on C-band of some of the package channels, in my opinion, the cost of that package is similar to the cost of comparable programming on C-band.

Some Final Thoughts

Which picture quality is better? I have never seen the same program via all three systems at the same time on the same type of TV. I have watched both C-band and the DSS systems. In my opinion, each delivered excellent picture quality which I think is superior to the picture quality for the same programming available over many cable systems. Since picture quality is in many ways subjective, I urge you to try out and view each of the systems before you make any decision as to which you should have in your home. With C-band being a lower frequency than those used for the other two delivery systems, it may not be subject to the "Rain Fade" characteristics that is possibly on Primestar and DSS. You may wish to inquire of the equipment provider of the system that you are considering whether they have experienced any rain fade outages and if so, how many and for what period of time.

There is no free lunch. If you do not have space restrictions to limit your dish size, if cost of purchase and installation is not an issue, if you are reasonably comfortable operating the controls of a C-band system and if you want the greatest number of currently available video channels with free channel availability, then C-band is a strong consideration. If you want pure entertainment (cable without the hassles of cable) then investigate DSS or Primestar. Although I have a C-band system, if I were entering the market for a satellite system today, I would have to give strong consideration to the other two options available.

Due to space limitations I am unable to review all of the pros and cons of each satellite system in this column. If you would like to learn more about the new digital satellite technology, I recommend the *Miniature Satellite Dishes*, 2nd Edition by *ST* columnist Frank Baylin. Additional information on C-band systems can be found in another Baylin book, *Install, Aim and Repair Your Satellite TV System.* Both books are available from Grove Enterprises at 1-800-438-8155.

Are the DSS, Primestar and future direct broadcasting systems going to mean the death of C-band systems? I'll answer that question in about ten years. In my opinion however, the future for any satellite system will lie in their ability to deliver programming desired by the consumer at a cost-effective price, with easy to use, reliable equipment. The average John or Jane Doe doesn't care how the signal gets to the TV, but only about what programs are available for viewing and how easy the equipment is to use. After all, television is entertainment, and most people just want to watch something interesting that's *On-The-Air.* ST

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Disclaimer: Neither the author or Satellite Times endorses or recommends any company, product, individual dealer, satellite distributor, or programming supplier mentioned in this column. While Satellite Times makes every effort to ensure the information presented on programming and equipment cost is accurate, but we can not be held liable or responsible for any information that might have changed since this column went to press.

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

CLASSICAL

Classical music	E1, 9	6.32 (N)
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 service	G4, 6 (Ku-band)	7.40
	G4,6	7.398
Planet Connect, Planet Systems, Inc 100 kbps service	G1, 9	7.80
Skylink, Planet Systems, Inc	G1, 9	7.265
	G1,14	7.265
	G4,6	7.264
	G3,17	7.264
Storyvision	G5,3	7.30
Superguide	G5,7	5.48

CONTEMPORARY

Adult contemporary, unidenified station	E1, 9	7.58
CKRW-AM (610) Whitehorse, Yukon Canada — adult contemporary/oldies	E1,18	5.41, 6.80
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)
VOCM-AM (590) St. Johns, Newfoundland Canada — adult contemporary	E1,12	6.20 (W)
	E1,14	6.80

COUNTRY

CINC-FM (96.3) Thompson, Manitoba	E1,2	6.40
CISN-FM (103.9) Edmonton, Alberta Canada, ID-Country 104	E1,18	7.53/7.62 (DS)
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

Easy listening music, unidentified station	G4,6	6,20,7.69
Horizon — background music	E1,22	7.56 (N)
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

Antenna FM (Greek)	G3, 9	5.88 (W)
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
Cosmos FM, Hellenic Public Radio, New York, N.Y. (Greek)	S2,11	8.20
DZMM-Radyo Patrol (from Philippines)	G4,24 (Ku-band)	6.80
French language audio service	E1,15	6.12
French language audio service	E2,21	6.46 (N)
French language audio service	E1,24(Ku-band)	6.55
India ethnic radio (Hindu)	E1,22	7.70
Indian Sangeet Sager (Hindu)	E1,15(Ku-band)	6.12
Irish music (Sat 1430-0000 UTC)	S3, 3	6.20
Northern Native Radio (Ethnic)	E1,26 (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	E1,24(Ku-band)	6.12/6.30 (DS)
Radio Maria (Italian-Religious programming)	G7,10	5.80
	T2,9	8.00
Radio Sedeye Iran (Farsi)	S3,15	6.20 (N)
Radio Sonora-Mexico (Spanish)	SD1,6	6.80
Radio Tropical (Haitian Creole)	S2,11	7.60
Religious music (unid language)	G7,10	8.03
Russian-American radio network	G4,12 (Ku-band)	6.20
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	6.80, 6.20
WNWK-FM (105.9) Newark, N.J.(Ethnic)	S2,11	8.30
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

KJAZ-FM (92.7) Alameda, Calif, ID-K-Jazz	C1, 4	7.78/7.92 (DS)
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

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
O.J. Radio Network (trial hours only)	G5,5	6.30
USA Radio Network — news, talk and information	S3,13	5.01 (Ch 1), 5.20 (Ch 2)
Various talk radio programs	G6,14	7.58
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

Ambassador 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
Christian music service	S2,23	6.20, 7.60
Heaven Radio Network	G1,17	7.92
International Broadcasters Network	E1, 2	7.64
KILA-FM (90.5) Las Vegas, Nev. — SOS radio network	C4, 8	7.38/7.56 (DS)

Satellite Radio Guide

	G5,7	5.58/6.12 (DS)
Religious programming	E1,11 (Ku-band)	6.52
Salem Radio Network	S3,17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
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

CFMI-FM (101.1) New Westminister, British Columbia Canada, ID-Rock 101 — album rock	E1,22	6.80
CFRN-AM (1260) Edmonton, Alberta Canada - oldies	E1,18	6.435
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)
CIRK-FM (97.3) Edmonton, Alberta Canada, ID-K-97	E1,18	7.80 (N)
Rockline — classic rock	E1,11 (Ku-band)	6.12,6.30
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)

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-band)	5.76
Nebraska Talking Book Network	S3, 2	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
The Weather Network-Canada (English)	E1,9	5.41, 5.58, 5.76, 6.8, 7.78
Voice Print Reading Service	E1,16	7.44 (N)
Yesterday USA — nostalgia radio	G5, 7	6.80

TALK

AEN Michael Reagan (0100-0700 UTC)	C3, 1	6.20
Burlington Broadcast Network	G2,14	7.56
For the People radio network — (Chuck Harder) talk and information	C1, 2	7.50
Mutual Broadcasting Network-talk show feeds	E1, 2	7.54
One on One Sports radio network — sports talk	E1, 2	7.45
Prime Sports Radio—sports talk and info	C1,10	7.20
Sun Radio Network — talk programs (Tom Valentine 9p-12a ET)	C1,15	7.58
Talk America — talk programs	S3, 9	6.80
Talk Radio Network — talk programs	C1,5	5.80
Tech Talk Network	T2,21	5.80
(Note: TTR Network will follow Skyvision Channel video uplink to G7 or other occasional video spots in the arc that Skyvision will use in the future)		
USA Patriot Radio Network	G6,14	5.80

VARIETY

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) 5.76/5.94 (DS)		E1,16
CBKA-FM (105.9) La Ronge, Saskatchewan Canada (CBC-Multilingual)	E1,18	7.66
CBM-AM (940) Montreal, Quebec Canada — variety/fine arts	E1,20	6.12
CBU-AM (690) Vancouver, British Columbia Canada	E1,22	7.42
CBU-FM (105.7) Vancouver, British Columbia Canada	E1,22	5.76/5.94 (DS)
CFR-FM	E2,19 (Ku-band)	6.12/6.30
CFWE-FM (89.9) Lac Le Biche, Alberta Canada, ID-Aborigine Country—country music/ethnic	E1,2	6.40
	E1,12	5.40
	E1,18	6.435 (N)
	E1,18	7.875 (N)
	E2,19	6.80
CJRT-FM (91.1) Toronto, Ontario Canada — fine arts/jazz-nights	E1,26 (Ku-band)	5.76/5.94 (DS)
CKER-AM (1480) Edmonton, Alberta Canada — adult standard-day, ethnic-night	E1,18	7.42 (N)
CKLB-FM (101.9) Yellowknife, NWT Canada — country/ethnic	E1,14	5.41
CKUA-AM/FM (580/94.9) Edmonton, Alberta Canada	E1, 9 (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
MBC Radio (Saskatchewan Canada), ID-Aborigine Radio	E1,18	7.71
Peach State Public Radio (Georgia PBS)	T401,14 (Ku-band)	5.40/5.58 (DS)
Startalk Radio Network — talk/nostalgia music	G3,11	7.58
	G6,14	7.58
WUSF-FM (89.7) Tampa-St. Petersburg, Fl. (Public Radio), ID-Concert 90	C4,10	8.26 (N)

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/Seattle Mariners MLB radio network
1405.40 (54.6)	Sports Byline USA/Sports Byline Weekend
1404.60 (55.6)	Talk America radio network
1403.80 (56.2)	Occasional audio/Free Enterprise radio network
1403.20 (56.8)	Motor Racing Network (occasional audio)
1400.80 (59.2)	WBAL-AM (1090) Baltimore, Md — Baltimore Orioles MLB radio network
1398.30 (61.7)	WGN-AM (720) Chicago, Ill — talk radio/ Chicago Cubs MLB radio network
1398.00 (62.0)	Michigan News Network
1397.20 (62.8)	WTMJ-AM (620) Milwaukee, Wis — talk radio/Milwaukee Brewers MLB network
1394.70 (65.3)	Sun Radio Network
1394.50 (65.5)	WSB-AM (750) Atlanta, Ga. — news/talk, Atlanta Braves MLB network
1393.40 (66.6)	WGN-AM (720) Chicago, Ill — talk radio/ Chicago Cubs MLB radio network/Interstate Radio Network/Other occasional audio
1393.20 (66.8)	Wisconsin Radio Network
1393.00 (67.0)	USA Radio Network/WCXL-FM (104.1) Kill Devil Hills, NC — adult contemporary, ID - *Beach 104*
1392.70 (67.3)	WGN-AM (720) Chicago, Ill — talk radio/ Chicago Cubs MLB radio network/Interstate Radio Network
1391.60 (68.4)	XEPRS-AM (1090) Tijuana, Mexico — Spanish language programming, ID - *Radio Express*
1390.60 (69.4)	KABC-AM (790) Los Angeles, Calif. — talk radio/Los Angeles Dodgers MLB radio network (English)
1390.40 (69.6)	KWKW-AM (1330) Los Angeles, Calif. — Spanish language programming, ID - *Radio Lobo*/Spanish Information Service/Los Angeles Dodgers MLB radio network (Spanish)
1389.70 (70.3)	Occasional audio/data transmissions (burst)
1389.50 (70.5)	Data transmissions (burst)
1387.50 (72.5)	KWKW-AM (1330) Los Angeles, Calif — Spanish language programming, ID - *Radio Lobo*/Spanish Information Service, Los Angeles Dodgers MLB radio network (Spanish)
1386.70 (73.3)	Michigan News Network
1386.50 (73.5)	WJR-AM (760) Detroit, Mich — talk radio/ Detroit Tigers MLB radio network
1386.30 (73.7)	Illinois News Network
1385.80 (74.2)	WMAQ-AM (670) Chicago, Ill — news, Chicago White Sox MLB radio network
1385.10 (74.9)	For the People radio network
1384.20 (75.8)	KMPC-AM (710) Los Angeles, Calif — talk radio/California Angels MLB radio network
1383.80 (76.2)	KJR-AM (950) Seattle, Wash — sports talk radio
1383.40 (76.6)	KFRC-AM (610) San Francisco, Calif. — adult pop music/Oakland A's MLB radio network
1383.20 (76.8)	KDKA-AM (1020) Pittsburgh, Penn. — talk radio/Pittsburgh Pirates MLB radio network
1375.40 (84.6)	USA Radio Network
1374.10 (85.9)	Northwest Direct — news and talk

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 1-Horizontal (C-band)

1437.20 (62.8)	Associated Press (AP) 3 radio network
1435.00 (65.0)	Associated Press (AP) 2 radio network
1433.40 (66.6)	Associated Press (AP) 1 radio network

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)	WBIG-FM (100.3) Washington, D.C. - oldies, ID - *Oldies 100*
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 — nostalgia
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
1435.20 (64.8)	National Public Radio (NPR) feeds
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
1399.00 (81.0)	Oklahoma State sports radio network
1398.80 (81.2)	Progressive Farmers Network
1398.20 (81.8)	KWBW-AM (1450) Hutchinson, Kan. — talk radio/Occasional audio
1398.00 (82.0)	Oklahoma News Network
1397.20 (82.8)	Oklahoma News Network

Galaxy 4 Transponder 3-Horizontal (C-band)

1405.00 (55.0)	Mutual Broadcasting System
1404.80 (55.2)	KOA-AM (850)/KTLK-AM (760) Denver, Colo — news and talk/Colorado Rockies MLB radio network
1404.60 (55.4)	Occasional audio/ABC Direction Network
1404.00 (56.0)	South Carolina Radio Network
1403.50 (56.5)	International Broadcasting Network — 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)
1398.00 (62.0)	Tennessee Radio Network
1397.50 (62.5)	Minnesota Talking Book network
1397.10 (62.9)	WORD-AM (910) Spartanburg, SC — news/talk
1396.90 (63.1)	Spanish Information Service (SIS) radio network (Spanish)
1396.70 (63.3)	Tennessee Radio Network
1396.40 (63.4)	Georgia Network News/Univ of Georgia sports radio network
1396.20 (63.8)	WCNN-AM (680) Atlanta, GA — all sports talk radio
1396.00 (64.0)	WHO-AM (1040) Des Moines, Iowa — talk/ Iowa News Network
1395.80 (64.2)	Kentucky News Network
1395.50 (64.5)	American Public Radio (APR) - Monitor Radio programming
1395.10 (64.9)	National Public Radio (NPR) channel 12
1394.60 (65.4)	WHAS-AM (840) Louisville, Ky — adult contemporary music/Univ of Louisville sports radio network
1394.40 (65.6)	National Public Radio (NPR) channel 11
1394.00 (66.0)	National Public Radio (NPR) channel 10/ American Public Radio (APR) carrying Monitor Radio programming
1393.50 (66.5)	Atlanta Braves MLB radio network
1392.90 (67.1)	Minnesota Twins radio network
1392.60 (67.4)	National Public Radio (NPR) channel 9/ American Public Radio (APR)
1392.30 (67.7)	National Public Radio (NPR) channel 8
1392.00 (68.0)	Minnesota Public Radio
1391.70 (68.3)	National Public Radio (NPR) channel 7
1388.90 (71.1)	Data transmissions (burst)
1388.40 (71.6)	KSJV-FM (91.5) Fresno, Calif — spanish programming, ID - *Radio Bilingue* (network serves Spanish stations in several western states)
1388.10 (71.9)	National Public Radio (NPR) channel 6
1387.80 (72.2)	Data transmissions (constant)
1387.50 (72.5)	National Public Radio (NPR) channel 5
1387.20 (72.8)	National Public Radio (NPR) channel 4
1386.80 (73.2)	National Public Radio (NPR) feeds
1386.20 (73.8)	KSJV-FM (91.5) Fresno, Calif — Spanish programming, ID - *Radio Bilingue* (network serves Spanish stations in several western states)
1385.80 (74.2)	National Public Radio (NPR) channel 3
1385.40 (74.6)	U.S. Naval Observatory Master Clock and National Public Radio (NPR) channel 2
1384.70 (75.3)	National Public Radio (NPR) channel 1
1384.40 (75.6)	KOA-AM (850)/KTLK-AM (760) Denver, Colo — news and talk/Colorado Rockies MLB radio network
1383.70 (76.3)	Minnesota Network News (MNN)
1383.10 (76.9)	VSA Radio Network — Ag news

Single Channel Per Carrier (SCPC) Services Guide

1382.90 (77.1) Minnesota News Network (MNN)
1382.60 (77.4) Soldiers Radio Satellite (SRS) network — U.S. Army information and entertainment/ Army sports radio network
1382.30 (77.7) Motor Racing Network (occasional audio)
1382.00 (78.0) WFAE-FM (90.7) Charlotte, N.C. — NPR affiliate
1381.80 (78.2) WHO-AM (1040) Des Moines, Iowa — talk radio/Iowa News Network
1381.60 (78.4) Alabama Radio Network
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
1387.10 (52.9) Mid-America News Network/Mid-America Ag Network
1381.80 (58.2) Data transmissions
1379.00 (61.0) Louisiana Network
1378.80 (61.2) WLAC-AM (1510) Nashville, Tenn. — news and talk/Road Gang truck driver radio network (overnight)
1378.60 (61.4) Arkansas Radio Network
1378.10 (61.9) Data transmissions
1377.50 (62.5) Mid-America News Network/Mid-America Ag Network
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) TV Northen Canada network program audio

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 12-Vertical (C-band)

1226.00 (54.0) CKRW-FM (90.5) Whitehorse, Yukon Territory, Canada — adult contemporary music
1225.50 (54.5) CHON-FM (90.5) Whitehorse, Yukon Territory, Canada — variety

Anik E1 Transponder 13-Horizontal (C-band)

1206.00 (54.0) Canadian Broadcasting Company (CBC) Radio — southwestern Northwest Territories service
1205.50 (54.5) Canadian Broadcasting Company (CBC) Radio — southwestern Northwest Territories service — occasional carrier

Anik E1 Transponder 14-Vertical (C-band)

1185.50 (54.5) CKLB-FM (101.9) Yellowknife, NWT Canada — country music

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

Note: This transponder also has 62 other carriers consisting of data transmissions and six blank audio carriers.

SBS5 Transponder 2-Horizontal (Ku-band)

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

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2) RFD Radio Service
1404.60 (55.4) Wyoming News Network/Univ of Wyoming sports radio network
1400.60 (59.4) Indiana Radio Network
1400.40 (59.6) Occasional audio (Missouri Net?)
1400.20 (59.8) Occasional audio
1400.00 (60.0) Indiana Radio Network
1396.60 (63.4) Kansas Information Network/Kansas Agnet
1396.40 (63.6) Nebraska Ag Network
1396.20 (63.8) KMOX-AM (1120) St. Louis, Mo — news and talk/Missouri Network/St. Louis Cardinals MLB radio network
1396.00 (64.0) Occasional audio
1395.70 (64.3) WIBW-AM (580) Topeka, Kan — news and talk/Missouri Net/Kansas City Royals MLB radio 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
1386.20 (73.8) Radio Iowa
1386.00 (74.0) People's Radio Network
1384.60 (75.4) North Carolina News Network/Capitol Sports Network
1384.40 (75.6) Capitol Sports Network/Durham Bulls minor league baseball
1384.20 (75.8) Capitol Sports Network
1384.00 (76.0) Occasional audio/ABC Direction Network
1383.80 (76.2) Occasional audio
1383.60 (76.4) WPTR-AM (1540) Albany, N.Y. — talk radio
1383.40 (76.6) Capitol Sports Network
1382.90 (77.1) Missouri Network
1382.60 (77.4) North Carolina News Network
1382.30 (77.7) Virginia News Network
1378.70 (81.3) Radio Pennsylvania Network
1378.50 (81.5) Radio Pennsylvania Network
1378.30 (81.7) Radio Pennsylvania Network/Philadelphia Phillies radio network
1374.60 (85.4) National Association of Broadcasters (NAB) — misc audio and various sports radio network broadcasts (occ audio)

RCA C5 Transponder 21-Vertical (C-band)

1045.00 (55.0) KABC-AM (790) Los Angeles, Calif. — news and talk/Los Angeles Dodgers MLB radio network (English)
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
1041.00 (59.0) Occasional audio
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 AND TELEVISION SERVICE (AFRTS)

AFTRS-BC, 10888 La Tuna Canyon Road, Sun Valley, CA 91352-2098
AFRTS radio service carries a variety of radio network news and sports programming for servicemen overseas aboard Navy ships. Satellites carrying AFTRS transmissions include: 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, London, WC2. 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.

UTC/EDT/PDT	SERVICE/PROGRAM
0000/2000/1700	Radio Havana Cuba - Havana
0100/2100/1800	YLE Radio Finland - Helsinki
0130/2130/1830	Classical Music (taped)
0200/2200/1900	Radio Prague - Prague
0230/2230/1930	Radio Austria - Vienna
0300/2300/2000	Deutsche Welle - Cologne
0400/0000/2100	China Radio International - Beijing
0500/0100/2200	Classical Music (taped)
0530/0130/2230	Radio Austria - Vienna
0600/0200/2300	Swiss Radio International - Berne
0700/0300/0000	ABC Radio Australia - Melbourne
0800/0400/0100	KBS Radio Korea International - Seoul
0900/0500/0200	Voice of Russia -Moscow (Mon-Fri)
0930/0530/0230	Radio Netherlands - Hilversum
1030/0630/0330	KBS Radio Korea International - Seoul
1100/0700/0400	Radio Japan - Tokyo
1200/0800/0500	Radio Canada International - Montreal (Mon-Fri)
	Radio Telefis Eireann (RTE) - Dublin (Sat/Sun)
1300/0900/0600	KBS Radio Korea International - Seoul (Mon-Fri)
	Radio France International - Paris (Sat)/Rendezvous (taped)
	Canadian Broadcasting Company (Sun until 1600)/Sunday Morning
1330/0930/0630	Radio Sweden - Stockholm (Sat)/Sweden Today (taped)
1400/1000/0700	YLE Radio Finland - Helsinki (Mon-Fri)
	Classical Music (Sat until 1600) (taped)
1430/1030/0730	Radio Vlaanderen International - Brussels Calling (Mon-Fri)
1500/1100/0800	Radio France International - Paris (Mon-Fri)
1600/1200/0900	Voice of Russia - Moscow (Mon-Fri)
	C-SPAN Weekly Radio Journal (Sat until 1700) (taped)
	Classical Music (Sun until 1800) (taped)
1630/1230/0930	Radio Netherlands - Hilversum (Mon-Fri)
1700/1300/1000	Classical Music (Sat until 1800) (taped)
1730/1330/1030	Radio Telefis Eireann (RTE) - Dublin, Ireland (Mon-Fri)
1800/1400/1100 until 0000 UTC)	Voice of America (VOA) - Washington, D.C. (Broadcast last 6 hours

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)

Radio & TV Intl, D-50588 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, and Intelsat K (21.5 west) Tr H7 (11605 MHz H), 7.38/7.56 MHz audio.

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)
Eutelsat II F3 (16.0 east) Tr 33 (11596 MHz H) 7.02 MHz audio from 2300-0330 UTC

RADIO EXTERIOR DE ESPANA (REE)

Apartado 156202, Madrid 28080, Spain. Telephone +34 13461083/1080/1079/1121 (voice); 34 13461097 (fax).
Eutelsat II F2 (10.0 east) Tr 22 (11149 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, F-75016, Paris, 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, Palapa B2P (113 east) Tr 8 (3860 MHz V) 6.15 MHz audio to Asia, Anik E2 (107.3 west) Tr 21 (4120 Mhz H) 5.41/6.12 MHz.audio to the Americas, Spacenet 2 (69.0 west) Tr 4 (3780 MHz V) 7.38 MHz. audio to the Americas.

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 +31-35-724211 (voice), +31-35-724352 (fax)
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-105 10 Stockholm, Sweden.. Telephone: +46 8 6676283 (voice), +46 8 6676283 (fax).
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 F2 (10.0 east) Tr 26B (11095 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 2 732 6295 (fax)
Astra 1C (19.2 east) Tr 63 (10921 MHz H) 7.38 MHz audio.

International Shortwave Broadcasters via Satellite

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

Casa Postale, CH-3000 Bern 15, Switzerland. Telephone: +41 31 439222 (voice), +41 31 439544 (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 F1 (13.0 east) Tr 26 (11080 MHz V) 7.74 MHz. audio, Intelsat K (21.5 west) Tr 7 (11605 MHz H) 8.10 MHz audio, Satcom C4/F4 (135.0 west) Tr 5 (3800 MHz V) 8.10 MHz audio.

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.

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). E-mail via Internet: wrn@cityscape.co.uk or Compuserve 100041,3344. 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

Galaxy 5 (125.0 west) Tr 6 (3820 MHz V) 6.80 MHz audio. All broadcasts are daily unless otherwise indicated. WRN program information can be heard daily on North American 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.

UTC/EDT/PDT	SERVICE/PROGRAM
0025/2025/1725	YLE Radio Finland - Helsinki (News in Finnish)
0030/2030/1730	Radio Sweden - Stockholm
0100/2100/1800	YLE Radio Finland - Helsinki*+
0130/2130/1830	Israel Radio - Jerusalem
0200/2200/1900	Radio Prague (Slovakia)
0230/2230/1930	Radio Austria International - Vienna
0300/2300/2000	Radio Budapest (Hungary)
0330/2330/2030	Radio Netherlands - Hilversum
0430/0030/2130	BBC Europe Today (Mon-Sat) BBC International Call (Sun)
0500/0100/2200	Deutsche Welle - Cologne (Germany)
0600/0200/2300	Swiss Radio International - Berne
0630/0230/2330	Radio Canada International - Montreal
0700/0300/0000	ABC Radio Australia - Melbourne*+
0800/0400/0100	KBS Radio Korea International - Seoul*+
0900/0500/0200	Voice of Russia - Moscow*
0930/0530/0230	Radio Netherlands - Hilversum
1030/0630/0330	WRN Program Information/TBA (Mon-Fri) BBC International Call (Sat) BBC Intl Money Prog & Health Watch (Sun)
1100/0700/0400	Radio Australia - Melbourne*+
1200/0800/0500	Radio Telefis Eireann (RTE) - Dublin, Ireland+
1300/0900/0600	KBS Radio Korea International - Seoul*
1400/1000/0700	YLE Radio Finland - Helsinki*
1430/1030/0730	Radio Vlaanderen International - Brussels Calling*
1500/1100/0800	Radio France International - Paris*
1600/1200/0900	Voice of Russia - Moscow*
1630/1230/0930	Radio Netherlands - Hilversum*
1730/1330/1030	Radio Telefis Eireann (RTE) - Dublin, Ireland*
1800/1400/1100	ABC Radio Australia - Melbourne*
1900/1500/1200	Blue Danube Radio - Vienna (Mon-Fri) UN Radio and BBC Europe Now (Sat) Glen Hauser's World of Radio (Sun)
1930/1530/1230	Radio Vlaanderen International - Brussels Calling
2000/1600/1300	BBC Europe Today (Sun-Fri) BBC International (Sat)
2030/1630/1330	Radio Sweden - Stockholm
2100/1700/1400	Radio Telefis Eireann (RTE) - Dublin, Ireland/News and Both Sides Now
2300/1900/1600	Polish Radio - Warsaw
2330/1930/1630	Radio Netherlands - Hilversum

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 78, 00024 Yleisradio, Finland. Telephone: +358 0 14801 (voice), +358 0 1481169 (fax)
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

DBS/Primestar Channel Guide

By Robert Smathers

DirecTV™ Channel Guide

DirecTV
2230 East Imperial Highway
El Segundo, Calif. 90245
1-800-DIRECTV (347-3288)

100	DirecTV Previews	Previews
102-190	Direct Ticket Pay Per View	PPV
200	Previews	Previews
201	Special Events Calendar	Promo
202	CNN	News
203	Court TV	Speciality
204	CNN Headline News	News
206	ESPN 1	Sports
207	ESPN Alternate	Sports
208	ESPN 2	Sports
212	TNT	TV programming
215	E! Entertainment TV	Speciality
216	MuchMusic	Music Videos
219	American Movie Classics (AMC)	Movies
220	Turner Classic Movies (TCM)	Movies
222	The Disney Channel (East)	Movies/Kids
224	The Disney Channel (West)	Movies/Kids
225	The Discovery Channel documentary	Science/TV
226	The Learning Channel (TLC) documentary	Science/TV
227	Cartoon Network	Cartoons
229	USA Network	TV
230	Trio	TV
232	The Family Channel	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	Science Fiction
242	C-Span 1	Congress-House
243	C-Span 2	Congress-Senate
245	Bloomberg Direct	News
246	CNBC	Financial/Talk
247	America's Talking	Talk
248	The Weather Channel (TWC)	Weather
250	Newsworld International	News
252	CNN International	News
254	The Travel Channel (TTC)	Travel Shows
256	Arts & Entertainment	TV
268	Previews	Previews
269	STARZ! - West	Movies
270	STARZ!	Movies
271	Encore	Movies
272	Encore-Love	Movies
273	Encore-Westerns	Movies
274	Encore-Mystery	Movies
275	Encore-Action	Movies
276	Encore-True Stories	Movies
277	Encore-WAM!	Movies
282	WRAL-CBS, Raleigh, N.C.	Network TV
284	WXIA-NBC, Atlanta, Ga.	Network TV
286	PBS	Network TV
287	WABC-ABC, New York, N.Y.	Network TV
289	WFLG-FOX, Chicago, Ill.	Network TV
298	TV Asia	Ethnic Programming
299	In-store dealer info channel	Retailers only
300-399	Regional and PPV Sports	Sports
301	Special Events Calendar	Promo
302	Sunday Ticket 95 Promo/World League of American Football	Sports
304	The Golf Channel	Sports
305	SportsChannel New England	Sports
306	Madison Square Garden	Sports
307	New England Sports Network	Sports
308	SportsChannel New York	Sports
309	SportsChannel Philadelphia	Sports
310	Prime Sports KBL	Sports
311	Home Team Sports (HTS)	Sports
312	SportsSouth	Sports
314	Sunshine	Sports
316	Pro AM Sports (PASS)	Sports
317	SportsChannel Ohio	Sports
318	SportsChannel Cincinnati	Sports
319	SportsChannel Chicago	Sports
322	Prime Sports Southwest	Sports
323	Prime Sports Midwest/Upper Midwest/ Rocky Mountain/Intermountain West	Sports
325	Prime Sports West	Sports
326	SportsChannel Pacific	Sports
330-348	NFL Sunday Ticket	Sports
350	NFL Sunday Ticket/NBA League Pass	Sports
356	NFL Sunday Ticket/NBA League Pass	Sports
401	Spice	Adult
402	Playboy	Adult
501	Music Choice — Hit List	Audio
502	Music Choice — Dance	Audio
503	Music Choice — Hip Hop	Audio
504	Music Choice — Urban Beat	Audio
505	Music Choice — Reggae	Audio
506	Music Choice — Blues	Audio
507	Music Choice — Jazz	Audio
508	Music Choice — Jazz Plus	Audio
509	Music Choice — Contemporary Jazz	Audio
510	Music Choice — New Age	Audio
511	Music Choice — Electric Rock	Audio
512	Music Choice — Modern Rock	Audio
513	Music Choice — Classic Rock	Audio
514	Music Choice — Rock Plus	Audio
515	Music Choice — Metal	Audio
516	Music Choice — Solid Gold Oldies	Audio
517	Music Choice — Soft Rock	Audio
518	Music Choice — Love Songs	Audio
519	Music Choice — Progressive Country	Audio
520	Music Choice — Contemporary Country	Audio
521	Music Choice — Country Gold	Audio
522	Music Choice — Big Bands Nostalgia	Audio
523	Music Choice — Easy Listening	Audio
524	Music Choice — Classic Favorites	Audio
525	Music Choice — Classics in Concerts	Audio
526	Music Choice — Contemporary Christian	Audio
527	Music Choice — Gospel	Audio
528	Music Choice — For Kids Only	Audio
529	Music Choice — Music of the Season	Audio

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DBS/Primestar Channel Guide

USSB Channel Guide

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

963	All New Channel (ANC)	News
965	Video Hits One (VH-1)	Rock Music Videos
967	Lifetime	TV
968	Nickelodeon (Nick)	TV/Kids
970	Flix	Movies
973	Cinemax (East)	Movies
974	Cinemax 2	Movies
975	Cinemax (West)	Movies
977	The Movie Channel (East)	Movies
978	The Movie Channel (West)	Movies
980	HBO (East)	Movies
981	HBO 2 (East)	Movies
982	HBO 3	Movies
983	HBO (West)	Movies
984	HBO 2 (West)	Movies
985	Showtime (East)	Movies
986	Showtime 2	Movies
987	Showtime (West)	Movies
989	MTV	Rock Music Videos
990	Comedy Central	Comedy
999	USSB Background audio/Information	Enviromental sounds

Primestar Channel Guide

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 — occ service	Financial/Talk
49	The Weather Channel (TWC)	Weather
50	CNN International	News
51	Cable Network News (CNN)	News
52	CNN Headline News	News
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
84	QVC — occ service	Home Shopping
111	WHDH-NBC, Boston, Mass.	Network TV
114	WPLG-ABC, Miami/Ft. Lauderdale, 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	
151	Prime Sports Upper Midwest	Sports
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
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 — occ service	PPV
207	Continuous Hits 3	PPV
208	Request 2	PPV
209	Request 3	PPV
210	Request 4	PPV
221	Playboy — occ 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	

Ku-band Satellite Transponder Services Guide

By Robert Smathers

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

Spacenet 2 (S2) 69° West

19	11740-H	Data Transmissions
20	11820-H	Occ video
21	11900-H	TV ASAHI [Leitch]
22	11980-H	Occ video
23	12060-H	Kentucky Educational Television (half-transponders)
24	12140-H	Occ video

SBS 2 (SBS2) 71° West (Inclined Orbit)

1	11725-H	NBC feeds (occ video)
2	11780-H	NBC feeds (occ video)
3	11823-H	NBC feeds (occ video)
5	11921-H	NBC feeds (occ video)
6	11970-H	NBC feeds (occ video)
7	12019-H	NBC feeds (occ video)
9	12117-H	NBC feeds (occ video)

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

(Occasional video on all transponders)

1	11725-H	Data transmissions
10	12166-H	Data transmissions

Satcom K2 (K2) 81° 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	FM³ 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) 85° 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) 87° 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)

Galaxy 7 (K7) 91° West

1	11720-V	Occ video/G.O.P. TV (occasional)
2	11750-H	Data Transmissions
3	11750-V	Indiana Higher Education [Compressed video]
4	11780-V	Occ video
5	11810-H	Occ video
6	11810-V	Classic Sports Network
7	11840-V	Occ video
8	11870-H	Data Transmissions
9	11870-V	Data Transmissions
10	11900-H	The People's Network (TPN)/ Hospitality TV [B-MAC]/Occ video
11U	11945-H	[Compressed video]
12	11930-V	Asian American TV Network
13	11960-V	Occ video
14	11990-H	Occ video/Muslim TV (half-transponders)
15	11990-V	The Asian Network (TAN)/Your Choice TV/Occ video
16	12020-V	Occ video/Microsoft TV (occasional)
17	12050-H	Westcott Communications ASTN [B-MAC]/ANTN (Half-transponders)
18	12050-V	Occ video
19	12080-V	The People's Network/Occ video
20	12110-H	Data Transmissions
21	12110-V	TCI Promo Channel [B-MAC]
22	12140-V	BBC 9 p.m. News (PAL)/Real Estate TV Network/Occ video
23	12170-H	Data Transmissions
24	12170-V	Occ video

GSTAR-3 (GST3) 93° 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

SBS 6 (SBS6) 95° West

1	11717-H	Occ video/BBC 9pm News [PAL]
2	11749.5-V	SCPC transmissions
3	11774-H	Occ video/Northfield horse racing
4	11798.5-V	Occ video/IBM TV [B-MAC]
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 - occ video
12	11994.5-V	CONUS Communications - occ video (full & half-transponders)/ Megabingo
13	12019-H	CONUS Communications - occ video/Catholic Telecommunications Network
14	12043.5-V	CONUS Communications - occ video (full & half-transponders)
15	12075-H	CONUS Communications - occ video
16	12092.5-V	Occ video/Massachusetts Educational Network
17	12110-H	Occ video
18	12141.5-V	Occ video (half transponders)
19	12174-H	Occ video

Telstar 401 (T401) 97° 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/DMX music on half of this transponder
12	12046-H	AT&T Skynet TV [compressed video]
13	12095-V	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) 99° West

1	11720-H	SCPC services/Data Transmissions
2	11750-V	Data transmissions
3	11750-H	FM² services/MUZAK/Data Transmissions
4	11780-H	FM² services/Planet Connect computer service (19.2 kbps)/Data Transmissions
5	11810-V	Data Transmissions
6	11810-H	Occ video
7	11840-H	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	WMNB Russian-American TV [inverted video]/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	Occ video
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) 101° West

20	11820-H	Occ video
22	11980-H	Occ video
24	12140-H	Occ video/Texas education feeds

DBS-1 101.2° West/DBS-2 & DBS-3 100.8° West
A complete DIRECTV‡ and USSB channel guide is presented in the DBS section of Satellites Times Satellite Service Guide. These satellites operate in the 12.2-12.7 GHz range.

GSTAR-1 (GST1) 103° West

1	11730-H	Data Transmissions
2	11791-H	Data Transmissions
3	11852-H	Fed-X - occ video [B-MAC]
4	11913-H	Data Transmissions
5	11974-H	O.J. TV (CourtTV)/CourtTV feeds (half transponders)
6	12035-H	Data Transmissions
7	12096-H	Healthcare Satellite [B-MAC]
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	Old Dominion University EdNet/ Occ video
14	12049-V	Data Transmissions
15	12110-V	Data Transmissions
16	12171-V	Data Transmissions

GSTAR-4 (GST4) 105° West

1	11730-H	Data Transmissions
2	11791-H	Data Transmissions
3	11852-H	CNN Newsource (Primary) [Leitch]/some feeds in clear
4	11913-H	Occ video
5	11974-H	O.J. TV (CNN/ABC/others)/Occ video
6	12035-H	CNN feeds/Occ video
7	12096-H	CNN feeds/Occ video
8	12157-H	Occ video
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	CNN feeds/occ video

Anik E2 (A1) 107.3° West

1	11717-V	Data transmissions
2	11743-V	Data transmissions
3	11778-V	Future home of Expressvu
4	11804-V	Future home of Expressvu/occ video
5	11839-V	Occ video (continental beam)
6	11865-V	Occ video (continental beam)
7	11900-V	Future home of Expressvu
8	11926-V	Future home of Expressvu
9	11961-V	Data Transmissions
10	11987-V	Data Transmissions
11	12022-V	Showcase TV (West)
12	12048-V	Woman's Television Network (WTN) (West)
15	12144-V	Telesat Canada stationkeeping
16	12170-V	MovieMax! — movies
17	11730-H	Discovery Channel Canada [Oak]
18	11756-H	New Country Network (NCN)
19	11791-H	Bravo! Canada
20	11817-H	Life Network
21	11852-H	TeleLatino (TLN) — Spanish-language variety
22	11878-H	Meteo Media
23	11913-H	Showcase TV (East)
24	11939-H	Woman's Television Network (WTN) (East)
25	11974-H	Data Transmissions
26	12000-H	Data Tranmsissions
27	12035-H	MoviePix! — movies
28	12061-H	Canal D — French arts channel
29	12096-H	RaiUno
30	12122-H	Telesat Canada stationkeeping
31	12157-H	Super Ecran [V2+]
32	12183-H	Canal Famile [V2+]

Solidaridad 1 SD1 109.2° West

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

Anik E1 (A2) 111° West

1	11717-V	Data transmissions
2	11743-V	Telesat services
3	11778-V	Partial channel services
4	11804-V	Partial channel services
5	11839-V	MuchMusic simulcast
6	11865-V	NovaNet FM² Services
7	11900-V	Rogers Network [compressed video]
8	11926-V	Occ video
9	11961-V	Access Network of Alberta (distant learning)
10	11987-V	Canadian Parliamentary Channel
11	12022-V	The Family Channel [Oak]
12	12048-V	R eseau de l information (RDI)
13	12083-V	CBC Newsworld feeds/Occ video
14	12109-V	RDI feeds/Occ video
15	12144-V	Knowledge Network
16	12170-V	Saskatchewan CommunicaNetwork
17	11730-H	Data transmissions
18	11756-H	Data transmissions
19	11791-H	SCPC/Data transmissions
20	11817-H	SCPC/Data transmissions
21	11852-H	Radio Quebec
22	11878-H	Quatre Saisons
24	11939-H	Musique Plus
25	11974-H	La Chaine
26	12000-H	TV Ontario (English)
28	12061-H	Ontario Legislature
29	12096-H	Reseau des Sports [V2+]
30	12122-H	The Family Channel [V2+]
31	12157-H	The Movie Network [V2+]
32	12183-H	Atlantic Satellite Network

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

(This satellite rarely has video transmissions)

Morelos 2 (M2) 116.8° West

(No video has been seen on any Ku transponder)

SBS 5 (SBS5) 123° West

1	11725-H	Comsat Video in-room programming [B-MAC] (half transponders) — Satellite Cinema 1/3
2	11780-H	SCPC services
4	11872-H	Comsat Video in-room programming [B-MAC] (half transponders) — Satellite Cinema 4/2
5	11921-H	Data Transmissions
6	11970-H	Data Transmissions
7	12019-H	Data Transmissions
8	12068-H	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) 125° West

1	11730-H	Data Transmissions
2	11791-H	Data Transmissions
3	11852-H	Occ video
4	11913-H	Occ video
5	11974-H	Occ video
6	12035-H	Occ video
7	12096-H	Occ video
8	12157-H	Occ video
9	11744-V	Data transmissions
10	11805-V	Occ video
11	11866-V	GSTAR-2 ID slate/Occ video
12	11927-V	Occ video
13	11988-V	Occ video
14	12049-V	Occ video
15	12110-V	Occ video
16	12171-V	Occ video

Amateur and Weather Satellite Two Line Orbital Element Sets

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

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

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

AMATEUR RADIO SATELLITES

OSCAR 10 (AO-10)
1 14129U 83058B 95209.03342820 +.00000085 +00000-0 +10000-3 0 03663
2 14129 026.4477 256.1390 5995039 296.7835 014.9822 02.05877850063170
OSCAR 11 (UoSAT 2, UO-11, UoSAT 11)
1 14781U 84021B 95208.97653023 +.00000088 +00000-0 +22634-4 0 08418
2 14781 097.7832 209.5999 0012923 053.7426 306.4996 14.69362757609895
COSMOS 1861 (Carries RS-10/11 or Radio Sputnik-10/11)
1 18129U 87054A 95208.88056751 +.00000034 +00000-0 +21272-4 0 00939
2 18129 082.9234 028.9874 0011881 346.1824 013.9006 13.72354776405559
OSCAR 13 (AO-13)
1 19216U 88051B 95209.02333835 -.00000273 +00000-0 -41183-3 0 00695
2 19216 057.5040 173.7107 7313321 014.8174 358.1855 02.09724730023029
OSCAR 14 (UoSAT 3, UO-14, UoSAT 14))
1 20437U 90005B 95209.15812349 -.00000018 +00000-0 +97120-5 0 01286
2 20437 098.5669 292.8693 0011949 076.7720 283.4795 14.29892507287601
OSCAR 16 (AO-16, PACSAT)
1 20439U 90005D 95209.19832565 -.00000021 +00000-0 +87785-5 0 09259
2 20439 098.5781 294.6326 0012217 077.4375 282.8174 14.29946538287624
OSCAR 17 (DO-17, DOVE)
1 20440U 90005E 95209.18276876 -.00000003 +00000-0 +15647-4 0 09243
2 20440 098.5798 295.0969 0012359 076.8441 283.4122 14.30087964287649
OSCAR 18 (WO-18, WEBERSAT)
1 20441U 90005F 95208.74606249 -.00000014 +00000-0 +11456-4 0 09321
2 20441 098.5795 294.6357 0012940 078.9188 281.3444 14.30058983287586
OSCAR 19 (LU-19, LUSAT)
1 20442U 90005G 95206.17737271 -.00000044 +00000-0 +00000-0 0 09138
2 20442 098.5791 292.4754 0013130 084.0130 276.2551 14.30161654287231
JAS 1B (FUJI 2, FO-20, Fuji Oscar 20)
1 20480U 90013C 95209.18703244 -.00000023 +00000-0 +13179-4 0 08238
2 20480 099.0724 290.1676 0540998 140.4355 223.7570 12.83231598256208
COSMOS 2123 (Carries RS-12/13 or Radio Sputnik 12/13)
1 21089U 91007A 95209.12783336 +.00000037 +00000-0 +23196-4 0 08203
2 21089 082.9220 070.4211 0031115 058.5691 301.8500 13.74059187224397
OSCAR 22 (UoSAT F, UoSAT 5, UO-22, UoSAT 22)
1 21575U 91050B 95209.15973112 -.00000007 +00000-0 +12024-4 0 06335
2 21575 098.3902 279.4609 0007538 150.8586 209.3025 14.36983889211381
OSCAR 23 (KITSAT 1, KITSAT A, KO-23)
1 22077U 92052B 95208.94357075 -.00000037 +00000-0 +10000-3 0 05238
2 22077 066.0761 150.4305 0004839 187.9475 172.1461 12.86291447138973
KITSAT B (KITSAT 2, KO-25, OSCAR 25)
1 22825U 93061C 95209.16954606 -.00000006 +00000-0 +15239-4 0 04299
2 22825 098.6157 285.0030 0009392 098.3545 261.8701 14.27668081095611
POSAT 1 (PO-28)
1 22826U 93061D 95209.19045901 -.00000010 +00000-0 +13435-4 0 04091
2 22826 098.6161 285.1276 0009758 098.3441 261.8848 14.27775882095622
EYESAT A (AO-27)
1 22829U 93061G 95209.18971400 -.00000001 +00000-0 +17256-4 0 04089
2 22829 098.6127 285.2017 0010908 086.6759 273.5673 14.28086253095648
RADIO ROSTO (RS-15, Radio Sputnik 15)
1 23439U 94085A 95209.03535053 -.00000039 +00000-0 +10000-3 0 00747
2 23439 064.8148 188.9246 0167821 255.1984 103.0286 11.27525034024120

WEATHER SATELLITES

NOAA 9
1 15427U 84123A 95209.14840013 +.00000003 +00000-0 +25428-4 0 03467
2 15427 098.9957 268.1144 0015030 149.1424 211.0637 14.13719706547700
GOES 7
1 17561U 87022A 95208.43090694 +.00000080 +00000-0 +10000-3 0 04827
2 17561 002.4036 071.9241 0002273 002.5107 249.7045 01.00279287014035
HIMAWARI 4 (GMS 4)
1 20217U 89070A 95201.63942877 -.00000374 +00000-0 +10000-3 0 02216
2 20217 001.1034 076.0883 0010052 083.6618 128.5591 01.00130542022084
NOAA 12
1 21263U 91032A 95209.05336680 +.00000124 +00000-0 +74462-4 0 05782
2 21263 098.5850 232.0678 0012893 133.9113 226.3132 14.22544243218239
METEOR 3-5
1 21655U 91056A 95209.01649094 +.00000051 +00000-0 +10000-3 0 08212
2 21655 082.5502 190.1110 0011927 267.7640 092.2106 13.16839909189870
METEOR 2-21
1 22782U 93055A 95209.15688814 +.00000015 +00000-0 -26484-6 0 04261
2 22782 082.5467 244.7179 0022246 164.1622 196.0238 13.83035347096200
METEOSAT 6
1 22912U 93073B 95201.96892940 -.00000099 +00000-0 +00000-0 0 03445
2 22912 000.7450 277.8460 0001155 135.2046 223.4965 01.00260156004524
METEOR 3
1 22969U 94003A 95209.15472497 +.00000051 +00000-0 +10000-3 0 02069
2 22969 082.5592 129.8348 0015716 336.5432 023.4971 13.16730085072270
GOES 8
1 23051U 94022A 95209.15838196 -.00000258 +00000-0 +10000-3 0 03538
2 23051 000.1114 085.7647 0003545 061.5371 140.5718 01.00271809012105
NOAA 14
1 23455U 94089A 95209.21496746 +.00000089 +00000-0 +73654-4 0 02644
2 23455 098.9037 151.4102 0010617 077.6525 282.5833 14.11524406029604
GOES 9
1 23581U 95025A 95209.20235509 -.00000186 +00000-0 +00000-0 0 00437
2 23581 000.4714 269.0448 0000400 215.3290 163.5481 01.00280790000663

Satellite Transponder Guide

By Robert Smathers

	Spacenet 2 (S2) 69º	Galaxy 6 (G6) 74º	Telstar 302 (T2) 85º	Spacenet 3 (S3) 87º	Galaxy 7 (G7) 91º	Galaxy 3 (G3) 93.5º	Telstar 401 (T1) 97º	Galaxy 4 (G4) 99º	Spacenet 4 (S4) 101º	Anik E2 (A1) 107.3º
1	SC New York [V2+]	o/v	o/v	SCPC/FM2 (AP) services	Sega Channel [interactive digital]	Hero Teleport contract channel	Exxxtasy (Adult) [V2+]/VTC	SCPC services	Data Transmissions	Spice (adult) [V2+]
2	GEMS TV (Spanish) [V2+]	(none)	o/v	Nebraska Educational TV (NETV)	CBS West [VC1]	Western Video Market/CBU feeds/o/v	Data Transmissions	SCPC services	WHDH-NBC Boston (Atlantic 3) [V2+]	Adam and Eve (adult) [V2+]
3	USIA Worldnet TV	SCPC services	o/v	WSBK-Ind Boston [V2+]	Action PPV [V2+]	o/v	Parmount Syndication feeds/o/v	SCPC services	Data Transmissions	Canadian Horse Racing/o/v
4	Canal de Canales SUR (Spanish)	o/v	o/v	Nebraska Educational TV (NETV)	fX East	o/v	Fox feeds	SCPC services	WUSA-CBS Washington (Atlantic 3) [V2+]	TVN Cable Video Store [V2+]
5	NASA Contract Channel [Leitch]	NHK New York feeds	o/v	Univision [V2+]	fX West	Fox News Feeds/o/v	4MC Syndicated feeds/NC Open Net/o/v	o/v	Data Transmissions	Canadian Horse Racing/o/v
6	Data Transmissions	NHK TV Japan feeds	o/v	(none)	Game Show Network [V2+]	American Independent Network	Buena Vista TV feeds	Sheperd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	o/v
7	Test Pattern	o/v	TurnerVision Infomercials/o/v	Data Transmissions	The Golf Channel [V2+]	o/v	Fox feeds-East	o/v	Data Transmissions	ABC East [Leitch]
8	Data Transmissions	(none)	o/v	Data Transmissions	HBO East 2 [V2+]	Data Transmissions	PBS X	Telemundo [GI Digicipher]	KDMO-ABC Seattle (PT24W) [V2+]	Global TV [Leitch]/Global feeds
9	NASA TV	MuchMusic U.S. [V2+]	Radiotelevisao Portuguesa Internacional (RTPI)	WPIX-Ind New York [V2+]	MCI (Andover) contract channel/o/v	Antenna Satellite TV [V2+]/High Tech Channel	Fox SNG feeds	o/v	Data Transmissions	Empire Sports Network [V2+]
10	Data Transmissions	Arab Network of America (ANA)	ABC West [Leitch]	Data Transmissions	Unied Arab Emirates TV Dubai	o/v	Fox SNG feeds-West	WABC-ABC New York (PT24E) [V2+]	WFLD-Fox Chicago (PT24E) [V2+]	Channel America
11	SC Philadelphia [V2+]	FOX News Feeds/o/v	o/v	CNN feeds	Estacion Montellano (Spanish rel)/o/v	Keystone International (Rel)	ABC feeds	o/v	STARZ! Encore 8 [V2+]	Canadian Horse Racing/o/v
12	Data Transmissions	TV Asia [V2+]	The Outdoor Channel	Data Transmissions	International Channel [V2+]	Data Transmissions	ABC NewsOne feeds	o/v	Data Transmissions	CTV (Blue)/o/v
13	Data Transmissions	Independent Film Channel [V2+]	o/v	SCPC/FM2 services	CSN/Kaleidoscope/PSS [Digicipher]	o/v	Fox East	o/v	Data Transmissions	Canadian Horse Racing/o/v
14	Data Transmissions	Cornerstone TV WPCB-TV (Rel)	NPS Promo Channel	CNN [Leitch]	HBO West 2 [V2+]	o/v	Fox West	WRAL-CBS Raleigh (PT24E) [V2+]	Data Transmissions	adulTVision - adult [V2+]
15	HERO Teleport [Digicipher]	Midwest Sports Channel [V2+]	Exxxtreme/Climaxxx TV Promos (adult) [V2+]	KTLA-Ind Los Angeles [V2+]	TV! [V2+]	LVTN/o/v	Exxxtasy 2 (adult) [V2+]	World Harvest TV (Rel)	Data Transmissions	Global feeds/Exxxtasy promos/o/v
16	Data Transmissions	(none)	o/v	CNN International [Leitch]	Access TV/o/v	o/v	o/v	CBS West [VC1]	Data Transmissions	CTV (Green)
17	Data Transmissions	Tokyo BS New York feeds	TV Erotica [V2+]	FM2/SCPC services	Via TV - home shopping	Shop at Home (SAH)	o/v	CBS East [VC1]/o/v	Data Transmissions	Climaxxx (adult) [V2+]
18	(none)	Merchandise and Entertainment TV (MET)	TV EroticaPromos/AWAD [V2+]/o/v	Shop-at-Home/In-store radio audio	CBS feeds [VC1]/o/v	Univision feeds/o/v	o/v	CBS feeds [VC1]/o/v	WPLG-ABC Miami (Atlantic 3) [V2+]	Video Catalog Channel
19	Data Transmissions	University Network/Dr. Gene Scott (Rel)	o/v	SSN Sportsouth [V2+]/ American Collectables Network	CBS East [VC1]	o/v	United Paramount Network/o/v	CBS East [VC1]/o/v	Data Transmissions	TV Northern Canada (TVNC)
20	Armed Forces Radio & Television Service [B-MAC]	CNN Headline News Clean Feed [V2+]	ABC East (contingency channel) [Leitch]	Shop-at-Home	National Empowerment TV (NET)	o/v	ABC East [Leitch]	CBS East [VC1]	Data Transmissions	CJON-TV Newfoundland TV (NTV)
21	SC New England [V2+]	o/v	Skyvision	SSN Pro Am Sports (Pass) [V2+]	La Cadena de Milagro (Spanish rel)	America's Collectables Network (ACN)	ABC East [Leitch]	Warner Brothers Syndication-Network /CBS feeds/o/v	Data Transmissions	TV 5 (French)
22	Newsport [V2+]	o/v	o/v	Data Transmissions	NewsTalk Television	High Tech Channel/o/v	ABC West [Leitch]	WXIA-NBC Atlanta (PT24E) [V2+]	Data Transmissions	3 Angels Broadcasting (Rel)
23	NHK TV Japan secondary feeds	Worship TV (Rel)	o/v	SSN Home Teams Sports (HTS) [V2+]	fX Movies	o/v	ABC East [Leitch]	SCOLA [Wegener compression]	Data Transmissions	Exxxtreme TV/The Cupid Network (adult) [V2+]
24	SC New York Plus-o/v [V2+]	o/v	o/v	America One	HBO East 3 [V2+]	o/v	NASA TV highlights/o/v	CBS Newspath feeds	KPIX-CBS San Francisco (PT24W) [V2+]	CTV (Red)

Unscrambled/non-video — Subscription — Not available in U.S. — o/v = occasional video

Satellite Transponder Guide

By Robert Smathers

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	Satcom C5 (F5) 139º West	
(none)	Data Transmissions	Data Transmissions	TVN 1 PPV [V2+]	Disney East [V2+]	Family Channel West [V2+]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	SC Hawaii/SC Chicago Plus/o/v	(none)	1
(none)	The Sports Network [Oak]	Data Transmissions	TVN 2 PPV [V2+]	Playboy (Adult) [V2+]	The Learning Channel	Spanish language networks [SA MPEG]	Request TV PPV [GI Digicipher]	KUSA-ABC Denver [V2+]	(none)	2
SCPC services	Data SCPC	Data Transmissions	TVN 3 PPV [V2+]	Trinity Broadcasting (Rel)	Viewer's Choice PPV [V2+]	Encore [V2+]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2+]	SCPC services	3
(none)	Data SCPC	Data Transmissions	TVN 4 PPV [V2+]	Sci-Fi [V2+]	Lifetime West [V2+]	TV Food Network [GI Digicipher]	Lifetime East [V2+]	SC Pacific [V2+]	(none)	4
(none)	Data SCPC	Data Transmissions	TVN 5 PPV [V2+]	CNN [V2+]	Faith and Values Channel/ACTS (Rel)	Classic Arts Showcase	Deutsche Welle TV (German)	KDVR-Fox Denver [V2+]	Data Transmissions	5
Telemax	WDIV-NBC Detroit [Oak]	Data Transmissions	TVN 6 PPV [V2+]	WTBS-Ind Atlanta [V2+]	Court TV [Digicipher]	Z-Music	Madison Square Garden [V2+]	KMGH-CBS Denver [V2+]	(none)	6
XEQ-TV canal 9	Data SCPC	Data Transmissions	TVN 7 PPV [V2+]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN Prime Sports West [V2+]	Data Transmissions	7
(none)	Cancom (CHCH City TV WUHF CFTM) [SA MPEG]	XHGC canal 5/Q-CVC	TVN 8 PPV [V2+]	HBO West [V2+]	QVC-2 Fashion Channel	Cartoon Network [V2+]	Prevue Guide	NBC-East	(none)	8
o/v	The Weather Network	(none)	TVN 9 PPV/CVS [V2+]	ESPN [V2+]	Music Choice [digital audio]	ESPN2 Blackout [V2+]/SAH	QVC Network	SC Alt/o/v	Data Transmissions	9
Mexican Parliament	WXYZ-ABC Detroit [Oak]	SEP	Ostrich Emu TV/Superior Livestock Auction/o/v	MOR Music	Home Shopping Club 2	America's Talking [V2+]	Home Shopping Club 1	Prime Sports SW [V2+]	(none)	10
(none)	CBC-North Pacific feed	XEIPN canal 11	Data Transmissions	Family Channel East [V2+]	Prime Network [V2+]	Eternal Word TV Network (Rel)	The Box [Digicipher]	Network One 'N1'	Data Transmissions	11
Data Transmissions	WTOL-CBS Toledo [Oak]	Data Transmissions	Data Transmissions	Discovery West [V2+]	History Channel [V2+]	Valuevision	Nustar (Promo Channel)	(none)	(none)	12
(none)	CBC feeds/o/v	(none)	(none)	CNBC [V2+]	The Weather Channel [V2+]	Encore [GI Digicipher]	Travel Channel [V2+]	SC Chicago [V2+]	o/v	13
Data Transmissions	WTVS-PBS Detroit [Oak]	XEW canal 2	(none)	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Blackout [V2+]/SAH	Cable Health Club	KCNC-NBC Denver [V2+]	(none)	14
Multivision [GI Digicipher]	CBFT-CBC (French)	Data Transmissions	Data Transmissions	HBO East [V2+]	Showtime East [V2+]	CNN International [V2+]	WWOR-Ind New York [V2+]	SC Cincinnati/Ohio [V2+]	DART Services	15
Data Transmission	CBC Newsworld [Oak]	Canal 22 o/v	Flix [V2+]	Cinemax West [V2+]	MTV West [V2+]	Turner Classic Movies [V2+]	Request TV 1 [V2+]	Newsport [V2+]	(none)	16
(none)	CBC feeds/o/v	o/v	PandaAmerica - Home Shopping	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	MTV East [V2+]	SSN Prime Network Rocky Mtn [V2+]/Cal-Span/o/v	Data Transmissions	17
o/v	CITV-Ind Edmonton [Oak]	Clara Vision (rel)	Showtime 2 [V2+]	TNN [V2+]	Nickelodeon West [V2+]	HBO Multiplex [GI Digicipher]	Viewer's Choice [GI Digicipher]	Prime Sports Showcase	o/v	18
Multivision [GI Digicipher]	CBC feeds/o/v	Tele Noticias o/v	(none)	USA East [V2+]	Showtime/MTV [GI Digicipher]	Cinemax East [V2+]	C-SPAN 2	FoxNet	SEDAT Services	19
(none)	CBMT-CBC (English)	Data Transmissions	Spice/TVN 10 PPV (Adult) [V2+]	BET	Jones Intercable [GI Digicipher]	Home and Garden Network	Showtime West [V2+]	(none)	(none)	20
(none)	SCPC/Data Transmissions	(none)	(none)	MEU	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	Prime Sports West [GI Digicipher]	SCPC services	21
Caliente Jai Alai/Caliente greyhound racing	Cancom (BCTV-Vancouver) [SA MPEG]	XHIMT canal 7	o/v	CNN/HN [V2+]	Your Choice TV [Digicipher]	Nostalgia Channel	Movie Channel-West [V2+]	SSN PSNW [V2+]/o/v	(none)	22
(none)	CBC-North Atlantic feed	(none)	(none)	A&E [V2+]	E! Entertainment TV [V2+]	Cinemax East 2 [V2+]	VH-1 [V2+]	KWGN-Ind Denver [V2+]	SEDAT Services	23
(none)	Superchannel [Oak]	XHOF canal 13	TVN Preview/TVN PPV o/v [V2+]	Showtime/Movie Channel [SA MPEG]	Digital Music Express Radio [Digital Audio]	ESPN International [B-MAC]	CMT [V2+]	SSN Sunshine [V2+]	Alaska Rural TV Project	24

Unscrambled/non-video — Subscription — Not available in U.S. — o/v = occasional video

Geostationary Satellite Locator Guide

By Larry Van Horn

This guide shows the orbital locations of active (223) geostationary satellites at publication deadline. 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 for providing satellite background information: 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; NASA Headquarters—Mr. Keith E. Stein; Social Security Administration—Ed Rosen; Chief D.R. Hill-Fla.; Gary Dunn-Calif. and *Satellite Times* staff.

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

Service Key

BSS	Broadcasting 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

"i" indicates orbital inclination greater than 1 degree and "#" indicates satellite has started into an inclined orbit. "d" indicates the satellite is drifting—moving into a new orbital slot or at end of life.

OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
18952	1988-018B Telecom 1C (France)	3.0E	Dom FSS/Gov-Mil (C/Ku)
19919	1989-027A Tele X (Sweden)	4.9E	Reg DTH/FSS (Ku)
20193	1989-067A Sirius/Marcopolo 1(BSB R-1)	5.0E	Reg DTH (Ku)
22921	1993-076A USA 98 (NATO 4B)	6.0E/i	Mil-Comm (P/S/X)
22028	1992-041B Eutelsat II F4	6.9E	Reg FSS (Ku)
21056	1991-003B Eutelsat II F2	9.9E	Reg FSS (Ku)
22269	1992-088A Cosmos 2224 (Russia)	11.5E/#	Mil-Early Warning (X)
22557	1993-013A Raduga 29 (Russia)	11.8E/#	Dom FSS/Gov-Mil (X/C)
19596	1988-095A Raduga 22 (Russia)	12.2E/i	Dom FSS/Gov-Mil (X/C)
21055	1991-003A Italsat 1 (Italy)	13.0E	Dom-Telephone (S/K/Ka)
20777	1990-079B Eutelsat II F1	13.0E	Reg FSS (Ku)
23537	1995-016B Hot Bird 1 (Eutelsat II F6)	13.4E	DTH (Ku)
21803	1991-083A Eutelsat II F3	16.0E	Reg FSS (Ku)
19876	1989-020B Meteosat 4 (MOP 1)(ESA)	18.4E/#/d	Met (L)
19688	1988-109B Astra 1A	19.2E	Reg DTH (Ku)
22653	1993-031A Astra 1C	19.2E	Reg DTH (Ku)
23331	1994-070A Astra 1D	19.3E	Reg DTH (Ku)
21139	1991-015A Astra 1B	19.6E	Reg DTH (Ku)
14234	1983-077A Telstar 3A (301) (USA)	19.8E/#	Dom FSS-Saudi Arabia (C)
19331	1988-063B Eutelsat 1 F5	21.4E/#	Reg FSS (VHF/Ku)
13010	1981-122A Marecs 1 (ESA)	22.4E/i	Int Mar-EUR (L/C)
22175	1992-066A DFS 3 (Germany)	23.4E	Dom BSS (S/Ku/K)
18351	1987-078B Eutelsat 1 F4 (ECS 4)	25.4E/#	Reg FSS (VHF/Ku)
20359	1990-054A Gorizont 20 (Russia)	25.8E/i	Dom/Gov FSS (C/Ku)
20706	1990-063B DFS 2 (Germany)	28.5E	Dom BSS (S/Ku/K)
21894	1992-010B Arabsat 1C	30.8E	Reg FSS/BSS (S/C)
20041	1989-041B DFS 1 (Germany)	33.5E	Dom BSS (SKu/K)
21821	1991-087A Raduga 28 (Russia)	36.0E/#	Dom FSS/Gov-Mil (X/C)
20953	1990-102A Gorizont 22 (Russia)	40.2E/i	Dom/Gov FSS (C/Ku)
23200	1994-049B Turksat 1B (Turkey)	42.0E	Reg FSS (Ku)
23010	1994-012A Raduga 31 (Russia)	44.3E/#	Dom FSS/Gov-Mil (X/C)
14421	1983-105A Intelsat 507	46.9E/i	Int FSS/Mar (L/C/Ku)
22981	1994-008A Raduga 1-3 (Russia)	48.7E/#	Dom FSS/Gov-Mil (X/C)
21038	1990-116A Raduga 1-2 (Russia)	49.4E/i	Dom FSS/Gov-Mil (X/C)
19687	1988-109A Skynet 4B (UK)	52.9E/i	Mil-Comm (P/S/X/Ka)
22245	1992-082A Gorizont 27 (Russia)	53.1E/#	Dom/Gov FSS (C/Ku)
15629	1985-025A Intelsat 510	56.9E/i	Int FSS (C/Ku)
14675	1984-009A DSCS III A2 (USA)	60.0E/i	Mil-IOR primary (P/S/X)
20667	1990-056A Intelsat 604	59.9E	Int FSS (C/Ku)
20315	1989-087A Intelsat 602	62.9E	Int FSS (C/Ku)
20918	1990-093A Inmarsat 2 F1	64.4E/#	Int Mar-IOR (L/C)
13636	1982-106A DSCS II F16 (USA)	64.7E/i	Mil-IOR reserve (S/X)
13595	1982-097A Intelsat 505	64.8E/i	Int FSS/Mar (L/C/Ku)
23461	1995-001A Intelsat 704	65.9E	Int FSS (C/Ku)
20083	1989-048A Raduga 1-1 (Russia)	69.8E/i	Dom FSS/Gov-Mil (X/C)
23448	1994-087A Raduga 32 (Russia)	70.9E/#	Dom FSS/Gov-Mil (X/C)
22963	1993-002A Gals 1 (Russia)	71.0E	Dom BSS (Ku)
22787	1993-056A USA 95 (UFO-2)	71.1E/i	Mil-IOR primary (P/S)
20410	1990-002B Leasat 5 (USA)	71.5E/i	Mil-IOR reserve (P/S/X)
08882	1976-053A Marisat 2	72.8E/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)	75.5E/#	Met (L)
23314	1994-065B Thaicom 2 (Thailand)	78.4E	Reg FSS (C/Ku)
22931	1993-078B Thaicom 1 (Thailand)	78.4E	Reg FSS (C/Ku)
21759	1991-074A Gorizont 24 (Russia)	79.8E/#	Dom/Gov FSS (C/Ku)
23267	1994-060A Cosmos 2291 (Russia)	79.9E/#	Data Relay (C)
21111	1991-010A Cosmos 2133 (Russia)	80.1E/#	Mil-Early Warning (X)
20643	1990-051A Insat 1D (India)	82.9E	Dom FSS/BSS/Met (S/C)
22836	1993-062A Raduga 30 (Russia)	84.6E	Dom FSS/Gov-Mil (X/C)
19548	1988-091B TDRS F3 (USA)	85.1E/#	Gov (C/S/Ku)
18922	1988-014A PRC 22 (China)	87.2E/#	Dom FSS (C)
22880	1993-069A Gorizont 28 (Russia)	89.8E	Dom/Gov FSS (C/Ku)
12474	1981-050A Intelsat 501	91.6E/i	Int FSS (C/Ku)
22724	1993-048B Insat 2B (India)	93.4E	Dom FSS/BSS/Met (S/C)
23426	1994-082A Luch 1 (Russia)	95.3E/i	Tracking & Relay CSDRN (Ku)
20263	1989-081A Gorizont 19 (Russia)	96.5E/i	Dom/Gov FSS (C/Ku)
21016	1990-112A Raduga 26 (Russia)	97.7E/i	Dom FSS/Gov-Mil (X/C)
20473	1990-011A PRC 26 (China)	98.1E	Dom FSS (C)
22210	1992-074A Ekran 20 (Russia)	98.7E/#	Dom BSS (P)
19683	1988-108A Ekran 19 (Russia)	98.9E/i	Dom BSS (P)
21922	1992-017A Gorizont 25 (Russia)	102.6E/#	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)
23176	1994-040B BS-3N (Japan)	109.7E	Dom BSS (Ku)
20771	1990-077A BS-3A (Yuri 3A)(Japan)	109.9E	Dom BSS (Ku)
21668	1991-060A BS-3B (Yuri 3B)(Japan)	109.9E	Dom BSS (Ku)
19710	1988-111A PRC 25 (China)	110.3E	Dom FSS (C)
17706	1987-029A Palapa B-2P	113.0E	Reg FSS (C)
14985	1984-049A Chinasat 5 (Spacenet 1)	115.4E	Dom FSS (C/Ku)
21964	1992-027A Palapa B4	117.9E	Reg FSS (C)
15152	1984-080A GMS-3 (Himawari 3) (Japan)	120.0E/i	Met (P/L) reserve
21132	1991-014A Raduga 27 (Russia)	126.9E/i	Dom FSS/Gov-Mil (X/C)
22907	1993-072A Gorizont 29 (Rimsat 1)	129.1E	Reg FSS (C/Ku)
20217	1989-070A GMS 4 (Himawari 4)	129.4E/#/d	Met (P/L)
18877	1988-012A CS 3A (Sakura 3A)(Japan)	132.0E	Dom FSS (C/K)
14134	1983-059C Palapa B1 (Indonesia)	134.0E/i	Reg FSS (C)
19508	1988-086A CS 3B (Sakura 3B) (Japan)	136.0E	Dom FSS (C/K)
23185	1994-043A Apstar A1 (China)	138.0E	DTH (C)
20107	1989-052A Gorizont 18 (Russia)	139.9E/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)	142.2E/#	Reg FSS (C/Ku)

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OBJ NO.	INT-DESIG/COMMOM NAME	LONG (DEG)	TYPE SATELLITE
20923	1990-094A Gorizont 21 (Russia)	144.8E/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)
23227	1994-055A Optus B3 (Australia)	152.3E	DTH/Mob (L/Ku)
20402	1990-001B JCSAT 2 (Japan)	153.9E	Dom FSS (Ku)
18350	1987-078A Optus A3 (Aussat K3)	155.9E	DTH (Ku)
22253	1992-084A Superbird A (Japan)	157.4E	Dom FSS (Ku/K)
22087	1992-054A Optus B1 (Aussat B1)	160.0E	DTH/Mob (L/Ku)
21893	1992-010A Superbird B (Japan)	161.3E	Dom FSS (Ku/K)
16275	1985-109C Optus A2 (Aussat 2)	163.9E/#	DTH (Ku)
23175	1994-040A PanAmSat 2 (PAS-2)	169.0E	Int FSS (C/Ku)
13969	1983-026B TDRS 1 (USA)	170.8E/i/d	Gov (C/S/Ku)
12046	1980-087A OPS 6394 (FltSatCom F4)(USA)	171.0E/i	Mil-POR rsv. (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	178.0E/#	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	178.4W/i	Int Mar-POR (P/L/C)
15236	1984-093C Leasat 2 (USA)	176.6W/i	Mil-POR primary (P/S/X)
12994	1981-119A Intelsat 503	176.0W/i	Int FSS (C/Ku)
23467	1995-003A USA 108 (UFO-4) (USA)	176.8W/i	Mil-POR (P/S/K)
21639	1991-054B TDRS F5 (USA)	174.2W	Int FSS/Gov (C/S/Ku)
23589	1995-027A USA-111 (UFO-5) (USA)	171.0W/i	Mil-POR (P/S/K)
20499	1990-016A Raduga 25 (Russia)	171.0W/i	Dom FSS/Gov-Mil (X/C)
18631	1987-100A Raduga 21 (Russia)	170.5W/i	Dom FSS/Gov-Mil (X/C)
21392	1991-037A Satcom C5 (Aurora II)(USA)	139.0W	Dom FSS (C)
20945	1990-100A Satcom C1 (USA)	137.0W	Dom FSS (C)
17561	1987-022A GOES 7 (USA)	135.9W/i	Met (P/L/S)
22096	1992-057A Satcom C4 (USA)	135.1W	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)	131.0W	Dom FSS (C)
13637	1982-106B DSCS III A1 (USA)	130.2W/i	Mil-EPAC reserve (P/S/X)
21906	1992-013A Galaxy 5 (USA)	125.1W	Dom FSS (C)
16649	1986-026A Gstar 2 (USA)	125.0W/#	Dom FSS (Ku)
15826	1985-048D Telestar 3D (USA)	123.1W/#	Dom FSS (C)
19484	1988-081B SBS 5 (USA)	123.0W	Dom FSS (Ku)
16274	1985-109B Morelos B (Mexico)	116.8W	Dom FSS (C/Ku)
13652	1982-110C Anik C3 (Canada)	115.0W/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)
23598	1995-029A DBS 3 (USA)	110.6W	DTH (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)	105.8W/i	Mil-Exp comm (P/Ka)
08697	1976-017A Marisat 1	105.4W/i	Int Mar-AOR (P/L/C)
15643	1985-028C Leasat 3 (USA)	105.4W/i	Mil-CONUS reserve (P/S/X)
03029	1967-111A ATS 3 (USA)	105.2W/i	Exp comm (VHF/C)
20946	1990-100B Gstar 4 (USA)	105.1W	Dom FSS (Ku)
15677	1985-035A Gstar 1 (USA)	103.1W	Dom FSS (Ku)
22930	1993-078A DBS 1 (USA)	101.2W	DTH (Ku)
21227	1991-028A Spacenet 4 (USA)	101.1W	Dom FSS (C)
23553	1995-019A MSAT-2 (USA)	101.0W	Mobile (L/X)
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)	99.3W/i	Mil-CONUS prim. (P/S/X/K)
22694	1993-039A Galaxy 4 (USA)	99.1W	Dom FSS (C/Ku)
22927	1993-077A Telstar 401 (USA)	97.0W	Dom FSS (C/Ku)
08746	1976-023A LES 8 (USA)	97.0W/i	Mil-Exp comm (P/Ka)
20872	1990-091A SBS 6 (USA)	95.0W	Dom FSS (Ku)
15308	1984-101A Galaxy 3 (USA)	93.6W/#	Dom FSS (C)
19483	1988-081A Gstar 3 (USA)	92.8W/i	Dom FSS/Mob (L/Ku)
22205	1992-072A Galaxy 7 (USA)	91.0W	Dom FSS (C/Ku)
23581	1995-025A GOES 9 (USA)	90.6W	Met (P/L/S)
22988	1994-009A USA 99 (Milstar 1)	90.0W	Mil-Comm (P/S/K)
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)	75.8W/i	Dom FSS (Ku)
12309	1981-018A Comstar D4 (USA)	75.7W/i	Dom FSS (C)
23051	1994-022A GOES 8 (USA)	74.9W	Met (P/L/S)
16650	1986-026B SBTS 2 (Brazil)	74.8W/d	Dom FSS (C)
20873	1990-091B Galaxy 6 (USA)	74.1W	Dom FSS (C)
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)	70.1W	Dom FSS (C)
15385	1984-114A Spacenet 2 (USA)	69.0W	Dom FSS (C/Ku)
19215	1988-051A Meteosat P2 (ESA)	68.4W/i	Met (L)
23536	1995-016A Brasilsat B2 (Brazil)	65.1W	Dom FSS (C/X)
15561	1985-015B SBTS 1 (Brazil)	63.0W/#	Dom FSS (C)
21940	1992-021B Inmarsat 2 F4	54.0W/i	Int Mar-AOR-W (L/C)
23571	1995-023A Intelsat 706	53.5W	Int FSS (C/Ku)
19121	1988-040A Intelsat 513	53.0W	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	50.2W	Int FSS (C/Ku)
22314	1993-003B TDRS F6 (USA)	46.3W/#	Gov (C/S/Ku)
19217	1988-051C PanAmSat 1 (PAS 1)	45.0W	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)	41.0W	Int FSS/Gov (C/S/Ku)
12089	1980-098A Intelsat 502	40.3W/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	33.8W/i	Mil-comm (P/S/X/Ka)
14077	1983-047A Intelsat 506	31.5W/i	Int FSS/Mar (L/C/Ku)
13083	1982-017A Intelsat 504	29.4W/i	Int FSS (C/Ku)
22116	1992-060A Hispasat 1A (Spain)	30.1W	Dom BSS/FSS (Ku)
22723	1993-048A Hispasat 1B (Spain)	30.0W	Dom BSS/FSS (Ku)
21765	1991-075A Intelsat 601	27.5W	Int FSS (C/Ku)
19928	1989-030A Raduga 23 (Russia)	25.8W/i	Dom FSS/Gov-Mil (X/C)
21653	1991-055A Intelsat 605	24.5W	Int FSS (C/Ku)
22112	1992-059A Cosmos 2209 (Russia)	24.3W/#	Mil-Early Warning (X)
23168	1994-038A Cosmos 2282 (Russia)	24.2W/#	Mil-Early Warning (X)
20253	1989-077A USA 46 (FltSatCom 8)	23.9W/i	Mil-AOR prim. (P-Charlie/S/X/K)
21989	1992-032A Intelsat K	21.7W	Int FSS (Ku)
16101	1985-087A Intelsat 512	21.3W/#	Int FSS (C/Ku)
15391	1984-115A NATO III D	21.2W/i	Mil-Comm (P/S/X)
18384	1987-084A Cosmos 1888 (Russia)	18.9W/i/d	Data Relay (C)
19621	1988-098A TDF 1 (France)	18.9W	DTH (Ku)
20705	1990-063A TDF 2 (France)	18.8W	DTH (Ku)
19772	1989-006A Intelsat 515	18.1W	Int FSS (C/Ku)
21047	1991-001A NATO IV A	17.8W/i	Mil-Comm (P/S/X)
20391	1989-101A Cosmos 2054 (Russia)	15.8W/i	Tracking & Relay WSDRN (Ku)
10669	1978-016A Ops 6391 (FltSatCom 1) (USA)	15.7W/i	Mil-AOR reserve (P-Alpha/S/X)
21149	1991-018A Inmarsat 2 F2	15.6W/i	Int Mar-AOR-E (L/C)
15386	1984-114B Marecs B2	15.1W/i	Int Mar-AOR (L)
23132	1994-035A USA-104 (UFO-3)(USA)	14.2W/i	Mil-AOR primary (P/S)
23319	1994-067A Express 1 (Russia)	14.0W	Int FSS (C/Ku)
21789	1991-079A Cosmos 2172 (Russia)	13.9W/#	Data Relay (C)
22009	1992-037A DSCS III B12 (USA)	12.0W	Mil-ELANT primary (P/S/X)
22041	1992-043A Gorizont 26 (Russia)	10.9W/#	Dom/Gov FSS (C/Ku)
22912	1993-073B Meteosat 6 (ESA)	9.7W/#	Met (L)
21813	1991-084A Telecom 2A (France)	8.1W	Dom FSS/Gov-Mil (X/C/Ku)
21939	1992-021A Telecom 2B (France)	5.1W	Dom FSS/Gov-Mil (X/C/Ku)
23124	1994-034A Intelsat 702	1.1W	Int FSS (C/Ku)
20776	1990-079A Skynet 4C (UK)	1.0W/#	Mil (P/S/X/Ka)
20762	1990-074A Thor/Marcopolo 2 (BSB R-2)	0.9W	Reg BSS (Ku)
20168	1989-062A TV Sat 2 (Germany)	0.7W	Dom BSS (Ku)
21140	1991-015B Meteosat 5 (MOP 2)	0.2W	Met (L)

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Satellite	Mode		Frequencies															
OSCAR 13 (AO-13) (Notes 1 & 13)	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)	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)	A (v/A)	Dn	29.360	370	380	390	29.400				Robot	29.403						
		Up	145.860	870	880	890	145.900				(CW)	145.820						
	Bcn		29.357 (CW)															
RS-12/13 (Notes 3, 6 & 7)	K (h/A)	Dn	29.410	420	430	440	29.450				Robot	29.454						
		Up	21.210	220	230	240	21.250				(CW)	21.129						
	Bcn		29.408															
RS-15 (Note 13)	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)	Bcns	Dn	145.826	435.025	2401.500													
		Up	None															
PACSAT (AO-16) (Notes 8, 9 & 11)	[a]	Dn	437.025 (Sec) 437.050															
		Up	145.900	145.920	145.940	145.960												
DOVE (DO-17) (Notes 10 & 11)	[b,c]	Dn	145.825	2401.220														
		Up	None															
WEBERSAT (WO-18) (Note 11)	[a]	Dn	437.075	437.100 (Sec)														
		Up	None															
LUSAT (LO-19) (Notes 8 & 11)	[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.

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

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-73	Sept. 1995 Columbia*	39.0/150	16 days	USML-2
STS-74 S/MM-2	Nov. 1995 Atlantis**	51.6/160		6 days

*Crew Assignment: CDR-Kenneth Bowersox, PLT-Kent Rominger, MS (PLC)-Kathryn Thornton, MS-Catherine Coleman, MS-Michael Lopez-Alergria, MS-Fred Leslie, MS-Albert Sacco.

**Crew Assignment: CDR-Kenneth Cameron, PLT-James Halsell, MS-Chris Hadfield (Canada), MS-William McArthur, MS-Jerry Ross.

STS Downlink Frequency Assignment: VHF Voice 259.7 and 296.8 MHz, S-band TRK 2041.9 MHz, S-band TLM 2106.4 MHz, TTC&V (TDRSS) 2217.5 and 2287.5, K-band TLM (TDRSS) 15003.4 GHz.

Russian Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
September 1995	Soyuz	Baikonur	Soyuz TM-22*
September 1995	Soyuz	Baikonur	Progress M
September 1995	Cosmos	Plesetsk	COSMOS FAISAT 2
November 1995	Proton	Baikonur	PRIRODA
November 1995	Soyuz	Baikonur	Progress M

*Crew Assignment: CDR-Y. R. Gidzenko, Engineer-Sergei Avdeyev, and Researcher-Christer Fuglesang.

SOYUZ TM-22 Downlink Frequency Assignment: 121.750 MHz (WBFM)

PROGRESS Downlink Frequency Assignment: 165.000 MHz, 166.000 MHz, and 922.755 MHz.

COSMOS Downlink Frequency Assignments: 149.910-150.030 MHz,

FAISAT 2 Downlink Frequency Assignments: 137-138 MHz, and 400-401 MHz.

U.S. Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
September 1995	Pegasus XL	WWF	SAC-B/HETE
September 1995	Delta II		VAFB RADARSAT SURFSAT
September 1995	Titan 4	CCAS	MILSTAR 1-2
September 1995	Atlas 2-A		CCAS GALAXY III-R
October 1995	Pegasus XL	VAFB	ORBCOMM 3
October 1995	Atlas 2AS	CCAS	SOHO
October 1995	Pegasus XL	VAFB	FORTE
November 1995	Pegasus XL	VAFB	SEAWIFS/SEASTAR

PEGASUS Downlink Frequency Assignments: Telemetry 2288.500 MHz, Tracking Transponder (transmit/downlink) 5765.000 MHz.

SAC-B Downlink Frequency Assignments: 2255.5 MHz.

HETE Downlink Frequency Assignments: 137.96 MHz and 2272.0 MHz.

Delta II Downlink Frequency Assignments: S-band TLM 2244.5 MHz, 2241.5 MHz, 2252.5 MHz, C-band TRK 5765.0 MHz.

RADARSAT Downlink Frequency Assignments: 2230.0 MHz.

MILSTAR 1-2 Downlink Frequency Assignments: 20220.0 MHz

SOHO Downlink Frequency Assignments: S-band TLM & TRK 2245.0 MHz

SEAWIFS/SEASTAR Downlink Frequency Assignments: L-band TLM 1702.5 MHz, and S-band TLM 2272.5 MHz

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
September 1995	Ariane 4	Guiana	ISO
September 1995	Ariane 4	Guiana	ASTRA-1E
October 1995	Ariane 4	Guiana	SPOT-4
November 1995	Ariane 5	Guiana	CLUSTER (4)

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

ISO Downlink Frequency Assignments: S-band TLM and TRK 2266.5 MHz.

SPOT-4 Downlink Frequency Assignments: S-band TLM 2218.0 MHz, TRK 2205.930 MHz, X-band TLM 8253.0 MHz

CLUSTER Downlink Frequency Assignments: CLUSTER 1: 2242.0 MHz, CLUSTER 2: 2249.0 MHz, CLUSTER 3: 2277.0 MHz, CLUSTER 4: 2270.0 MHz, SPARE: 2256.0 MHz.

China Expandable Launch Vehicles

Launch Date	Launch Vehicle	Launch Site	Payload
September 1995	Long March	Xichang	ASIASAT 2
October 1995	Long March 2E	???????	ECHOSTAR 1
October 1995	Long March 3	Xichang	INTELSAT 708
November 1995	Long March	Xichang	INTELSAT 801

Satellite Launch Schedules

List of Abbreviations and Acronyms

ASIASAT	Asia Satellite Telecommunications Company will provide services to China, Thailand, and Pakistan.
ASTRA	These satellites will establish a medium-power system for TV distribution from geostationary orbit.
C-band	3700 to 6500 MHz
CCAS	Cape Canaveral Air Station.
CDR	Commander.
CLUSTER	The four spacecraft will study the bow shock, dayside cusp, magnetopause, and the geomagnetic tail of Earth's electromagnetic field.
COSMOS	Russian navigation satellite.
ECHOSTAR	Echostar will begin a direct home TV system working through 45cm satellite dishes.
FAISAT 2	The system will provide data acquisition services, remote monitoring, tracking, personal and business non-voice massaging, and emergency communications/distress calls.
GALAXY 3R	Principal applications include network TV, radio, VSAT, business video and data services.
GHz	Gigahertz.
HETE	High Energy Transient Experiment, a spacecraft to study gamma ray burst sources and source locations, and x-ray burst sources and source locations.
INTELSAT	The International Telecommunications Satellite Organization is a non-profit commercial co-operative of 133 member nations.
ISO	The Infrared Space Observatory will conduct imaging, photometric, spectroscopic and polarimetric observations of selected sources.
K-band	10.90 to 17.15 GHz.
MHz	Megahertz.
MILSTAR	A telephone switchboard in space to route all military message traffic and conversations around the world.
MS	Mission Specialist.
ORBCOMM	ORBCOMM will provide low-cost alphanumeric data communications and position determination for emergency assistance, data acquisition and massaging services using pocket portable and mobile subscriber terminals.
PLC	Payload Commander.
PLT	Pilot.
Priroda	A new module for the Russian space station Mir, planned for remote sensing of land, oceans and atmosphere.
Progress	Unmanned cargo flight to resupply manned space station.
PS	Payload Specialist.
RADARSAT	Radarsat is a remote sensing free flying satellite that will monitor land, sea and ice for five years over the poles (U.S./Canadian).
RNG	Ranging.
S/MM-2	Shuttle mission to the Russian Space Station MIR to support design and assembly of the international space station.
SAC-B/C	Satelite de Aplicaciones Cientificas-B/C, a Argentine spacecraft carrying hard x-ray spectrometer to investigate solar flares and cosmic transient x-ray emissions.
S-band	2000 to 2300 MHz
SEAWIFS/	The spacecraft will conduct global ocean observations to estimate ocean
SEASTAR	to estimate ocean color, and derive from these measurements, various biological indicators and other useful scientific products.
SOHO	Solar Heliospheric Observatory, a European Space Agency spacecraft to provide optical measurements as well as plasma field and energetic particle observations of the sun system for studies of the solar interior, atmosphere and solar wind.
SOYUZ TM	Manned spacecraft for flight in Earth orbit.
SPOT 4	This earth observation satellite will help in accurate mapping and geologic studies.
SURFSAT	Summer Undergraduate Research Fellowship Satellite is a secondary payload launched to simulate a deep space vehicle by radiating in S, X, Ku, and Ka Bands.
TDRSS	Tracking & Data Relay Satellite System.
TLM	Telemetry.
TRK	Tracking.
TT&C	Tracking, Telemetry and Command.
TTC&V	Tracking, Telemetry, Commanding and Voice.
USML-2	United States Microgravity Laboratory-2. A series of flights of a microgravity materials processing laboratory attached to the Shuttle.
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
WFF	Wallops Flight Facility.

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

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 May and June 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.

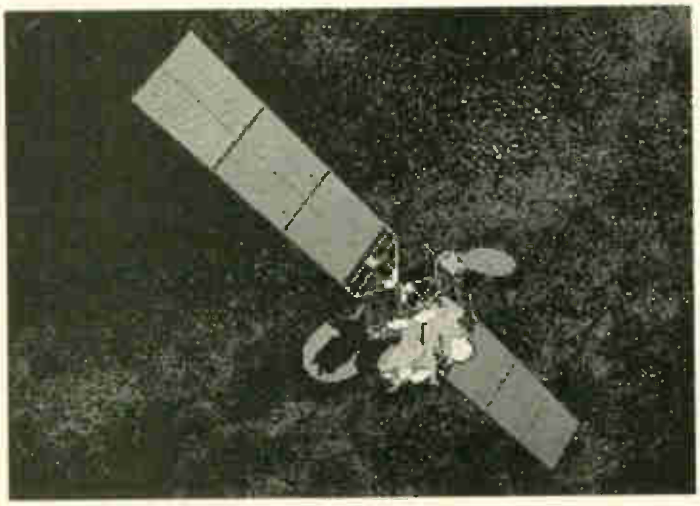
Second line: date and time (in decimals of a day, UTC) of the orbital determination, orbital inclination, period, perigee and apogee. In some cases where a satellite has manoeuvred, more than one set of orbital data will be listed.

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	 Incl	Int Des Period	Satellite Perigee	Mass Apogee
1995 May 14/1345		1995-022A	USA 110	4,500 kg *
Geosynchronous orbit ?				

No details released of this classified Department of Defense launch. Payload is reportedly an ELINT satellite in geosynchronous orbit. Third stage (Centaur) of Titan-4 launch vehicle might have been left in a geosynchronous transfer orbit or possible entered geosynchronous orbit before the payload was deployed. Launched from Cape Canaveral.



Launch Date/Time Epoch	 Incl	Int Des Period	Satellite Perigee	Mass Apogee
1995 May 17/0634		1995-023A	INTELSAT 706	4,180 kg
1995 May 17.07	7.01 deg	631.19 min	172 km	35,820 km
1995 Jun 1.22	0.06 deg	1,435.90 min	35,729 km	35,837 km

Communications satellite, built by Space Systems/Loral for INTELSAT. Mass of the satellite quoted above is at launch: the dry mass of the satellite is 1,776 kg. Initially located over 304° E: to be operated over 307° E. Third stage (H-10-3) from Ariane 44LP launch vehicle is in an orbit similar to the first one listed above: launched from Kourou.

1995 May 20/0333		1995-024A	Spektr	19,640 kg
1995 May 20.32	51.65 deg	89.84 min	216 km	317 km
1995 May 21.38	51.66 deg	90.56 min	262 km	341 km
1995 May 29.15	51.65 deg	91.75 min	336 km	385 km
1995 Jun 1.85	51.65 deg	92.49 min	393 km	400 km

Remote sensing module (also designated Module O, 77KSO before launch), launched to dock with and expand the capabilities of the Mir Complex: manufactured by Khrunichev State Research and Production Space Centre, designed by KB Salyut. Some sources quoted the mass of Spektr as 23.5 tonnes, but this figure appears to include the payload shroud and/or a payload interface unit. Dry mass of the basic module is 11.5 tonnes. Onboard the spacecraft are additional equipment for the Mir Complex (3.24 tonnes), "structures for payload deployment" (not otherwise identified, 3.85 tonnes), scientific equipment (2.15 tonnes), United States equipment (700 kg), general cargo, consumables (1.26 tonnes). Spacecraft docked with Mir Complex June 1 at 0058 UTC at the +X axis (front longitudinal port), relocated to -Y axis during approximately Jun 2.8 where it will be permanently positioned. Third stage of Proton launch vehicle left in an orbit similar to the firts one listed for the Spektr above: launched from Tyuratam.

1995 May 23/0552		1995-025A	GOES 9	2,105 kg
1995 May 22.99	27.46 deg	758.22 min	183 km	42,148 km
1995 May 26.47	8.22 deg	989.89 min	10,929 km	42,118 km
1995 May 29.34	0.29 deg	1,604.32 min	35,623 km	42,414 km
1995 Jun 2.70	0.29 deg	1,434.74 min	35,633 km	35,887 km
1995 Jun 4.78	0.24 deg	1,436.06 min	35,651 km	35,921 km

Satellite called GOES J (Geostationary Operational Environmental Satellite) prior to launch: part of U.S. National Oceanic and Atmospheric Administration's (NOAA) programme to provide synoptic visible and infra-red imaging and an infra-red/thermal sounding for atmospheric temperature profiles. Prime spacecraft contractor is Space Systems/Loral. Orbit initially

stabilised over 260º E, but the satellite is to be operated over 225° E. Second stage (Centaur) of Atlas-1 launch vehicle left in an orbit similar to the first one listed for the satellite: launched from Cape Canaveral.

Launch Date/Time Epoch	Int Des Incl	Satellite Period	Perigee	Mass Apogee
1995 May 24/2010	1994-026A	Cosmos 2312		1,900 kg *
1995 May 25.38	62.90 deg	709.11 min	606 km	39,320 km
1995 May 27.35	62.89 deg	717.66 min	604 km	39,745 km

"Oko" early warning satellite, built by NPO Lavochkin: orbital plane suggests a replacement for Cosmos 2063. Molniya-M launch vehicle third stage (Block I) left in a 62.81 deg, 92.50 minutes, 213-581 km orbit: Molniya-M fourth stage (Block 2BL) left in an orbit similar to the first one listed for the satellite: launched from Plesetsk.

1995 May 31/1527	1995-027A	UFO 5 (USA 111)		3,000 kg *
1995 May 31.73	26.97 deg	461.58 min	290 km	26,522 km
1995 Jun 4.42	13.39 deg	810.00 min	8,301 km	36,511 km
1995 Jun 5.84	6.54 deg	1,189.16 min	25,090 km	36,515 km
1995 Jun 6.68	5.22 deg	1,401.57 min	33,698 km	36,519 km
1995 Jun 10.29	5.09 deg	1,436.28 min	35,060 km	36,520 km

"UHF Follow-On" satellite is based on the Hughes HS-601 satellite bus: Mass of the satellite on-station is 1,360 kg. Satellite initially located over 189º E. Second stage (Centaur) of Atlas-2 launch vehicle is in an orbit similar to the first one listed for the satellite: launched from Cape Canaveral.

1995 Jun 8/0443	1995-028A	Cosmos 2313		3,000 kg *
1995 Jun 8.31	65.04 deg	92.87 min	400 km	430 km
1995 Jun 8.83	65.04 deg	92.77 min	403 km	418 km

"US-P" EORSAT (ELINT Ocean Reconnaissance Satellite) launched to operate with Cosmos 2293 (1994-072A). Originally designed by NPO Yuzhnoye, but now manufactured by KB Arsenal. Tsyklon-M (also called Tsyklon-2 in Russian and Ukrainian literature) second stage left in a 65.01 deg, 89.39 minutes, 114-375 km orbit from which it quickly decayed: launched from Tyuratam.

Launch Date/Time Epoch	Int Des Incl	Satellite Period	Perigee	Mass Apogee
1995 Jun 10/0024	1995-029A	DBS 3		2,934 kg
1995 Jun 9.85	6.96 deg	550.68 min	222 km	31,532 km
1995 Jun 14.69	0.80 deg	1,144.50 min	23,906 km	35,826 km
1995 Jun 16.59	0.05 deg	1,389.71 min	33,914 km	35,833 km
1995 Jun 25.43	0.01 deg	1,436.07 min	35,777 km	35,795 km

DBS 3 (Direct Broadcast System) is an HS-601 communications satellite manufactured by Hughes Communications Inc and to be operated by Hughes Space and Communications Inc. Mass of the satellite quoted above is at launch: on station it is 1,707 kg and the dry mass is 1,259 kg. Satellite deployed over 248-249º E. Third stage (H-10-3) from Ariane 42P launch vehicle in an orbit similar to the first one listed for the satellite: launched from Kourou.

1995 Jun 22/1958		STEP 3 (P92-2)		268 kg
Failed to reach orbit				

STEP (Space Test Experiment Program) satellite built by TRW carried five experiments: ACTEX (advanced controls technology experiment), EDMM (erasable disk mass memory), SAMMES (space active modular materials experiment), SAWAFE (satellite attach warning and assessment flight experiment) and SQUOD (space qualified optical disk). Planned orbit was circular at 450 km (no orbital inclination available). Stargazer L-1011 Tristar took off from Vandenberg Air Force Base approximately 1900 UTC on June 22 and deployed Pegasus XL at 1958 UTC. First stage fired as planned, but the failure of a second stage interstage ring to separate as planned resulted in Pegasus being destroyed at an altitude of 144 km by the Range Safety Officer. This was the second launch of a Pegasus XL variant and the second launch failure (the previous flight was June 27, 1994 and carried STEP 1).

1995 Jun 27/1932	1995-030A	Atlantis (STS-71)		97,387 kg
1995 Jun 27.87	51.65 deg	88.59 min	106 km	303 km
1995 Jun 27.84	51.64 deg	89.02 min	158 km	294 km
1995 Jun 27.96	51.64 deg	91.37 min	294 km	389 km
1995 Jun 28.45	51.65 deg	91.47 min	303 km	391 km
1995 Jun 29.33	51.65 deg	92.37 min	382 km	399 km
1995 Jun 29.68	51.64 deg	92.48 min	392 km	400 km

First Shuttle-Mir Mission (SMM-01). Carried five astronauts and two cosmonauts into orbit on the first shuttle mission to dock with the Russian Mir Complex: at launch the crew comprised R L Gibson (commander), C J Precourt (pilot), E S Baker (mission specialist, MS-1), G J Harbaugh (MS-2), B J Dunbar (MS-3), A Y Solovyov (new Mir commander) and N M Budarin (new Mir flight engineer). Mass quoted above is that projected at the time of landing. Orbiter carried a docking module for Mir operations (mass 1,822 kg), a SPACELAB module and transfer tunnel (mass 858 kg) and SPACELAB payloads (2,603 kg) in its payload bay.

Atlantis docked at the front longitudinal port of the Kristall module attached to the Mir Core module Jun 29 1300 UTC. Crew transfer to Mir Complex began approximately 90 minutes later. While docked Atlantis/Mir Complex was the most massive assembly in orbit (approximately 223 tonnes) and was housing the largest number of people in one place (6 US astronauts, 4 Russian cosmonauts). After nearly five days of joint operations the five Americans launched on the shuttle together with astronaut Thagard and cosmonauts Dezhurov and Strekalov (launched aboard Soyuz-TM 21 and working on the Mir Complex when Atlantis arrived) transferred to the orbiter, while the new Mir crew of Solovyov and Budarin moved to Soyuz-TM 21. The Soyuz-TM undocked from Mir to permit photography of the Atlantis separation which took place Jul 4 1110 UTC. Atlantis due to return to Kennedy Space Center (from where it was launched) Jul 7 while Solovyov and Budarin remain in orbit until Soyuz-TM 21 returns to Earth in September 1995.

1995 Jun 29/1825	1995-031A	Cosmos 2314		6,500 kg *
1995 Jun 29.94	67.13 deg	89.56 min	166 km	340 km

"Yantar" fourth generation, close look photoreconnaissance satellite. Satellite releases data-return capsules during its mission with the main re-entry module being recovered when the flight is terminated after a lifetime of 60-70 days. Soyuz launch vehicle's third stage (Block I) was in an orbit similar to that of the satellite.

Updates to Previous Launches

1983-026B	TDRS 1 was manoeuvred off-station over 83-84° E approximately May 9, 1995. The satellite was still drifting to the east at the end of June.
1983-047A	INTELSAT 506 was manoeuvred off-station over 309-310° E approximately May 8-9, 1995 and was relocated over 328-329° E approximately May 24.
1983-094A	RCA Satcom 2R was retired from service Feb 28, 1995.
1986-017JE	GFZ 1 was ejected from Mir Apr 19, 1995 at 1912 UTC.
1986-026B	BRASILSAT A2 was manoeuvred off-station over 294-295° E approximately June 19, 1995: the satellite was still drifting at the end of June.
1988-091B	TDRS 3 was manoeuvred off-station over 188-189° E. The two-line orbital elements suggest that the satellite drifted as far as 53° E by June 7, but by June 16 the satellite's longitude had been re-stabilised over 84-85° E.
1989-004A	Gorizont 17 stabilised its longitude over 33° E approximately May 11-12, 1995.
1989-020B	METEOSAT 4 was manoeuvred off-station over 352° E approximately May 10, 1995. At the end of June the satellite was still drifting to the east.
1989-070A	Himawari 4 was manoeuvred off-station over 139° E approximately 1995 June 9: the satellite was still drifting at the end of June.
1990-061A	Cosmos 2085 drifted off-station over 79-80° E at the end of February 1995 and has not re-stabilised its orbital longitude through to the end of June: it is therefore assumed that the the satellite has ceased operating.
1990-054A	Gorizont 20 re-stabilised its orbital longitude over 25-26° E approximately Jun 9, 1995.
1993-044A	Cosmos 2258 decayed from orbit 1995 Jun 8.
1994-053A	Following its de-orbit manoeuvre debris from Cosmos 2290 decayed from orbit 2,720 km northeast of New Zealand Apr 4.75, 1995 at 1758 UTC.
1994-064B	Atlas 2AS second stage (Centaur) from the INTELSAT 703 launch decayed from orbit May 11, 1995.
1995-010A	The two cosmonauts Dezhurov and Strekalov and the astronaut Thagard undocked from the Mir Complex Jul 4, 1995 at 1110 UTC aboard the United States space shuttle orbiter Atlantis (1995-030A, see above): return to Earth is scheduled for July 7. The new resident crew for Mir — Solovyov and Budarin — were taken into orbit aboard Atlantis, launched June 27. Soyuz-TM 21 with Solovyov and Budarin on board undocked from the Mir Complex/Kvant 1 -X port Jul 4 at 1055 UTC and retreated to a distance of about 100 metres to photograph the undocking of Atlantis: the Soyuz-TM re-docked at the -X port Jul 4 1139 UTC.
1995-011B	During Jun 5-18, 1995 Himawari 5 was relocated from 159-160° E to 140° E: no two-line orbital elements were issued which permit the manoeuvre dates to be estimated.
1995-014A	Cosmos 2311 was de-orbited May 31, 1995: if it came down on a normal recovery pass then it would have re-entered the atmosphere approximately May 31.8.
1995-017	Both ORBCOMM 1 (1995-017A) and ORBCOMM 2 (1995-017B) have started operating following communications problems immediately after launch.
1995-018A	A small orbital manoeuvre appears to have been completed by Ofeq 3: 1995 May 22.50, 143.38 deg, 95.54 min, 367 km, 722 km (pre-manoeuvre) 1995 May 23.23, 143.37 deg, 95.59 min, 369 km, 725 km
1995-019A	Add the following orbit for AMSC 1: 1995 May 21.54, 0.02 deg, 1,436.05 min, 35,777 km, 35,794 km The satellite's location has been stabilised over 258-259° E.

1995-020A Progress-M 27 undocked from the Mir Complex May 22, 1995 at 2340 UTC and was de-orbited May 23 at 0317 UTC: debris was expected impact the Pacific Ocean approximately 3,600 km southeast of New Zealand. No mention was made of an attempt to recover a Raduga capsule.

Comments on Orbit Epochs

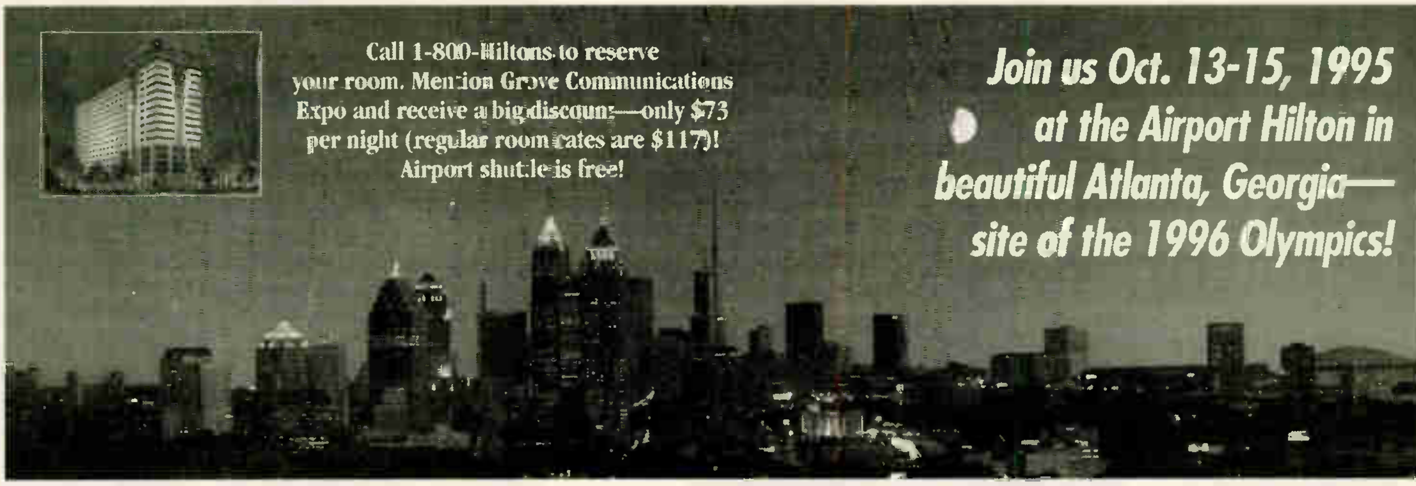
In view of the number of launches to geosynchronous orbits which are included in this listing, an important point about the orbital epochs needs to be made. The epochs usually refer to the time that a satellite crosses the ascending node of its orbit (ie, passes from the southern to northern hemisphere). For the first circuit around the Earth, the epoch is a "fictional" one, generated by projecting the orbit back in time. In some cases, especially when the orbital period is greater than 100 minutes, the epoch of the first circuit orbit will therefore be prior to the satellite being launched.

MIR Complex, Soyuz-TM 21 and Atlantis/STS-71 Docking and Undocking Activity

In view of the interest in the visit to the Mir Complex by Atlantis during the STS-71 mission, the various docking and undocking events are summarised below (All event in 1995):

Date	Module	Event
May 26	Kristall	Relocated from -Y radial port on the Mir Core to the +X (front) longitudinal port.
May 29	Kristall	Relocated from the +X longitudinal port on the Mir Core to the -Z radial port.
Jun 1	Spektr	Docked at +X longitudinal port on the Mir Core.
Jun 2	Spektr	Relocated from the +X longitudinal port on the Mir Core to the -Y radial port.
Jun 10	Kristall	Relocated from the -Z radial port on the Mir Core to the +X longitudinal port.

Date	Time (UTC)	Time (dec)	Piloted Craft	Event/Port	Crew
Jun 29	1300	Jun 29.542	Atlantis/STS-71	Docked, Mir/Kristall +X	Gibson, Precourt, Baker, Harbaugh, Dunbar, Solovyov, Budarin
	1306	Jun 29.546	Atlantis/STS-71	Hard dock	As above
Jul 4	1055	Jul 4.455	Soyuz-TM 21	Undocked, Mir/Kvant 1 -X	Solovyov, Budarin
	1109:45	Jul 4.465	Atlantis/STS-71	Undocked, Mir/Kristall +X	Gibson, Precourt, Baker, Harbaugh, Dunbar, Dezhurov, Strekalov, Thagard
	1139	Jul 4.485	Soyuz-TM 21	Docked, Mir/Kvant 1 -X	As Soyuz-TM 21 above
	1235	Jul 4.524	Atlantis/STS-71	Fly-around complete	As Atlantis/STS-71 undocking above



Communications Event!

Special programs this year include scanning Atlanta during the Olympics, Atlanta-area tours an all-new "Listening Post," sales and demos by top manufacturers, a fabulous banquet, International Broadcasters Forum—and much more!

Preliminary Schedule (Abbreviated)

FRIDAY, October 13, 1995

10am-4pm	Workshop for Educators(call Grove for additional information)
12-4 pm	Demonstrations by leading manufacturers and staff
9:30am-11:15am	Tours of WSB Broadcasting
1-2 pm	Scanning Atlanta - Roger Cravens
3-4:30pm	Tours of the Fulton County Sherriff's Dept. w/Roger Cravens
2 - 4 pm	International Broadcaster's Forum Ian McFarland, moderator
5:30-6:00	Speakers meeting; Bob, Rachel, Larry
7-7-:30	Opening ceremony; greet VIPs (espec int'l broadcasters) w/Bob Grove host
7:30-8:30	MT Expert panel w/Rachel Baughn host
8:45-9:45	ST Expert Panel w/Larry Van Horn host

SATURDAY, October 14, 1995

	SW Ute/BC	Scanner/Pers. Comm	Satellite
9:00 - 10:00	Utility DX L.Van Horn	Public Service Bob Kay	Satellite Monitoring K. Stein
10:15-11:15	BC Developments G.Hauser	Monitoring & the Law J.Rodriguez	Weather Sats J.Wallach
11:15-1:00	LUNCH		
1:00-2:00	Begin SW L. Magne	Monitoring the Military UHF/VHF L. Van Horn	Beginning Sats K. Reitz
2:15-3:00	SWBC Programs J.Frimmel	Federal Monitoring J.Fulford	Personal Comm. D. Dickerson
3:15-4:15	HF Aero B.Evans	Causes & Cures of Computer Interfer. J. Catalano	Domestic TVRO K. Reitz
4:30	Bug Hunt (outdoors)		
5:15	Prize dawing		
7:00	Banquet		

Post banquet Bug hunt, Listening post, special interest groups

SUNDAY, October 15, 1995

9:00-10:00	AM DXing G. Hauser	Begin Scanning B.Grove	Monitor NASA L. Van Horn
10:15-11:15	HF Digital Modes B.Evans	Trunking Technology Doug Graham	Amateur Sats K.Baker
11:30-12:30	Pirate/Cland G.Zeller	VHF Aero J Baker	Radio Astronomy J. Lichtman
12:45	Close w/Bob Grove host		

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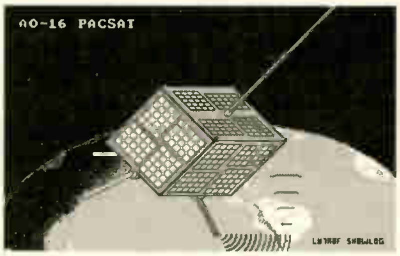
By John A. Magliacane, KD2BD

Telemetry: Monitoring The Heartbeat of the OSCARs

Over its 30 years existance, the amateur satellite program, headed by such organizations as Project OSCAR and AMSAT, has produced a wide variety of reliable communication satellites for the amateur radio community. The current constellation of Orbital Satellites Carrying Amateur Radio (OSCARs) support everything from continuous wave telegraphy (CW) and voice communications, to high-speed packet switching and store-and-forward file transfer operations. Although amateur satellites have diverse transponder capabilities, they all share one similarity in that they all report telemetry information to ground stations via beacon transmitters. The information carried on the beacon is free for the asking. Typically, beacons carry scientific and engineering data from various subsystems on the satellite. The beacon may also carry news bulletins from the spacecraft controllers that are of interest to users of the satellite.



The number of satellite users who frequent the transponder passbands far outnumber those who monitor the telemetry transmissions from the satellite. Telemetry analysis, however, can be a fascinating activity, and is invaluable in the classroom for teaching scientific data collection techniques, statistical analysis, orbital mechanics, and communications technology. Monitoring satellite telemetry gives command stations and satellite users alike, valuable information on the health and the "living conditions" on the satellite. While a typical low-earth orbiting satellite may be in range of a ground station for less than 30 minutes in a single pass, the scientific data gathered over that period from the satellite's telemetry beacon can provide enough information to keep the avid OSCAR user busy for days, weeks, or even months while the scientific data from the satellite is analyzed and digested.

A brief history

In the beginning, every OSCAR satellite was unique in the way in which it conveyed its telemetry information to ground stations. This was because every new satellite was significantly different from earlier satellites in attributes such as size, function, and orbit. The Microsat constellation of satellites launched in early 1990 changed this. For the first time in the OSCAR program, this new generation of amateur satellites used a more or less standard construction and spacecraft subsystem. These similar attributes brought with them generic mechanisms for gathering, storing, and transmitting telemetry information in a way that would allow for easy decoding and analysis using a microcomputer. The key to easy telemetry encoding was the use of a microprocessor in the satellite and enough memory to support telemetry generation software.

The first amateur satellite to transmit computer generated telemetry reports was UoSAT-OSCAR-9. Table 1 shows a telemetry frame copied by your ham satellite column editor on August 10, 1989. The UoSAT satellites were designed and built for scientific and educational purposes by the Electrical Engineering Department at the Unversity of Surrey in Guildford, Surrey (England). The first two satellites of the UoSAT series carried no open access communications transponders. Instead, emphasis was placed on scientific experiments and the generation of whole orbit data surveys whose results could be monitored through the beacon transmitters carried on these satellites. With this in mind, it is no surprise that the UoSAT satellites became well accepted in many science, technology, and engineering classrooms around the world.

Beacons and Telemetry

Beacon transmitters on OSCAR satellites typically identify the satellite by name and provide telemetry information that usually includes the results of voltage, current, and temperature measurements in "raw" form. Raw telemetry data is converted into units understandable by humans through the application of calibration equations. Calibration equations are developed by spacecraft designers and are adjusted from time to time to compensate for the aging of the telemetry sensors. Keeping an accurate list of calibration equations on hand will insure reliable monitoring of an OSCAR satellite's "vital signs".

Telemetry transmissions from OSCAR satellites can take the form of CW, RTTY, ASCII, binary, or even synthesized voice. Satellites that use ASCII (American Standard Code for Information Interchange) or binary modes of transmission do so in an effort to maintain compatibility with earth-based computers that also use ASCII for internal data representation. Computer software can be easily used to collect, decode, and analyze spacecraft telemetry. Decoded telemetry can be imported into spreadsheet or statistical software for easy graphing and analysis. This makes it easy to spot trends in

TABLE 1

Raw telemetry frame captured from the UoSAT-OSCAR-9 satellite on August 10, 1989.

```
UOSAT-1    8908100013659 COMPUTER GENERATED TELEMETRY
001001011202026765030003040004057 81B06655007586C08511D09646D
1010001111001200031300021402341533151638591772651852 0E19647D
20200021390922584923135624005325426726433027273328535929629 6
302706311102326601332 58F34010635269B36334137485D38543939665F
40080C41120642731343000744195D45000146001347535048555949581 1
500603511104522 69A53090F5469865541365644565752365855 1C595595
```

data and learn more about the near Earth environment that is home to all the OSCAR satellites.

The difference between ASCII and binary telemetry transmissions is sometimes difficult to explain and understand. Basically, ASCII transmissions use seven of the eight bits available for digital communications plus a few more for start bits, stop bits, and parity. ASCII telemetry data can be monitored directly using simple terminal software running on a PC. ASCII is the language most computers use to represent numbers, letters, and symbols frequently associated with text information.

With ASCII, bit patterns carry special meanings, but bit positions carry no special meaning except for their binary weight. Numerical data is represented by its ASCII equivalent. For example, the number zero (0) is represented as 48 in ASCII (0110000). Sending a code of 48 to a printer for example, will cause the printer to print the number zero (0) on the page.

Binary telemetry transmissions, on the other hand, use all 8 data bits and represent numbers in their true binary form. The number zero (0) is therefore represented as 0 (00000000). There is no conversion to 48, and the binary data cannot be directly displayed as a zero on a computer terminal or printer.

Binary transmissions, however, allow for a more efficient transfer of data, and computers have no trouble understanding and processing binary data. Telemetry analysis software can be written to handle this form of data and convert the results of the telemetry calibration equations to a form that can be displayed, printed, and easily understood by humans. Furthermore, since the telemetry data need not conform to ASCII standards, bit positions, rather than just bit patterns, can carry special meanings. It is therefore possible to convey as many as eight pieces of telemetry information with just one byte of data, especially if the information conveyed in that byte relates to the binary (ON/OFF, HI/LOW, enabled/disabled,) status of spacecraft subsystems. Binary status information can be conveyed using ASCII transmission codes, but it is not as efficient as using a binary mode of transmission.

A look at ASCII Telemetry

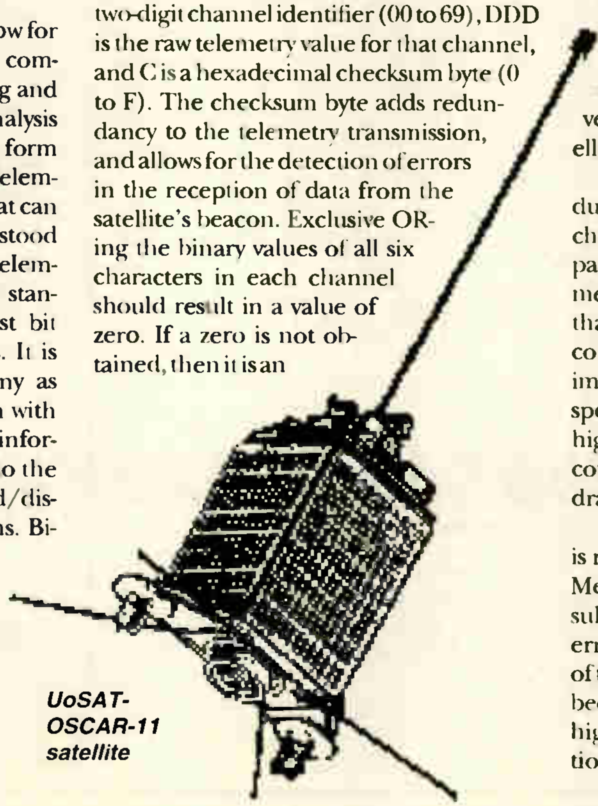
The UoSAT-OSCAR-11 satellite transmits telemetry information in both ASCII and binary formats. Telemetry information is gathered internally by the satellite and compiled into telemetry frames. Each frame carries the results of all the sensor measurements on the spacecraft. A complete telemetry frame is generated in just under five seconds. An example of an ASCII telemetry frame received from the UoSAT-OSCAR-11 satellite is shown in Table 2. This particular frame was copied on July 10, 1995.

TABLE 2

Raw telemetry frame captured from the UoSAT-OSCAR-11 satellite on July 10, 1995. Notice the similarity to the telemetry format of UoSAT-OSCAR-9.

```
              UOSAT-2       9507100210359
005005013507022088035215040466050324060204070456080392090035F
10441011303012000313056114039F153689165332174301184 17B19501C
20253621225622661123000124000625000726087B27451528446C294438
305170310354322883335702340061352141362744373 82D384249394583
407571411163426356430 59B441607450001460002474326484 56B49427C
5054265115115264145364735468695577005628 5C57446458347D59440C
60A2A4615FC1625F4A63331464440265 1E0C66144167F00E68000E69000F
```

The first line of the telemetry frame is called the header. The header includes the satellite name (UoSAT-2), and is followed by the date and time of the telemetry sample. The lines that follow include raw telemetry values for 70 channels of data. Each channel consists of six digits. The format for each channel is NNDDDC, where NN is a two-digit channel identifier (00 to 69), DDD is the raw telemetry value for that channel, and C is a hexadecimal checksum byte (0 to F). The checksum byte adds redundancy to the telemetry transmission, and allows for the detection of errors in the reception of data from the satellite's beacon. Exclusive ORing the binary values of all six characters in each channel should result in a value of zero. If a zero is not obtained, then it is an indication that the telemetry data was received in error. In that case, it's best to discard the telemetry data for that channel.



UoSAT-OSCAR-11 satellite

Channel 00, the first channel of UoSAT-OSCAR-11 telemetry, provides a reading of solar array current on the -Y facet of the spacecraft. The array current is given by the equation $I = 1.9*(516-NN)$, where NN is the raw telemetry value for channel 00 and I is given in millamperes. Substituting 500 for NN in the calibration equation yields a current of 30.4 milliamperes for the solar panel.

Telemetry channels 60 through 67 represent binary status information that has been encoded into hexadecimal digits. The bit patterns of the hexadecimal data reports which experiments or subsystems are powered on or off on the satellite. Channels 68 and 69 are not used and are set to zero.

Telemetry analysis software takes a lot of work out of decoding raw telemetry data from OSCAR satellites by hand. Table 3 shows the result of decoding the UoSAT-OSCAR-11 telemetry frame shown in Table 2. The software that produced this output was written in 'C' by your editor and compiled for execution under the Linux operating system. Additional telemetry analysis software is available through AMSAT-NA. See AMSAT's advertisement elsewhere in this issue of Satellite Times for their mailing address.

The results of UoSAT-OSCAR-11's space dust experiment can be found in telemetry channel 66, and is often an interesting parameter to watch. The space dust experiment carried on OSCAR-11 is similar to that flown on the Giotto spacecraft, and counts the number of space particles that impact a piezoelectric transducer within a specified period of time. During periods of high solar activity or meteor showers, the count reported by this experiment rises dramatically.

The number of spacecraft RAM errors is reported in channel 60. Random Access Memory (RAM) errors are primarily a result of ionizing radiation. Higher memory errors mean higher radiation levels. Both of these parameters are interesting to watch because they bear a direct correlation to high frequency (HF) propagation conditions.

Judging from the solar currents, it is

TABLE 3

The results of processing the raw telemetry data shown in Figure 2 through a telemetry analysis program. Channel numbers appear in [brackets] for the analog telemetry channels. Voltages are expressed in volts, currents in milliamperes, temperatures in degrees celsius, power in milliwatts, and magnetic fields in microTeslas.

UoSAT-2 Telemetry Received On Sunday 10-Jul-95 at 21:03:59 UTC

UoSAT-2 Analog Status Channels:

[10] Solar Array Current (+Y)	142.50
[00] Solar Array Current (-Y)	30.40
[30] Solar Array Current (+X)	-1.90
[20] Solar Array Current (-X)	499.70
[50] Battery Chrg/Dischg Curr	255.20
[51] +14 Volt Line Current	755.00
[21] +10 Volt Line Current	218.25
[41] + 5 Volt Line Current	112.52
[31] -10 Volt Line Current	16.80
[33] 1802 Comp. Current (+10v)	119.70
[34] Digitalker Current (+5v)	0.78
[54] Telemetry Current (+10v)	13.72
[44] Command RX Current	147.20
[43] DSR Current (+5v)	12.39
[23] P/W Logic Current (+5v)	0.00
[24] P/W Geiger Current (+14v)	0.00
[25] P/W Elec Sp. Curr (+10v)	0.00
[26] P/W Elec Sp. Curr (-10v)	8.09
[14] DCE RAMUNIT Current	-4.69
[15] DCE CPU Current	90.45
[16] DCE GMEM Current	196.05
[01] Navigation Mag X Axis	-17.35
[03] Navigation Mag Y Axis	3.96
[02] Navigation Mag Z Axis	-34.77
[04] Sun Sensor # 1	46.00
[05] Sun Sensor # 2	32.00
[06] Sun Sensor # 3	20.00
[07] Sun Sensor # 4	45.00
[08] Sun Sensor # 5	39.00
[09] Sun Sensor # 6	35.00
[35] 145 MHz Beacon Pwr O/P	260.00
[36] 145 MHz Beacon Current	60.28
[37] 145 MHz Beacon Temp.	19.60
[45] 435 MHz Beacon Pwr O/P	Range?
[46] 435 MHz Beacon Current	0.00
[47] 435 MHz Beacon Temp.	9.60
[55] 2.4 GHz Beacon Pwr O/P	1400.83
[56] 2.4 GHz Beacon Current	128.25
[58] 2.4 GHz Beacon Temp.	26.60
[52] Battery Voltage (+14v)	13.46
[22] PCM Voltage (+10v)	9.91
[42] PCM Voltage (+ 5v)	5.33
[32] PCM Voltage (-10v)	-10.37
[17] Facet Temperature +X	10.00
[27] Facet Temperature -X	5.80
[18] Facet Temperature +Y	12.60
[28] Facet Temperature -Y	6.80
[19] Facet Temperature +Z	-4.20
[29] Facet Temperature -Z	7.40
[38] Command Decoder Temp +Y	11.20
[49] BCR Temperature -Y	10.60
[39] Telemetry Temperature +X	4.40
[48] P/W Temperature -X	4.80
[59] CCD Imager Temperature	8.00
[57] Battery Temperature	6.80
[11] Nav Mag (Wing) Temperature	7.83
[12] Horizon Sensor	0.00
[40] Solar Array Voltage (+30v)	24.10
[53] Battery Cell Volts (MUX)	13.59
[13] 435 MHz Beacon VCO Control	0.28

UoSAT-2 Digital Status Channels:

Channel 60:

145 MHz General Beacon Power	On
435 MHz Engineering Beacon	Off
2401 MHz Engineering Beacon	On
Telemetry Mode Select	Run
TLM Dwell Address Load	Off
TLM Dwell Address Source	Gnd
Primary s/c Computer Power	On
Primary s/c Computer Errors	3
Primary s/c Computer Bootstrap	UART
Primary s/c Computer Bootstrap	A

Channel 61:

G. Gradient Boom Deploy Pyros	Safe
G. Gradient Boom Deploy Pyros	Hold
G. Gradient Boom Deployment	Safe
G. Gradient Boom Deployment	Hold
G. Gradient Boom Deployment	Retract
Attitude Control Magnetorquers	Arm
Attitude Control Magnetorquer -X	Off
Attitude Control Magnetorquer -Y	Off
Attitude Control Magnetorquer -Z	Off
Attitude Control Magnetorquer	Fwd
435 MHz Beacon PSK Mode	NRZI
2401 MHz Beacon PSK Mode	NRZI

Channel 62:

Attitude Control Magnetorquers	Hi Pwr
Digitalker Experiment Power	On
CCD Camera Experiment Power	Off
CCD Camera Integration Period	3
CCD Camera Video Amplifier Gain	3
Digital Store & Readout Power	On
Digital Store & Readout Mode	Read
Digital Store & Readout Mode	Reset
Rad. Detector Geiger-A EHT Power	Off
Rad. Detector Geiger-B EHT Power	Off

Channel 63:

Rad. Detector Geiger-C EHT Power	Off
Electron Spectrometer EHT Power	Off
DCE Experiment Power	On
DCE Experiment	Run
DCE Experiment PROM Select	A
DCE Experiment CPU Clock	0.9 MHz
Navigation Magnetometer Power	On
Space Dust Experiment Power	On
Status Calibrate	0
BCR Status	A
435 MHz Beacon Modulation Select	AFSK
2401 MHz Beacon Modulation Select	PSK

Channel 64:

Command Watchdog	Enable
Command Watchdog Reset	Run

Channel 65:

435 MHz Beacon Data Rate	A
435 MHz Beacon Data Rate	B
435 MHz Beacon Data Rate	C
Particle / Wave Counter Control	Reset
VHF/UHF Beacon Lockout Protect	Disable
Engineering Data	2H

Channel 66:

P/W Channel Plate Control	0
Space Dust	162
DSR Write Cycle Complete?	No

Channel 67:

1802 CWO Output	1
1802 Telemetry Port	700H

obvious that the satellite was in sunlight when this telemetry sample was taken. The solar panel generating the highest current is the one receiving the greatest solar illumination. Temperatures of the subsystems indicate comfortable living conditions for the spacecraft electronics. The 2.4 GHz S-band beacon temperature is quite a bit higher than that of the 145 MHz very high frequency (VHF) beacon, but this can be explained by higher power level at which the S-band beacon transmitter is operating.

Whole Orbit Data Surveys

The UoSAT-series of OSCAR satellites pioneered a telemetry gathering and transmission technique known as whole orbit data (WOD) surveys. In operation, the satellite's on-board computer (OBC) accesses the telemetry system and stores telemetry values in memory over the course of one or more orbits. The data collected over survey period is read out (dumped) during a WOD transmission. Another important aspect of WOD surveys is that they allow for the collection of telemetry data from the spacecraft during periods when the satellite is out of range of any ground stations.

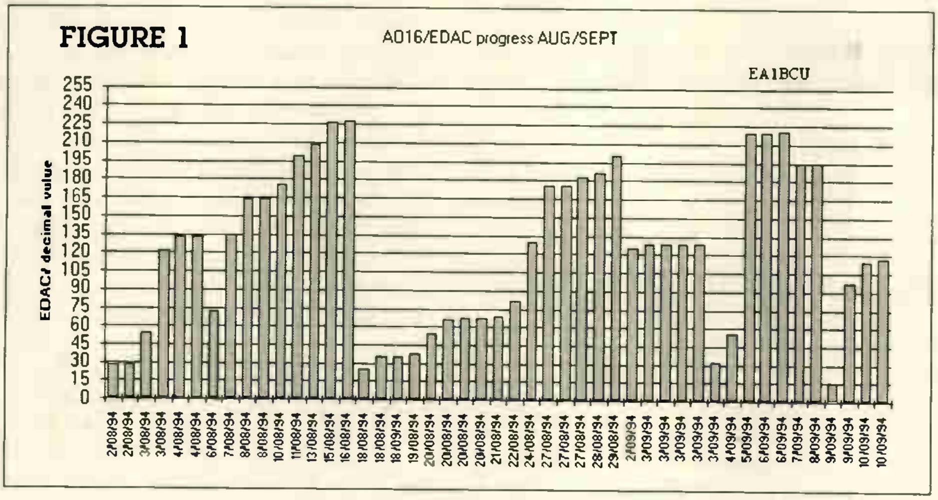
The very nature of WOD data lends itself quite nicely to plotting on graphs. The channels surveyed by the spacecraft are usually reported over the satellite's beacon transmitter. Table 4 shows an OBC computer status message from UoSAT-OSCAR-11 indicating the time the WOD survey was started and the telemetry channels corre-

TABLE 4

Computer status information received from UoSAT-OSCAR-11 on July 9, 1995. Transmissions of this type are made in plain ASCII and require no decoding. Downlink is on 145.826 MHz FM using AFSK modulation at 1200 baud.

**** UoSAT-OSCAR-11 OBC ****

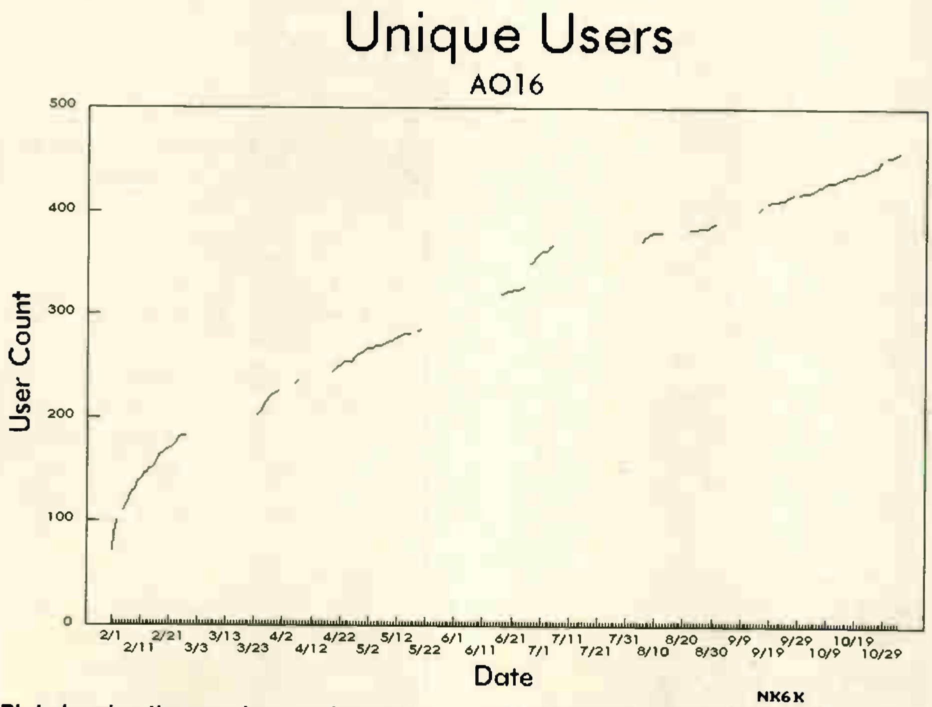
Diary Operating System:	V3.6
Date:	9 /7 /95 (Sunday)
Time:	20 :54 :27 UTC
Auto Mode;	selected
Spin Period:	- 363
Z Mag firings:	3
+ SPIN firings:	0
- SPIN firings:	3
SEU count:	-466
RAM WASH pointer:	47E
WOD commenced at:	25 /6 /95 at 0 :0 : 6 with channels 1 ,2,3, 61
Last Command:	109 to 0,0 Attitude control initiated, mode 3



Plot showing random access memory error detection and correction (EDAC) counts for a Whole Orbit Data (WOD) survey taken by AMSAT-OSCAR-16. Notice any correlation to the solar rotation cycle?

sponding to the survey. In this case, channels corresponding to the spacecraft's navigation magnetometer and magnetorquers is reported. The navigation magnetometer is used for determining the attitude and dynamics of motion of the satellite as well an for experimental measurement of magnetic field disturbances around the globe. Plotting this data over the course of an orbit or more shows the interaction of the Earth's changing magnetic field on the spacecraft's sensors.

A plot of whole orbit data taken by the AMSAT-OSCAR-16 satellite is shown in Figure 1. In this graph, random access memory error detection and correction (EDAC) counts are plotted against time. Every time the satellite's OBC needs to correct a bit in memory that has been corrupted by radiation, the EDAC count is incremented. The results, plotted over time, clearly indicate a cyclic pattern. Further study will reveal the cause of this pattern.



Plot showing the growing number of users of the AMSAT-OSCAR-16 "Pacsat" satellite during its early life. Data used to produce this graph was collected by NK6K through careful analysis of the spacecraft activity logs.

LOS

This article was intended to give a brief overview of OSCAR telemetry transmissions and uses of telemetry data. Telemetry analysis is a subject that can get quite complex and involved, but even in an elementary form, carries strong educational benefits. The large number of telemetry equations for the high volume of OSCAR satellites currently in operation precludes the inclusion of a complete list of such information in this column. If more information is desired on this subject, the reader is encouraged to contact AMSAT-NA for additional literature as well as telemetry decoding software for all popular personal computers. ST

TABLE 5

ASCII telemetry from the Fuji-OSCAR-20 satellite. Transmissions of this type are made using the AX.25 packet radio communications protocol and require a packet radio TNC to decode. The last line of telemetry indicates binary status information in the form of ones and zeros.

8J1JBS>BEACON <UI C>:
JAS1b RA 94/09/05 20:06:58
428 442 674 678 730 817 835 821 000 673
608 000 463 482 503 487 497 507 645 000
670 704 655 662 999 635 865 490 018 000
010 101 000 001 111 100 001 111 011 000

8J1JBS>BEACON <UI C>:
JAS1b M0 94/09/05 20:07:00
Mailbox is at your service from 94/09/05 05:10:00
The JD Transmitter is available in all orbits during JD mode.

THE VIEW FROM ABOVE

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

Interpreting the Automatic Picture Transmission Image Frame

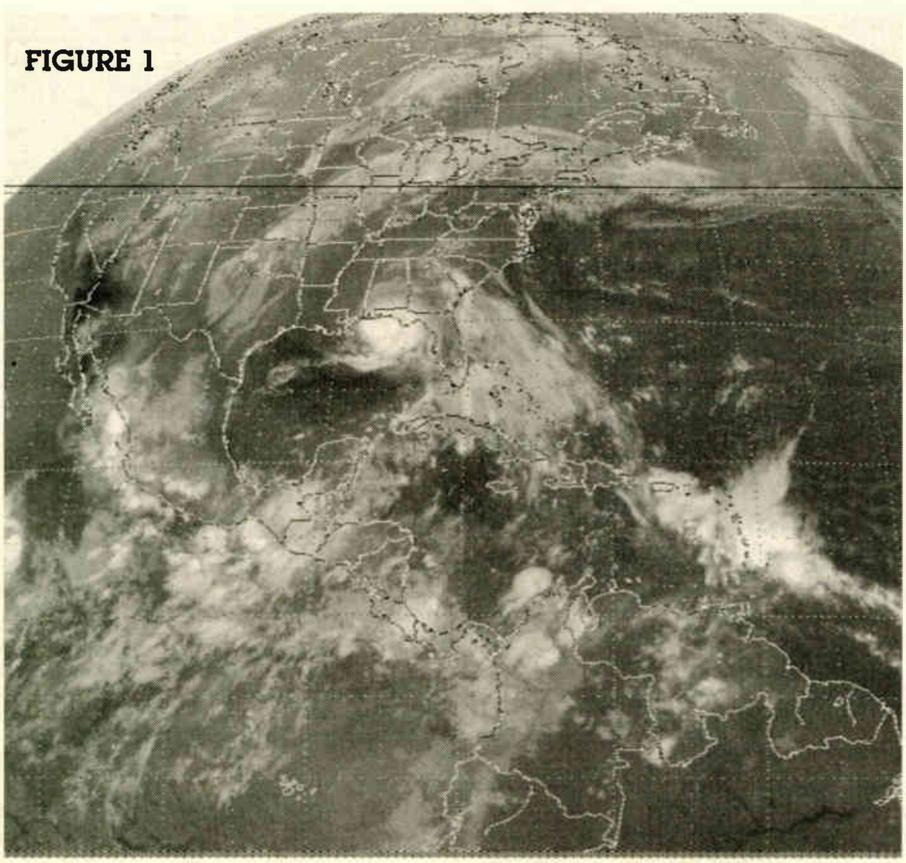
A recent survey of *Satellite Times* readership indicated that many readers are now actively receiving GOES WEFAX and NOAA APT polar orbiter imaging on a regular basis at their home ground stations, as well as conducting 'image-processing' of the satellite data.

In fact, as this article is being written, the GOES and APT stations at the Dallas Remote Imaging Group (DRIG) are doing some image-processing also — hurricane Erin off the west coast of Florida!

Figure 1 shows a GOES 8 infrared image of Erin as it was passing over the west coast of Florida moving into the Gulf of Mexico. Figures 2 and 3 show an Advanced-TIROS spacecraft APT visible and IR image taken from NOAA 14 of the remnants of Erin off the west coast of Florida. These two images were originally side-by-side as transmitted by the satellite, but the PC software saved them as individual images.

Previous articles in *ST* have discussed the frame and image format of the GOES WEFAX imagery (see January/February 1995 *View From Above*). In this column we will delve into the Automatic Picture Transmission (APT) frame format of the NOAA polar-orbiting Advanced-TIROS weather satellites.

FIGURE 1



The NOAA Advanced-TIROS satellites carry onboard an Advanced Very High Resolution Radiometer (AVHRR) instrument which scans the Earth (and space!) to provide both visible light and infrared (IR) imagery in up to five spectral bands or channels. The AVHRR instrument scans the Earth with a mirror, perpendicular to the direction of the satellite orbit. With each rotation of the AVHRR mirror, data from deep space (temperature measurement), an Earth scan (for the imagery) and a measurement of a warmed black body radiator on the satellite are obtained. Both the deep space and warmed black body radiator measurements help in calibration of temperature for the resulting imagery. The energy that is collected by the AVHRR mirror is passed through an on-board telescope, and then through five separate optical filters to produce five spectral bands, from the visible, near IR, and IR wavelengths. The five AVHRR channels are as follows (these five channels may vary slightly from spacecraft to spacecraft):

Channel 1	0.58-0.68 uM	(Visible)
Channel 2	0.72-1.10 uM	(near IR)
Channel 3	3.55-3.93 uM	(Thermal IR)
Channel 4	10.3-11.3 uM	(Thermal IR)
Channel 5	11.5-12.5 uM	(Thermal IR)

The three thermal IR detectors are actually mounted on a passively cooled platform called the 'patch'. The patch is maintained at 105 degrees Kelvin to assure proper operation of the detectors and temperature calibration.

The AVHRR instrument uses the five channels to product the High Resolution Picture Transmission (HRPT) digital imagery transmitted at 665 kbps on 1698 MHz. This imagery is at 1.1 km resolution and takes some sophisticated ground station equipment (and lots of hard disk space) to capture. The HRPT data is taken at 360 lines per minute scan rate by the AVHRR instrument. To accommodate a simple groundstation requirement, the Automatic Picture Transmission (APT) analog signal is produced. APT is actually a derivative of the HRPT digital data. Two of the five possible AVHRR spectral channels are multiplexed so that channel A of the APT frame is taken from one spectral channel of the first AVHRR scan line, and channel B of the APT frame is obtained from the second AVHRR scan line. The third scan line (remember - 3 lines per second or 360 lines per minute for HRPT) is omitted from the APT signal and the process

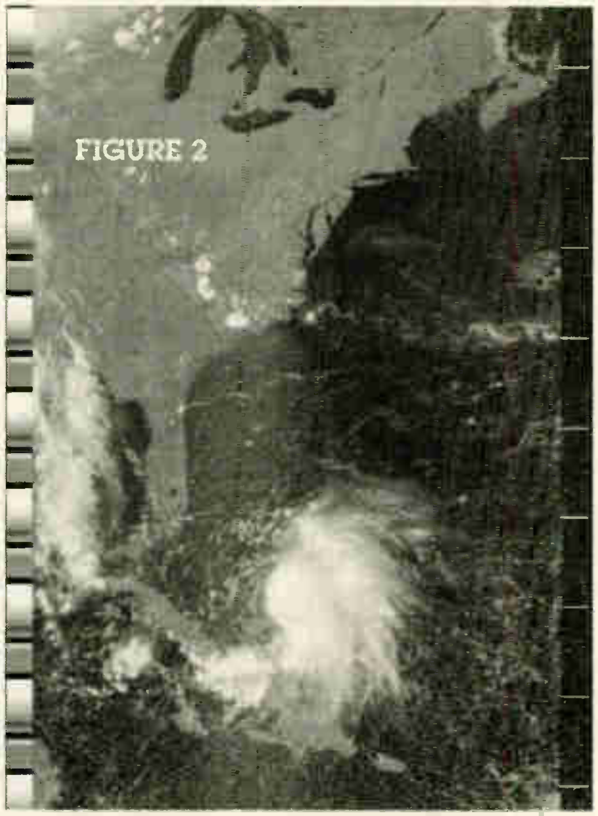


FIGURE 2

repeated. Thus, for the APT signal, there is 120 lines per minute actually scanned, using two channels.

Normally during daylight passes, channel 1 (visible) and an IR channel are used. During nighttime passes, the ground station at NOAA will command two IR channels to be used. If you listen carefully to the APT signal, when the spacecraft passes the night/day terminator, you can actually hear the signal switch over to either visible/IR or IR/IR! Try this one evening or early morning, using your favorite tracking program to show you when the satellite will pass the terminator.

Unlike the digital HRPT signal, the APT signal is analog and at a reduced resolution (4 km for visible and 7 km for IR). It is actually an FM signal, with an AM subcarrier that is modulated at 2400 hz with 8 of the 10 bits used from the digital HRPT signal (8 bits results in 256 shades of grayscale). It contains two of the five possible channels, as well as the corresponding calibration and temperature data.

A typical daylight pass will consist of the visible Earth scan, space data (with one-minute timing markers), telemetry frame, and the IR Earth scan with associated space data and telemetry frame. This imagery is a constant direct-readout image, with no start or stop tones as you have on the GOES WEFAX imagery. You will continue to receive the imagery as long as the satellite is above your local horizon (and is, of course, working!). Figures 2 and 3 are a good example of the visible and IR images with associated minute markers and telemetry frame.

APT telemetry frames.

Figure 4 shows the APT signal format. Each video line is 0.5 seconds (120 lpm is 0.5 seconds per line) in length, containing two equal segments. Each 0.25 second segment contains:

- Specific synchronization pulse
- Space data with the 1 minute timing insets (white minute markers on black background for visible and a black minute marker on white background for IR)
- Earth scan imagery from a selected AVHRR spectral channel
- A telemetry frame segment

Notice the telemetry frames A and B. The APT telemetry frame contains data that can be used to gather accurate temperature measurements from the thermal IR channels. Using this data from the AVHRR thermal channels 3, 4, 5, and the corresponding telemetry frame, a personal computer, and appropriate software, one can interpret sea surface temperatures, cloud temperatures and cloud heights, ground temperatures, etc. Most of the popular APT system software has this calibration measurement software built-in!

Now let's take a closer look at the APT telemetry frame. In the actual APT image (see Figures 2 and 3 and the grayscale wedges on the sides of the images) the telemetry frame contains 16 individual 'wedges' each of which is composed of eight successive video scan lines (one APT telemetry frame = 16 wedges x 8 lines per wedge = 128 lines/frame). Frames are continuously transmitted by the satellite, but only one frame is needed for the calibration process. Both images (visible and IR) have the same first 15 wedges. Wedge 15 and 16 differentiate the Channel A from Channel B data. Figure 5 shows the entire APT telemetry frame Figure 5 courtesy of Joe Summers of Chambersburg High School, Penn.

Wedges 1-8 are produced by modulating the 2400 Hz AM subcarrier with 8 linear 8 bit outputs, on the Manipulated Information Rate Processor (MIRP) located on the NOAA polar orbiters. The digital values used to modulate each wedge are shown in Figure 5 as a digital value. Corresponding modulation indexes in the analog signal are also shown. MI 10.6 is the dark gray wedge and MI 87.0 is the near white wedge.

Wedge 9 is the zero modulation (no signal modulation) wedge and appears as pure black. Wedges 10-13 represent the thermal temperatures 1-4, when the AVHRR scanner periodically 'views' a warmed black body radiator and is used to help calibrate wedges 1-8. Wedge 14 is the patch temperature measurement and is used in spacecraft imagery calibration monitoring. Wedge 15 is the 'Back Scan' telemetry value produced by radiance from the black body radiator. This data be used for in-orbit calibration of the spectral channel used to produce the APT IR images. Wedge 16 is the channel identifier used to specify which of the 5 AVHRR channels is being used to produce the APT image

Space Data

The space data immediately follows the sync pulse for each image - this is a continuous bar that is overwritten with two lines which mark the 60 second intervals during the orbit of the satellite (in Figures 2 and 3 it appears as one single line). The space data is SENT when the mirror is looking

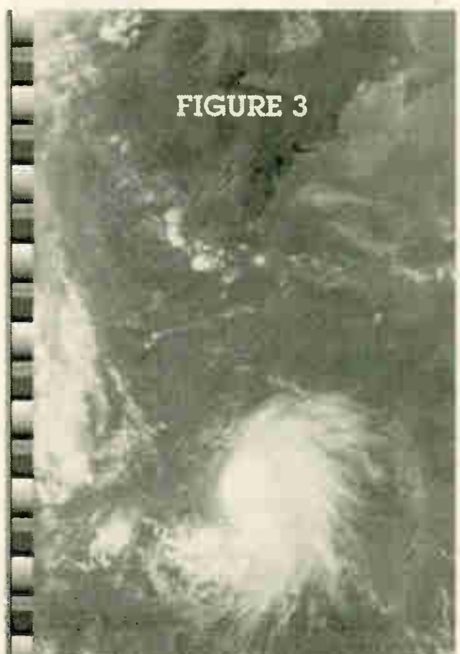


FIGURE 3

into the deep space (the IR is pure white due to the temperature of space; visible is Black for no light condition). It can be used for the temperature calibration in the APT software packages. Using the 60 second markers, one can compute distances on the imagery (remember that Rate x Time = Distance!)

In the 'olden days' of APT image reception, we used to have to print out and measure the wedge values, calibrate it with the space data value, and do some math to determine the actual temperatures imaged for a specific AVHRR instrument on a specific satellite. Today, software packages by Quorum Communications, GTI, Satellite Data Systems, OFS Software, Multifax, and a host of others process this temperature calibration data for you on the PC. It is very easy to find sea surface temperatures and calibrate the heights of clouds from the wedge data!

By the way, have any of you ever noticed a slight bending or 'bowing' of the APT satellite image during a full pass? Have you noticed that the bending of the image on the screen is least as the satellite passes overhead? Any ideas what physical laws can cause this image anomaly (first reader to correctly answer this question will win a year's free subscription to the DRIG BBS....Charlie Davis and all his relatives in or near the planet Earth are exempt from this offer).

FIGURE 5

WEDGES 1-8:

	APT ANALOG VOLTAGE	DIGITAL VALUE
1	0.757 V MI = 10.6%	31
2	1.538 V MI = 21.5%	63
3	2.319 V MI = 32.4%	95
4	3.101 V MI = 43.4%	127
5	3.881 V MI = 54.2%	159
6	4.663 V MI = 65.2%	191
7	5.444 V MI = 76.0%	223
8	6.225 V MI = 87.0%	255
9	ZERO MODULATION	0
10	THERM TEMP PRT #1	
11	THERM TEMP PRT #2	
12	THERM TEMP PRT #3	
13	THERM TEMP PRT #4	
14	PATCH TEMP	
15	BACK SCAN	
16	CHANNEL IDENT	

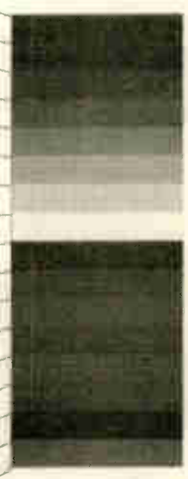
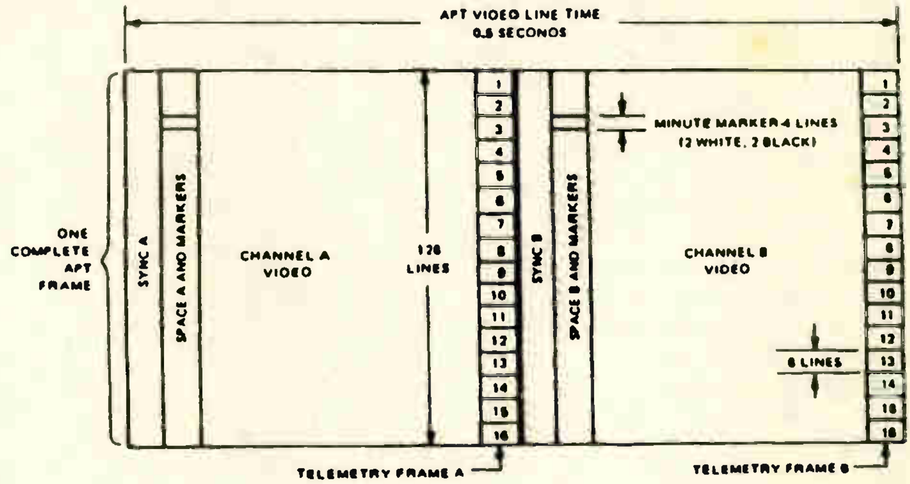


TABLE: X-1. Telemetry Frame Format Used in TIROS-N Series Satellite APT

FIGURE 4



So, you should now have at least an elementary understanding of the three main components of the APT image — the Earth image (visible/IR or two IR images), space data with one minute timing marks, and the telemetry frame. Hopefully, this information will give you a better appreciation of the 'bits and bytes' of the fascinating imagery you are now receiving!

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The Dallas Remote Imaging Group BBS is now available on the Internet! You may contact us by telnet, anonymous FTP, or World Wide Web! The DRIG BBS is now maintaining an active WEB site, with many links to other satellite and weather-related WWW servers. DRIG BBS will also have an active hyperlink with the Grove Enterprises/*Satellite Times* WWW server (yes, it is on-line!) Users may now Telnet to the DRIG BBS with no long-distance line charges, and have the normal subscription access levels. We have many plans for other services, including Gopher, telnet and ftp OUT from a dial-in phone line, direct SMTP mail, etc.

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WWW	http://www.drig.com/ or http://204.77.64.2/
telnet	telnet bbs.drig.com (login: bbs password: bbs Follow Menu)
info	info@drig.com
Landline:	214-492-7057 (28.8K modems)

Latest weather satellite elements: send mail to: weathkep@drig.com
Latest AMSAT satellite elements: elements@drig.com
Latest SHUTTLE elements: shuttle@drig.com ST

Latest Weather Satellite Constellation Information

NOAA 9	137.620 MHz	OFF
NOAA 10	137.500 MHz	OFF
NOAA 11	137.620 MHz	OFF
NOAA 12	137.500 MHz	ON
NOAA 14	137.620 MHz	ON
Meteor 2-21	137.850 MHz	ON
Meteor 3-5		OFF
Meteor 3-6		OFF
Okean 1-7 over Europe	137.400 MHz	ON
GOES 8 active at 75º West	1691 MHz	WEFAX
GOES 9 in engineering test phase at 90º West	1691 MHz	WEFAX

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PWR 4	PS-55 Style-matching power supply	$344.95
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Donald E. Dickerson, N9CUE

Advanced Communications Satellite (An ACTS Update)

Have you ever tried to use your mobile phone during peak activity times, or worse during a local or regional emergency, and found that all the circuits were busy and you could not get through at all? Have you ever found yourself on the edge of your cellular service and could barely reach a cell site or had a choppy, noisy or intermittent conversation?

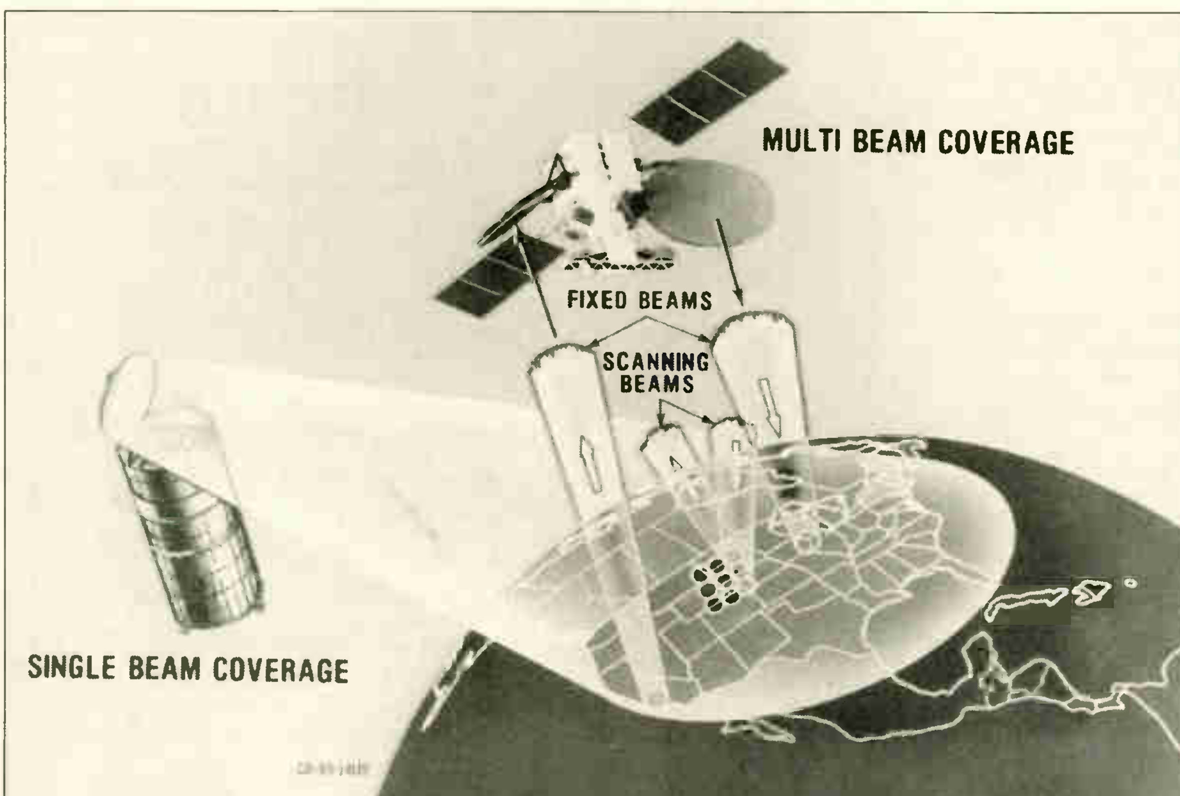
We have all faced these and similar problems with our terrestrial based cellular telephones and they are about to be overcome through the use of space technology. In this issue of *Personal Communications Satellites* we are going to take a look at some of the systems that are being developed that will solve many of these problems.

Before a new technology is introduced to the public, the U.S. federal government has usually been involved in the research and development (R&D). We'll start out by looking at the governments research and development in the field of personal communications satellites.

The first place we visit is the Jet Propulsion Laboratory (JPL) in California and the Lewis Research Center in Cleveland, Ohio. The personnel at these two facilities are, in large part, responsible for the R&D that will make seamless, world-wide digital quality cellular telephone service possible. Industry giants such as TRW, Orbcomm and Motorola are currently developing personal communications satellite systems that will do just that.

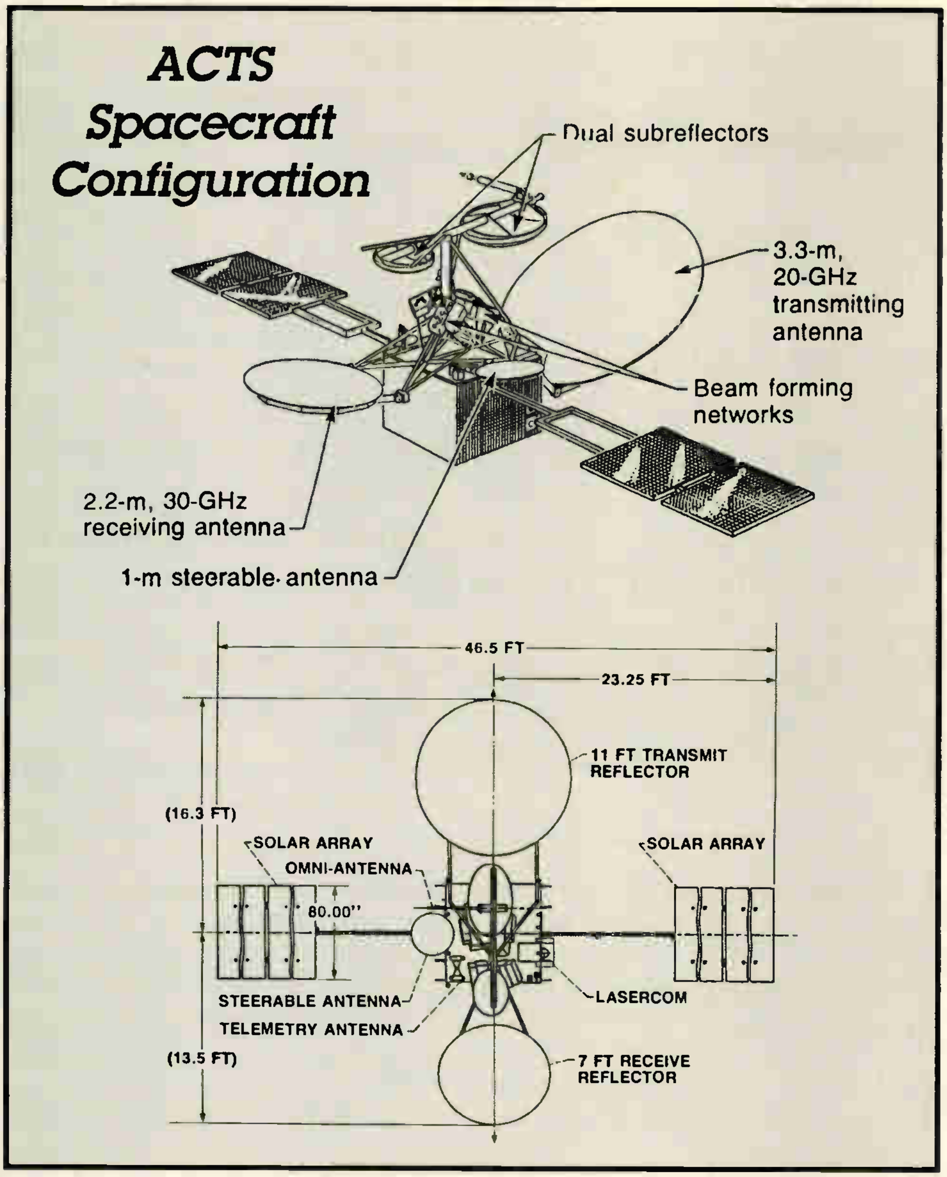
Much of the current activity in the satellite cellular market is a spin-off of a study done by the National Academy of Sciences in the late 1980's. The study indicated that our current government communications facilities were becoming more and more vulnerable to terrorist acts and natural disasters. This was, in part, due to the use of fiber optics and other high tech schemes which allow fewer and fewer high quality lines to carry more and more communications that are vital to our national defense. This means that fewer point failures in the system could take out larger portions of our national telecommunications capability. This was not acceptable. The study further suggested that satellite systems could be used to replace or at least back up normal lines of governmental communications. As a result, the U.S. government will be relying more and more on these new sophisticated, orbiting repeaters in the sky.

As is usually the case in space technology R&D, the government foot the bill for the research and passed the technology on to American industry to develop the operational models. In return the government gets to use of some of the new space systems capacity for the first few years of operation.



The test bed for satellite cellular service is NASA's Advanced Communications Technology Satellite (ACTS) program managed by Lewis Research Center. Satellite cellular experimentation is centered around a single ACTS spacecraft which is located at 100° West in geostationary orbit.

ACTS design is based on a RCA 4000 series spacecraft. The satellite measures 1413 cm (47.1 feet) across the deployed solar panels, 897 cm (29.9 feet) across the two dish antennas when deployed and 456 cm (15.2 feet) wide. ACTS two main



ACTS Spacecraft Configuration

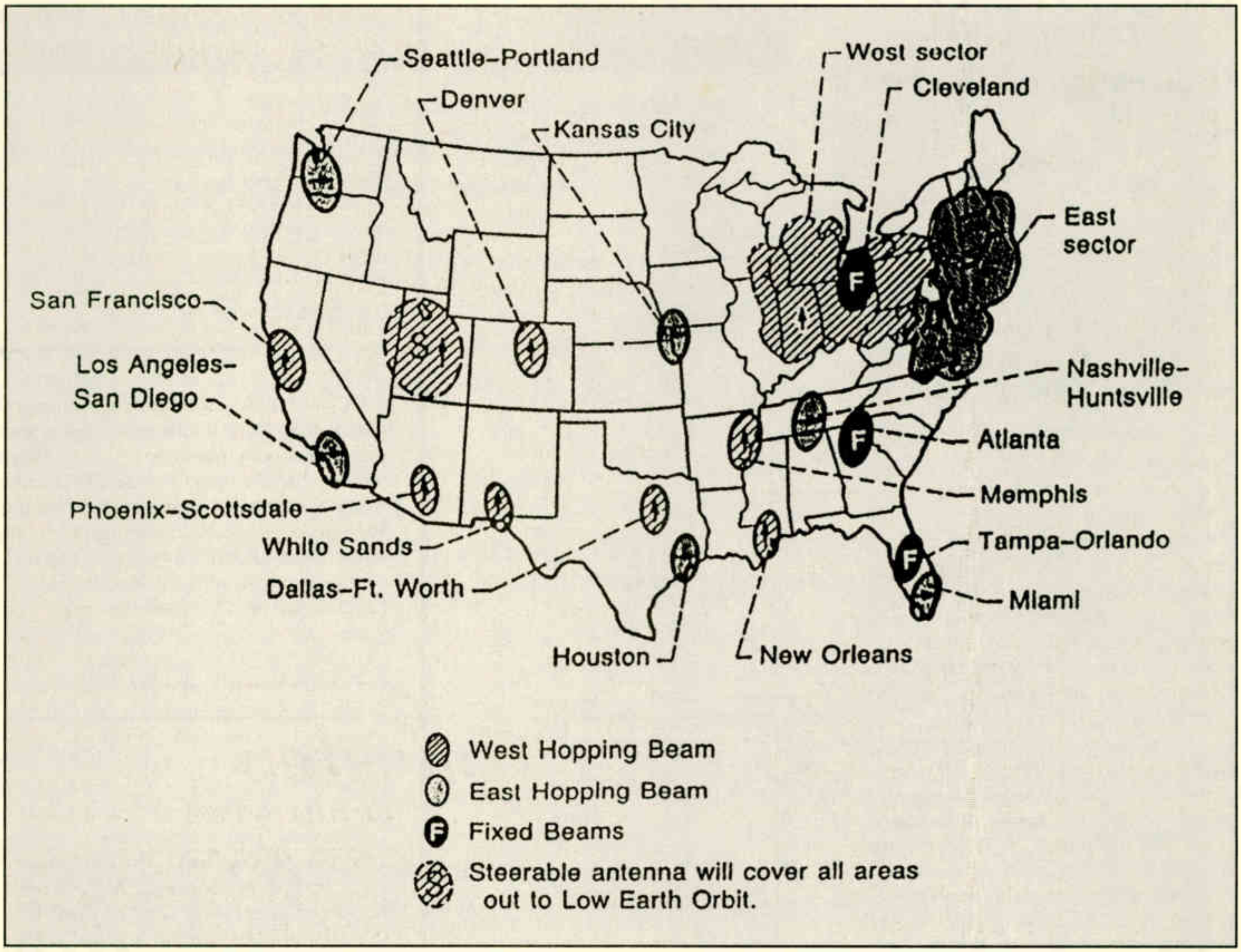
communications antennas are a 324 cm (10.8 foot) dish for 20 GHz frequencies and a smaller 216 cm (7.2 foot) dish is used for 30 GHz.

The ACTS program has several stated goals. One is to establish a digital network of very small aperture terminals (VSAT) with the capability of transmitting 1.5 Mbps. The second is to establish a very high data rate point-to-point network using microwave switching matrix systems. This last experiment was the test bed for Motorola's Iridium satellite system (see March/April 1995 of *ST* issue). This experiment using high data rate TDMA and DAMA formats in the Ka-band have been successful. The U.S. Army is currently using the T1-VSAT terminal in their High Data Rate (HDR) experiments with the ACTS (more on that below).

A third network will develop low data rate personal communication systems using the ultra-small aperture terminals (USAT). This system uses a 35.56 cm (14 inch) dish and can handle data rates between 2.4 to 4.8 Kbps A fourth network will be used to develop mobile and aeronautical services using high data rates (64 Kbps & 1.5 Kbps respectively) on the 30/20 GHz frequency bands.

Currently there are over 100 companies and organizations involved with the ACTS program. Eighty are authorized experimenters using transponder space on the satellite. There are 53 earth stations involved with the experiments aboard the ACTS. Some of the major companies involved with active experiments include: Motorola, TRW, Loral, Martin Marietta, Hughes, Harris, MA/COM, Composite Optics and Electromagnetic Sciences.

Perhaps the most intriguing user of ACTS maybe the Army Space Command. They have established seven ground stations across the US using the T1-VSAT terminals. According to Ron Schertler, Chief of the ACTS experimentation program at Lewis Research Center, "the army has a comprehensive program of experimentation with the idea of demonstrating to local tactical commanders that they can get simultaneous voice, video, data and other multi-media type services at the battle front, in real time. They have been taking part in a number of system demonstrations with various tactical war fighting groups. They have shown that real time reconnaissance imagery from Remotely Piloted Vehicles (RPV) can be delivered directly to the tactical commander in the field in-



stantly." Currently, most electronic intelligence is first dropped off at the corp command headquarters in a somewhat untimely fashion. This satellite delivery system includes weather maps, fused intelligence data, video conferencing for forward commanders as well as the images from the RPV's.

In a recent operational test, the Army took three TI-VSAT terminals with them into Haiti. This experiment called for the satellite terminals to be used in logistics and support operations. It gave the troops more circuits and wider bandwidths to work with.

In addition the Army is using ACTS to experiment in developing a tele-medicine capability. Experiments consist of sending real time medical data and x-ray images from the battlefield to rear command and medical facilities. So far the Army has been very pleased with both the versatility and quality of the results.

One of ACTS key aspects is that it can connect into any public telephone network. So you have a seamless satellite to public telephone network inter-connect compatibility. The army tied the ACTS terminals into a ground station at Ft. Bragg which was then connected to the public phone system. This gave commanders in Haiti instantaneous telephone communications to anywhere in the United States.

The Army Space Command is looking hard at future requirements and capabilities of their own space-based communication systems. The main focus of their planning is to demonstrate to tactical commanders the practical use of highly specialized tasks that future satellites will be able to provide. They are currently, thanks to ACTS, giving commanders the hands-on experience they need to evaluate such systems. Army Space Command is busy trying to keep up with the demand for their ACTS related services."

According to Schertler,"the National Communication System (NCS) is experimenting with ACTS to back-up their commercial satellite communications links in time of war or natural disasters which could disrupt the governments ability to communicate."

Another major goal of the ACTS program is to push the envelope for higher and higher data rates in a given bandwidth. The end product is to provide better, user friendly services to the demanding consumer of the 90's. On Jul 7, 1995, an experiment was conducted by NASA's Ames research facility in San Francisco, California. Ames is responsible for the aeronautical and mobile experiments of the ACTS program.

In an effort to improve data rates for personal communication services that will be offered to airline passengers in the fu-

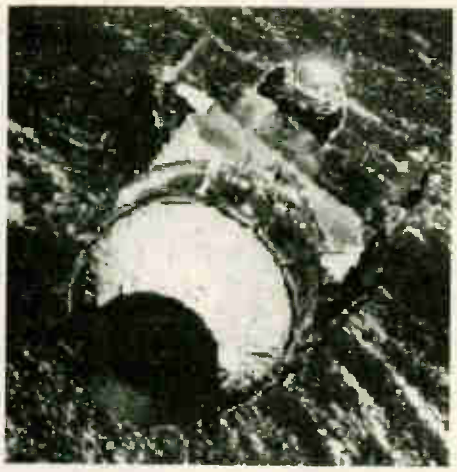


TABLE 1: *ACTS Communications Downlink Frequencies*

3700.5 MHz	C-band telemetry downlink
4199.5 MHz	C-band telemetry downlink
19200-20200 MHz	High baud rate downlink (900 MHz bandwidth)
19467 MHz	Low baud rate downlink (165 MHz bandwidth)
19910 MHz	High baud rate downlink (331 MHz bandwidth)
19914 MHz	High baud rate downlink (331 MHz bandwidth)
20185 MHz	Ka-band telemetry/propagation beacon downlink
20195 MHz	Ka-band telemetry/propagation beacon downlink
27505 MHz	Ka-band fade/propagation beacon downlink

ture, NASA's Kiper Airborne Observatory was used to conduct an experiment in which 1.5 Mbps data rates was uplinked to the ACTS. A special slotted waveguide antenna, which was manually controlled, was installed on the aircraft. JPL has been working on a phased array for the military and mobile operations which will allow far higher data rates, but it is still under development. Commercial industry, companies like Rockwell have shown an interested in this technology.

Lewis Research Center is working on two experiments with very high data rates. The first experiment is with Boeing Aircraft of Seattle, Washington. They are exchanging information on wind tunnel experiments and other numeric propulsion studies using super computers at a rate of 622 Mbps. Lewis has joined up with the Ohio Super Computer Center in Columbus and the National Center for Atmospheric Research in Bolder Colorado. They are working on atmospheric studies of the Great Lakes, again using super computers and the ACTS hign data rate (HDR) communications capability. The HDR terminals used in all these experiments are part of a joint program between NASA and the Advanced Research Projects Agency.

Other Experiments

Two final experiments we will mention that were recently conducted via ACTS were somewhat unique. The American Petroleum Institute placed a ACTS terminal on an oil platform some 40 miles offshore in the Gulf of Mexico. They relayed real-time seismic data to their on offices through ACTS to aid them in their work. In the future, they hope to be able to do real-time seismic data that will save time and money. This will eliminate ships from having to return to port to bring the seismic data in for study.

The second experiment was conducted by NBC. They were interested in two-way video communications and editing from mobile vans. Using two JPL terminals they were able to edit and multi hop broadcast quality video from their broadcasts vans at various locations throughout the U.S. to their studios in New York.

All of these companies, agencies and experiments are breaking new ground in advanced communications technologies. If these experiments prove fruitful, it could make possible in the future worldwide digitally-processed, satellite-based, user-friendly, voice, data and multimedia communication services from a phone the size of a beeper...till next time around. ST

By Jeffery M. Lichtman

Amplifiers for Radio Astronomy

The key to a sensitive receiver chain is the radio frequency (RF) amplifier. The lower the noise and the higher the gain, the better the receiver sensitivity.

In the May/June edition of this column, I reported on some of the earlier technology used in the field of radio astronomy research, namely parametric amplifiers and discrete components.

Amplifiers and the discrete components have been vastly improved over the past few years. For instance, RF amplifiers now have noise figures down in the .35 area, but several years ago parametric amplifiers had much higher noise figures. Transistor amplifiers were also not very quiet and generated a lot of thermal noise.

In the past few years, amateur radio astronomers have been utilizing the High Electron Mobility Transistor (HEMT) technology. These devices are excellent when compared with Gallium Arsenide Field Effect Transistors (GaAsFETs) for their extremely low noise figure and high gain.

Originally, HEMTs were very expensive, somewhere in the range of several hundred dollars. Yet professional radio astronomers were very willing to spend their budgeted money for the excellent results that these amplifiers achieved. The TVRO market also demanded low noise devices and this resulted in the mass production of these devices. At the present time, these devices are available for under $10.00.

HEMTS work in a slightly different way than GaAsFETS and the source/gate bias and the V_{DD} voltages have to be setup in a different way. Otherwise, the inductor/capacitor (L/C) components, construction, and tuning procedures are the same as the GaAsFET low noise amplifiers (LNA). If you observe the change in feed resistors shown in Table 1, you can still use the same L/C tables with GaAsFETs.

The main difference for HEMTs is that they are operated with a low +1.4 volts on the drain. This potential is setup by inserting approximately 180 ohms in series with a +5 volt regulator and the drain circuit. Additionally, the gate wants to see a low -.15 volts when measured to the source terminals. In self biasing, this is accomplished by raising the source terminals about 10 ohms from chassis ground as shown in the schematic. Total current passing into a good HEMT LNA is about 18 milliamperes. .5 milliamperes for the regulator and about 13 milliamperes for the HEMT.

TABLE 1 — *L/C Table for Various Frequencies*

Freq (MHz)	C1	C2	L1	L2	
470-550	0-6 pf	2-10 pf	2T #24 wire	8T #32 enamel thru1/8" form	ferret bead
550-700	0-6 pf	2-10 pf	1T #24 wire	8T #32 enamel thru1/8" form	ferret bead
700-900	0-6 pf	0-6 pf	1T #24 wire	8T #32 enamel thru1/8" form	ferret bead
1420	0-4 pf	0-4 pf	3/8" stub	8T #32 enamel thru#24 wire	ferret bead

To sum up, with the exception of the change of operating parameters, you can treat HEMTs the same as GaAsFETS in your construction. The improvement in performance is immediately noticeable. These devices show high gain and state of the art noise figure all the way out to 12 GHz and beyond.

Of course, you should also use the same precautions you use with GaAsFETS to protect these devices from static charges. It is always a good practice to build the LNA first and then carefully install the HEMT last. It is also important that you do not frequently interrupt the operating potential in a sparking manner. Even with a voltage regulator in between, you might destroy the device which is built to micrometer tolerances.

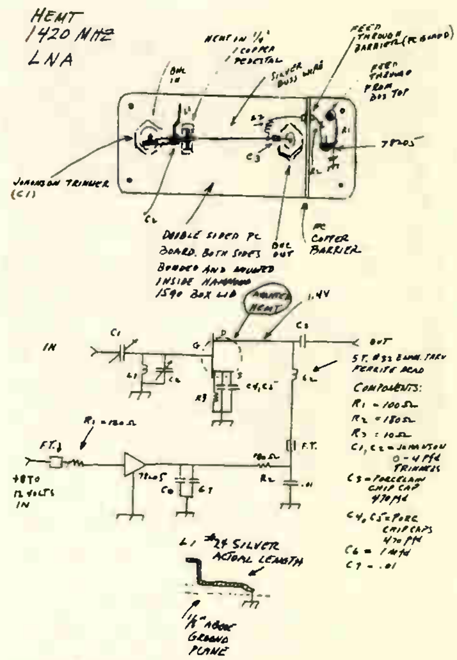


FIGURE 1: ***1420 MHz HEMT LNA Schematic/Pictoral***

The schematic detail in Figure 1 is for a HEMT LNA, designed for operation in the 1420 MHz Hydrogen Line band. In order to realize the very best performance from the device, we have avoided any possibility of signal radiation from PCB striplines and opted for point to point stripline wiring. Also, to realize high gain and low noise from these devices, high Q trim and cou-

TABLE 2: *MAR Amplifier Characteristics*

Min.	(dBm)		Typ.	(dBm)				Volts	(mA)	
MAR-1	DC	1000	13.0	0	5.0	+15	1.5:1	1.5:1	+5.0	17
MAR-2	DC	2000	8.5	+3	6.5	+18	1.3:1	1.6:1	+5.0	25
MAR-3	DC	2000	8.0	+8	6.0	+23	1.6:1	1.6:1	+5.0	35
MAR-4	DC	1000	7.0	+11	7.0	+27	1.9:1	2.0:1	+5.0	50
MAR-6	DC	2000	9.0	0	2.8	+15	2.0:1	1.8:1	+3.5	16
MAR-7	DC	2000	8.5	+4	5.0	+20	2.0:1	1.5:1	+4.0	22
MAR-8	DC	1000	19.0	+10	3.5	+27	3.1:1	3.1:1	+7.5	36

Table courtesy of Mini-Circuits

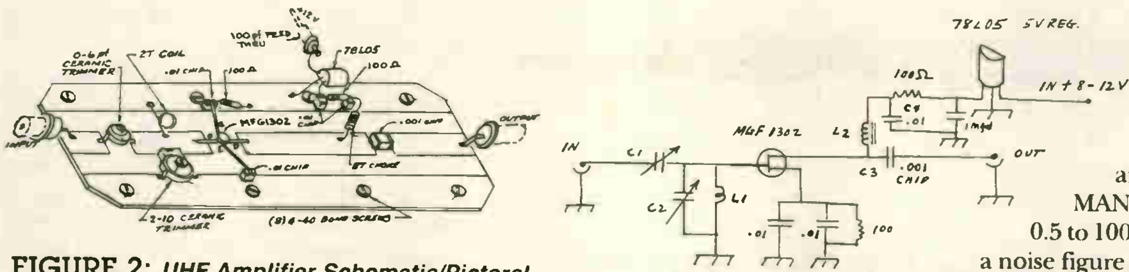


FIGURE 2: *UHF Amplifier Schematic/Pictoral*

pling capacitors are recommended. The slight additional cost of these high Q components are well worth the expense.

UHF GaAsFET Amplifier

A simple circuit UHF RF amplifier built by SARA (Society of Amateur Radio Astronomers) member, Mr. Tom Langevin of West Virginia, is shown in Figure 2. The frequency range is 470 - 900 MHz. The construction method is surface mount, stripline. Table 2 shows the associated LC values for various frequency ranges.

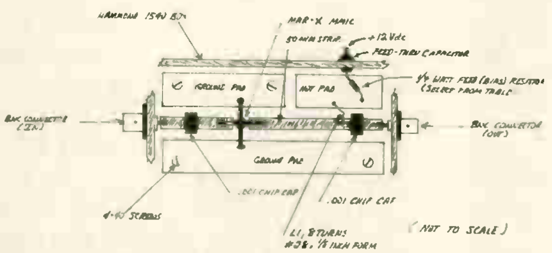


FIGURE 3: *Broadband NMIC Amplifier Pictorial*

Broadband Amplifier

There are many occasions when an additional boost of 12 to 21 dB of gain is necessary at the head end of your system. This is where an inexpensive broadband amplifier is a plus. These untuned amplifiers have slightly higher noise figures over other amplifiers mentioned above. This is not a problem, because you have already established a low noise figure in the prior stage GaAsFET or HEMT RF amplifier. These devices utilize silicon technology and are basically two transistors in a single package wired in a Darlington configuration. Various MMIC (Microwave Monolithic Integrated Circuit) devices may be used from 1 to 2 GHz.

To use these devices, all that is necessary is to select the appropriate input feed resistor and introduce the operating potential through a choke. The input and output signals are fed through chip capacitors. Table 2 provides information to determine the gain, noise figure, bias potentials, and usable frequency for these MMIC devices. Table shows the proper bias resistor for various supply potential voltages. Typical stripline construction for a single stage amplifier is shown here.

To obtain the correct circuit operation, select the device you are interested in from Table 2 which gives you the required gain, etc. Then you select the appropriate bias resistor from Table 3

Block Amplifiers

In the past, I have used block amplifiers from Mini-Circuits. Often referred to as a brick amplifier. These UHF devices are simple to use. All that is necessary, is to supply +12 vdc. There are two basic types in the MAN family, these are the MAN-2 and the MAN-LN, the LN being the lowest in noise figure. The MAN-1 performs well in the frequency range from 0.5 to 500 Mhz with a gain of 28 and a noise figure of 4.5 dB. MAN-2 operates in the range of 0.5 to 1000 MHz with a gain of 18 and a noise figure of 6.0 dB. Finally, MAN-LN operates in the range of 0.5 to 500 MHz with a gain of 28 dB and a noise figure of 2.8 dB. These devices should only be used as secondary amplifier stages in your radio astronomy station.

TABLE 3: *Bias Resistor Values for MAR Amplifiers*

Amplifier	Bias Current I_B (mA)	Bias Voltage $+V_O$	Approximate Bias Resistor (Ohms) +5V	+9V	+12V	+15V	Resistor Dissipation(Watts) $+V_{CC} = 12V$
MAR-1	17	5	—	235	412	588	.12
MAR-2	25	5	—	160	280	400	.18
MAR-3	35	5	—	114	200	286	.25
MAR-4	50	6	—	60	120	180	.30
MAR-6	16	3.5	98	344	531	719	.14
MAR-7	22	4	45	227	364	500	.18
MAR-8	36	8	—	—	111	194	.14

Table courtesy of Mini-Circuits

If you would like more information on Mini-Circuit amplifiers can contact the company at the following address and telephone number:

Mini-Circuits
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Brooklyn, NY 11235-0003
Telephone: (718) 934-4500 (voice) (718) 332-4661 (fax)

In July of this year, the Society of Amateur Radio Astronomers (SARA) held their yearly conference at the National Radio Astronomy Observatory (NRAO) located in Green Bank, West Virginia. In a future edition of this column I will report on the conference and programs presented.

Those of you interested in the exciting hobby of amateur radio astronomy listening can get more information by contacting the Society of Amateur Radio Astronomers (SARA) membership services by writing Mr. Vincent Caracci, 247 N. Linden St., Massapequa, N.Y. 11758.

Information presented in this column came from The Radio Astronomy Handbook *by Robert M. Sickels and Mini-Circuits Corporation.* ST

Hubble Sheds Light on the "Faint Blue Galaxy" Mystery

Astronomers using NASA's Hubble Space Telescope have solved a 20-year-old mystery by showing that a class of galaxy once thought to be rare is actually the most common type of galaxy in the universe.

Analyzing some of the deepest images ever taken of the heavens, the astronomers conclude that small irregular objects called "blue dwarfs" were more numerous several billion years ago, outnumbering the spiral galaxies like our Milky Way, and giant elliptical galaxies as well. This means the blue dwarfs are a more important constituent of the universe and figure more prominently in the evolution of galaxies than previously thought, researchers say.

Irregular Blue Galaxies HST · WFPC2
PRC95-08b · ST Sci OPO · July 24, 1995
R. Windhorst (AZ State Univ.), NASA

The discovery was made by the international Medium Deep Survey team, led by Richard Griffiths of the Johns Hopkins University, Baltimore, MD, and extended by a deeper survey with Hubble Space Telescope by a team led by Rogier Windhorst of Arizona State University, Tempe, AZ.

"The new results have overturned the conventional picture of a universe dominated by giant grand-design spiral systems and elliptical galaxies," said Griffiths. "Instead, we're going to have to come up with a new way of understanding the distorted galaxies we see in huge numbers, which seemed to have formed later than the giant galaxies."

However, they say it is not clear whether these small irregular systems are indeed the building blocks of galaxies like the Milky Way, or have simply faded into obscurity.

"Most of these faint objects are extremely blue in color, a strong indication that they are undergoing a brief, rapid burst of star formation," said Windhorst, who along with William Keel of the University of Alabama, Birmingham, AL, conducted a separate survey of remote galaxies.

These faint galaxies were randomly imaged as part of a key Hubble Space Telescope project, called the "Medium Deep Survey. "The survey uses Hubble's Wide Field and Planetary Camera 2 (WFPC2) to search for unexpected objects in uncharted areas of sky. This highly efficient and cost-effective survey is conducted in "parallel mode" where the WFPC2 takes detailed pictures while a "primary" instrument, such as a spectrograph, collects data from a predetermined celestial target.

For the past 17 months, Griffiths and co-investigators from the United States (Richard Green, John Huchra, Garth Illingworth, David Koo, Kavan Ratnatunga, Tony Tyson, Rogier Windhorst) and the United Kingdom (Richard Ellis, Gerry Gilmore), have studied more than 50 random snapshots containing high resolution information for a total of tens of thousands of galaxies.

"We were immediately struck by the large numbers of irregular and peculiar galaxies in these HST random images," said Griffiths.

Another deeper Hubble image has further extended these exciting results. The image was obtained by Windhorst and Keel, and analyzed by Simon Driver of Arizona State University, Windhorst, and associates.

"At last, Hubble has allowed crystal clear images of these extremely faint objects, and we find that our universe is dominated by distorted systems of stars," said Driver. "At the faintest limits more than half the galaxies seen are such systems."

"We all know that the (clear) sky during the day is blue — due to scattered sunlight — but if your eyes had much more sensitivity, they would also see a very dim blue glow in the sky at night caused by myriads of faint blue galaxies, the mysterious nature of which was unknown until we imaged them in detail with Hubble," said Windhorst.

The researchers are now measuring the distances to these galaxies using the new generation giant telescopes on Earth.

Hubble Uncovers Surprisingly Complex Structures in Radio Galaxies

Probing some of the most distant and energetic galaxies in the universe, NASA's Hubble Space Telescope has uncovered surprisingly varied and intricate structures of stars and gas that suggest the processes powering these so-called radio galaxies are more complex than previously thought.

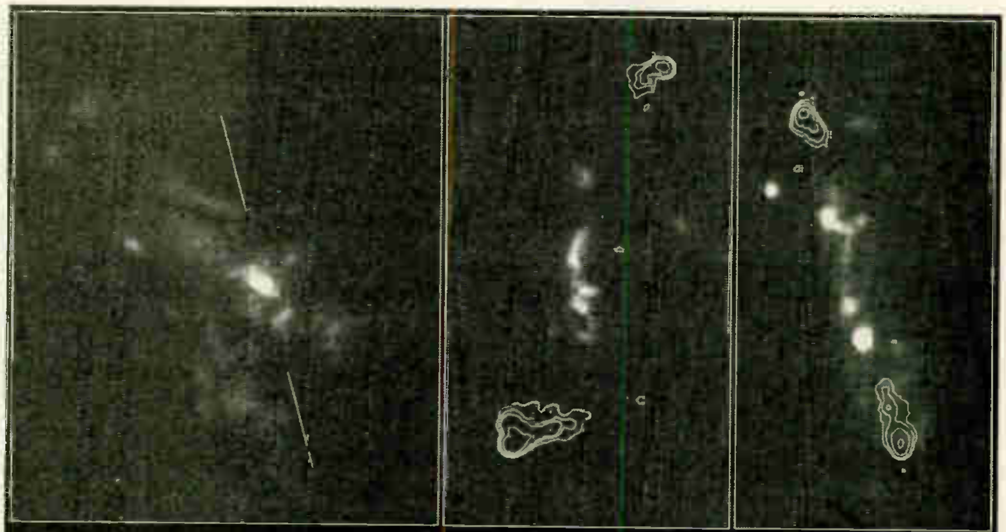
The Hubble observations, made by a team of astronomers at Cambridge University, England, should shed light on the nature of active galaxies, that might be powered by immense black holes at their cores, and more generally, on galaxy evolution. The radio galaxies observed are so far away they existed when the universe was half its present age, and the light is only now reaching us.

The bizarre, never-before-seen details

may be a combination of light from massive star forming regions, small satellite dwarf galaxies, and bow shocks caused by jets of hot gas blasted out of the galaxy's core by a suspected black hole.

The observations were made by Professor Malcolm Longair and Philip Best of the Cavendish Laboratory, Cambridge University, and Huub Rottgering of Leiden Observatory, The Netherlands, who have published images of three radio galaxies (3C368, 3C324 and 3C265) in the August 1, 1995 issue of the Monthly Notices of the Royal Astronomical Society.

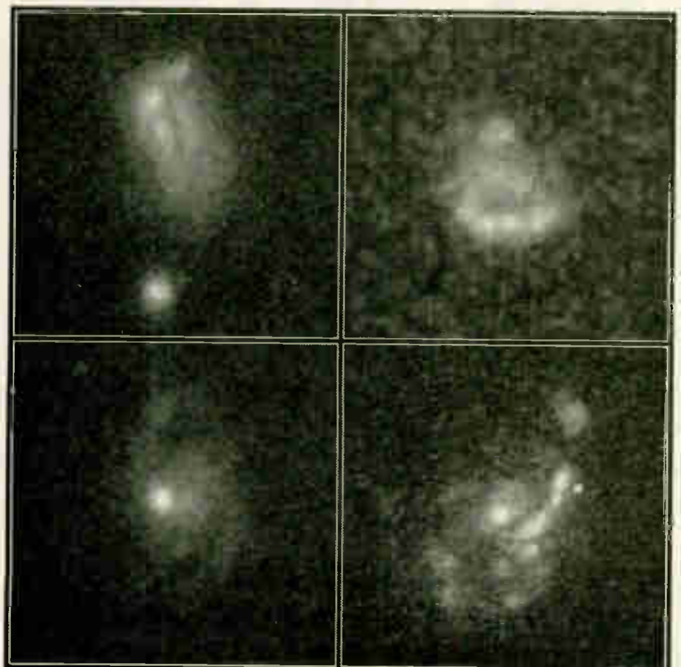
The team is analyzing a sample of 28 radio galaxies that have been imaged by Hubble in visible light, by the Very Large Array Radio Interferometer at radio wavelengths, and by the United Kingdom Infrared Telescope.



HST Observes Radio Galaxies HST · WFPC2

PRC95-30 · ST ScI OPO · August 7, 1995 · M. Longair (Cavendish Lab.), NASA

A radio galaxy emits powerful radio waves along two opposite directions pointing out from the galaxy's core. The radio lobes usually extend far beyond the host galaxy. The suspected powerhouse behind the radio emission is a one-billion solar mass black hole in a galaxy's core. Gaseous jets, traveling at nearly the speed of light, blast out along the rotation axis of the spinning black hole. These jets bore through space like a narrow stream of water from a garden hose nozzle plowing through sand.



Medium Deep Survey HST · WFPC2

PRC94-39b · ST ScI OPO · R. Griffiths (JHU), NASA

When they are finally stopped by the intergalactic medium, a huge amount of energy is released in the form of radio waves.

Previous ground-based observations since 1987 have shown that, in visible light, distant radio galaxies have an unusual elongated structure — unlike the classic spiral and elliptical shapes in normal galaxies — that align to the twin lobes of radio emissions that are the trademark of such active galaxies. In the Hubble views, these shapes break up into a string of bright knots that might be regions where new stars are forming, or could be glowing clouds of gas. In one galaxy, the knots align to the axis of the jet, while in another case they do not, and instead cluster around the galaxy like smaller "satellite" galaxies.

One explanation for the alignment between the invisible jets and optical structures is that the jets trigger the formation of stars along their paths. However, some of the galaxies emit highly polarized light. Since this type of light is not produced by stars, other processes must be at work. A possible explanation is that the light from the galaxy's hidden active nucleus is scattered in our direction by dust or electrons.

Longair, Best and Rottgering propose that the remarkable structures seen in the Hubble images are different manifestations of activity associated with radio galaxies. They conclude that at least two mechanisms must be responsible for the alignment effect, with both scattering of nuclear light and star-formation playing a role. They also note that the period during which there is strong radio emission is quite short relative to the total lifetime of a galaxy, so different processes may dominate as the radio source ages. They are planning further observations to determine the relative importance of the different effects. ST

Photos courtesy of the Space Telescope Science Institute.

by Wayne Mishler, KG5BI

Rugged Antennas are Gentle With Delicate Signals

The sport of DXing satellites is getting easier. A company that goes by the name of Woodhouse Communication is seeing to it, through their robust but selective line of VHF antennas.

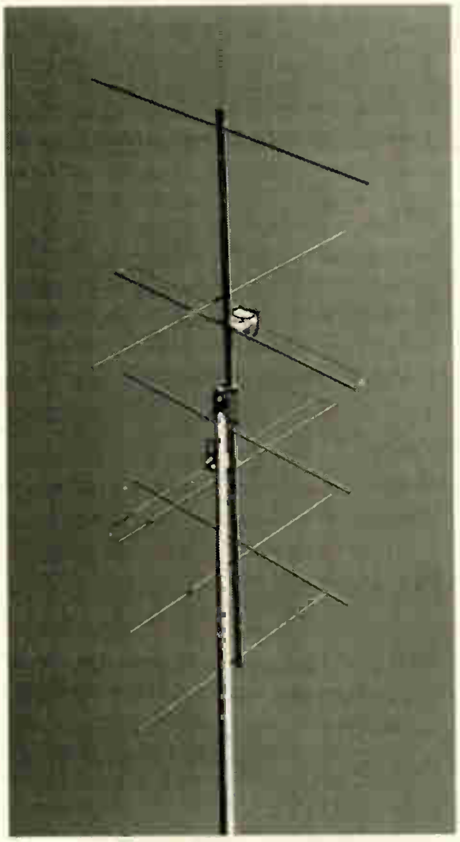
Their claim that "Woodhouse antennas are built to last" is pure modesty. Their antennas are made of 6061-T6 aluminum and stainless steel, right down to the last screw, nut, lock washer, and even the clamps and mounting brackets. The boom material is 1-inch outside diameter aluminum tubing with .065-inch thick wall. That's heavy. Elements are 3/8-inch solid rod that passes through the boom and is secured with a threaded machine screw. No crimping or self-tapping sheet metal screws for them. The driven element connector and balun block is milled from HDPE, known for its UV stability, cold temperature tolerance, and mechanical strength. HDPE is used to line the beds of dump trucks. It's tough. Woodhouse uses Belden cable for all their baluns, and their connectors are all Amphenol. These are world class antennas.

One of the antennas they manufacture, the APT-4X4, is made specifically for pulling in faint signals from polar orbital satellites.

"The APT-4X4 is the only circular polarized yagi antenna for 137 MHz orbital satellites we are aware of. This quality antenna carries the same tough construction and conservative design of our other antennas. It is available in a standard center mount or heavier duty rear-mount version," says Woodhouse.

The APT-4X4 standard sells for $249.95.

The standard mount uses a 35-degree fixed mounting bracket, for use with azimuth rotor. It holds the antenna to a vertical mast at a 35-degree incline, offering good performance on low-angle passes without an elevation rotor, a real money saver. The price of this mount is only $29.95



The mobile version of the APT-4X4, which Woodhouse calls the APT4X4RM, is an even tougher antenna that features stabilized elements to reduce wind noise at highway speeds. They say this antenna lets you chase satellite signals all over the countryside while pulling in the weak, low-angle passes.

The mobile version sells for $525.95.

Getting the most signal from your antenna

Not only does Woodhouse make and sell satellite antennas, they even tell you how to get the most from them. Their literature offers these tips for satellite DXing:

Signal levels from satellites may be as low as .1 microvolt (that's millionths of a volt) when you first acquire the bird. The signal may peak at .3 microvolts, including antenna gain. This is not much signal to work with. The difference between satellite signals and VHF radio signals is apple and oranges. In radio, voice signals are typically 5 KHz in bandwidth. The bandwidth of satellite signals, on the other hand, is usually about 45 KHz. Wider bandwidth means more noise. The trick is to increase signal strength without increasing noise levels. It takes a good antenna to do this, like the APT-4X4.

So why not just use a pre-amp and be done with it?

Pre-amps can be useful for long-haul, low angle passes, but be careful. Pre-amps will amplify the incoming signal all right, and they will also increase the noise of the entire system. They can actually reduce quality of reception due to increased intermodulation. If you decide to use a pre-amp, make sure you have a good, frequency-selective antenna ahead of it, and use only a quality pre-amp designed specifically for 137 MHz, not a broad-band preamp or one designed for 2-meter radio reception.

How important is the feed line?

You will want to use a good feed line with low loss and good shielding. Belden 9913 is a good cable for long runs. If you are close to the antenna, consider using Belden 9258 (RG-8X).

What about antenna height?

In satellite reception, height is only important for near-field clearances. Your horizon will be substantially determined by close objects (hills, buildings, etc..) If you have nothing nearby to limit the horizon or to cause reflections, raising the antenna to a great height may not be worth the effort and expense.

Why is intermod a problem?

The three most significant contributors to intermodulation problems are low signal level, local stations with strong signals, and a poor antenna. The 137 MHz frequencies of satellite transmissions are close to those of interfering stations, such as paging services and aircraft radio transmissions. These are strong local signals that can cause intermod problems. This is especially true when you consider the wide bandwidth of satellite receivers. Non-resonant antennas, such as discones and log periodic antennas, will pass the non-desired signal along with the desired one. Your best defense in the war against intermod is a frequency-selective antenna with the ability to reject unwanted signals.

Look for problems in your back yard

An unbelievable number of devices can radiate noise throughout the VHF spectrum, and this can degrade the quality of your received satellite image. The high sensitive of the receiver and its wide bandwidth will work against you.

Computers are notorious noise makers. This is unfortunate because you probably will have to be operating your computer to capture images. But there are some fixes. For example, modems are noisy. If your computer has one, try disconnecting the telephone line cord from it.

Here are some other tips:

- Be sure your antenna rotor contacts are by-passed with capacitors. Do not run your rotor cable next to your antenna coax.
- Some satellite demodulators have internal clocks that radiate interference throughout the VHF bands.
- Whatever you do, do not transmit with a 2-meter ham radio while trying to receive a satellite pass.
- And try not to let anyone in the house fire up the microwave oven while you are receiving.
- Those little winding motors in older automatic set-back thermostats are great little wide-band noise generators.
- From a mile away you can hear an electric fence clicking, clicking, clicking...
- Check any other receivers you may have running, especially VHF units. Their local oscillators or mixers may be producing intermod problems.
- Hair dryers of course create havoc in the VHF spectrum, but approach this one with caution. Family relationships are important, too.
- Don't be surprised if you find interference being generated by your water heater or hot tub. Any high current switch, such as thermostats, can be a real problem.

There are other possible causes, but these may get you started in your search for interference.

Woodhouse Communication can be reached at (616) 226-8873 (voice) or 226-9073 (fax).

DIRECTV Viewers Add MSG to Their Visual Diet...No, Not the Preservative

DIRECTV is adding the Madison Square Garden (MSG) network to its impressive lineup of regional sports programming.

As of July 4, DIRECTV was to begin broadcasting MSG events nationwide to subscribers of its Sports Choice package, and to New York area subscribers of its Total Choice package.

In all, DIRECTV delivers more than 150 channels of digital entertainment programming to owners of the DSS system, which features an 18-inch dish.

MSG, one of the nation's leading regional sports networks, carries collegiate football and basketball from the Big East conference, including Georgetown, Seton Hall, Boston College, Connecticut Pittsburgh.

With the addition of MSG, there are now 18 regional sports networks available on Sports Choice. Price of the package is $7.95 per month.

Addition of MSG to the Total Choice package means that subscribers in the New York area will now be able to view the Yankees, Knicks and Rangers games.

"MSG is one of the most popular regional sports networks in the nation," says DIRECTV president Eddy Hartenstein.

Marty Brooks of MSG points out that Knicks, Rangers and Yankees fans nationwide will now be able to watch their favorite teams all year long.

"Sports fans will be exposed to MSG's Sports Desk covering the happenings in the New York sports scene and have the opportunity to see extensive pre and post game coverage during every broadcast of the Knicks, Rangers and Yankees," he said.

Mobile Satellite Communications Handbook Debuts

Assembling a comprehensive book on the subject of mobile satellite communications was a daunting task in this extremely dynamic and diverse industry, says author Roger Cochetti, but his handiwork, *The Mobile Satellite Communications Handbook*, has debuted in style. It is the first and only reference book available for this emerging technology.

The Mobile Communications Handbook covers in depth the impact that satellite communications is having on business practices and standards of living worldwide. Mobile satellite communications is beginning to touch the lives of millions of people. Tiny satellite terminals costing less than a personal computer will become increasingly common in cars, trucks, boats, airplanes, and even briefcases and handheld telephones. To meet the rising demand, more than a dozen new mobile satellite communication systems are being planned, built, and introduced world wide. All are covered in the handbook.

The book's author is vice president of business development and planning for COMSAT Mobile Communications. Previously, he was assistant director, for legislative and public affairs, of the U. S. International Development Cooperation Agency.

The 342-page hardbound reference book is available for $95 from Quantum Publishing, Inc. Their mailing address is Box 1738, Mill Valley, CA 94942. You can call them toll-free by dialing 1-800-422-9666. They offer a free 32-page catalog of their publications.

Books and equipment for announcements or review should be sent to "What's New" c/o Satellite Times, P.O. Box 98, 300 S. Hwy 64 West, Brasstown, N.C. 28902

COMPUTERS & SATELLITES

By Dr. T.S. Kelso

Orbital Coordinate Systems, Part I

At this point, I hope to have helped you develop an understanding of two key aspects of practical orbital mechanics. The first has to do with why we use the orbital models we do for predicting the position of earth-orbiting artificial satellites. As with any computer model, orbital models must trade off accuracy for computational speed. Which model you decide to use will depend upon which of these factors is most important to you.

Of course, from a practical perspective, the choice of orbital model is also strongly influenced by the availability of data (element sets). Knowing that orbital element sets are generated by fitting observations to a trajectory based upon a particular orbital model is the second of our key aspects. Accuracy of our predictions will depend upon using that same orbital model.

However, all we've really talked about are orbital element sets. But how do we get from the data in these orbital element sets to something we can use, such as knowing where to look (or point an antenna) when a satellite passes over? To answer this question requires an understanding of the various coordinate systems involved and how to transform coordinates (typically position and velocity) from one system to another. The correct application of these coordinate transformations is every bit as important to our overall accuracy as the selection of the orbital model itself.

Let's start with the orbital element sets themselves and discuss some terminology. The two most common forms of orbital element sets are *state vectors* and *Keplerian orbital elements* (e.g., the NORAD two-line element sets). A *state vector* is a collection of values (states) that if known, together with the *state transformation rules* (how the state vector changes over time), the state vector for any past or future time can be computed. For a satellite in Earth orbit, if we

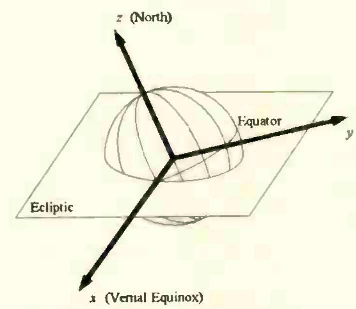


FIGURE 1: ***Earth-Centered Inertial (ECI) Coordinate System***

ignore atmospheric drag and maneuvering, the state vector would be comprised of the satellite's position and velocity. Knowing the position alone would not be sufficient, since a satellite with zero velocity would fall to Earth while one with orbital velocity would not, even if the satellites start at the same physical location.

We cannot, however, talk about position and velocity without discussing the coordinate system that these values are measured relative to. For most state vectors, this is the *Earth-Centered Inertial* (ECI) coordinate system. The first part of this designation should seem fairly obvious. That is, since we're studying objects that revolve around the center of the Earth, it seems natural to have the center (origin) of our coordinate system at the center of the Earth. Inertial, in this context, simply means that the coordinate system is not accelerating (rotating). In other words, it is 'fixed' in space relative to the stars. We shall see that this is an ideal definition of the ECI coordinate system, but we won't worry about the slight rotations involved until later.

The ECI coordinate system (see Figure 1) is typically defined as a *Cartesian* coordinate system, where the coordinates (position) are defined as the distance from the origin along the three orthogonal (mutually perpendicular) axes. The *z* axis runs along the Earth's rotational axis pointing North, the *x* axis points in the direction of the *vernal equinox* (more on this in a moment), and the *y* axis completes the right-handed orthogonal system. As seen in Figure 1, the vernal equinox is an imaginary point in space which lies along the line representing the intersection of the Earth's equatorial plane and the plane of the Earth's orbit around the Sun or the *ecliptic*. Another way of thinking of the *x* axis is that it is the line segment pointing from the center of the Earth towards the center of the Sun at the beginning of Spring, when the Sun crosses the Earth's equator moving North. The *x* axis, therefore, lies in both the equatorial plane and the ecliptic. These three axes defining the Earth-Centered Inertial coordinate system are 'fixed' in space and do not rotate with the Earth.

Now, while state vectors are normally used with numerical integration models for highly accurate calculations, Keplerian orbital elements are used for the vast majority of orbital predictions. But, the ECI coordinate system is still often used as the common coordinate system when performing coordinate transformations. For example, before a calculation can be made of the distance between a satellite and an observer on the ground, both the satellite and the observer's position must be defined in a common coordinate system. Since the satellite's position is typically represented by a Keplerian orbital element set and the observer's position is given in latitude, longitude, and altitude above the Earth's surface, we cannot perform the calculation directly without first converting to a common coordinate frame.

As it turns out, the NORAD SGP4 orbital model takes the standard two-line orbital element set and the time and produces an ECI position and velocity for the satellite. In particular, it puts it in an ECI frame relative to the "true equator and mean equinox of the epoch" of the element set. This specific distinction is necessary because the direction of the Earth's true rotation axis (the North Pole) wanders slowly over time, as does the true direction of the vernal equinox. Since observations of satellites are made by stations fixed to the Earth's surface, the elements generated will be referenced relative to the true equator. However, since the direction of vernal equinox is not tied to the Earth's surface, but rather to the Earth's orientation in space, an approximation must be made of its true direction. The approximation made in this case is to account for the precession of the vernal equinox, but to ignore the *nutation* (nodding) of the Earth's *obliquity* (the angle between the equatorial plane and the ecliptic). We'll address how to use this level of detail in a future column.

So, we now know that whether we're using state vectors or Keplerian orbital element sets, our calculations will likely yield ECI position and velocity. Let's begin working now to answer two common questions in satellite tracking. The first question is: Where do I look or point my antenna to acquire a particular satellite? The second question is: What is the latitude, longitude, and altitude of that satellite? These questions come up frequently, whether the goal is to watch the US Space Shuttle and Russian Mir Space Station pass overhead, to acquire an amateur radio satellite, or to determine the longitude of a geostationary TVRO satellite. But, to be able to answer these questions, we will need to determine either the position of an observer on the Earth relative to the ECI coordinate frame or the position of a satellite relative to the Earth. In either case, we will need to know the rotation angle between the Greenwich Meridian (zero degrees longitude) and the vernal equinox and, hence, the orientation of the Earth relative to the ECI coordinate frame.

Let's start by calculating the position of an observer in the ECI coordinate frame. For our initial discussions, we'll assume a spherical Earth. This assumption is not a particularly good one, as we'll see in our next column, but will make the initial development easier to follow. The calculation of the *z* coordinate is straightforward, as can be seen in Figure 2. This figure shows a side cutaway of the Earth with North up. For an observer at latitude *ö*, the *z* coordinate is shown in Figure 2, where R_e is the Earth's equatorial radius. To calculate the *x* and *y* coordinates, we will also need the value of *R* from Figure 2. If we wanted to calculate *z* and *R* for distances above mean sea level, we would simply replace R_e with $R_e + h$, where *h* is the distance above mean sea level.

Computing the *x* and *y* coordinates requires a bit more work. Since the Earth rotates in the *x-y* plane (i.e., about the *z* axis), the *x* and *y* coordinates of a point on the Earth's surface will vary with time, unlike the *z* coordinate. However, if we know the angle between the observer's longitude and the *x* axis (the vernal equinox), we can specify the *x* and *y* coordinates as a function of time. In fact, if we designate the angle between the *x* axis and the observer's longitude as *è ô*), where ô is the time of interest, *x*(ô) and *y*(ô) are given in Figure 3. This figure shows a slice through the Earth, parallel to the equatorial plane and through the observer's location.

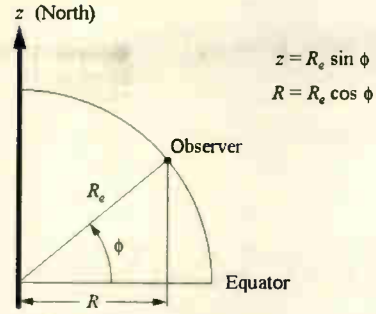


FIGURE 2: ***Latitude to ECI Conversion***

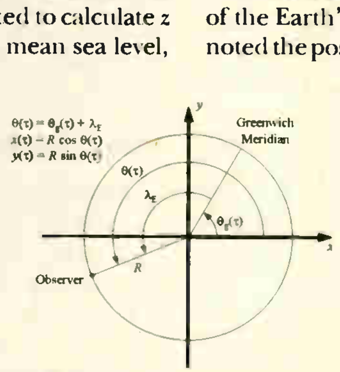


FIGURE 3: ***Longitude to ECI Conversion***

Upon first inspection, these equations would seem straightforward enough. But just what is *è ô*) and how is it calculated? The function *è ô*) is what astronomers refer to as the *local sidereal time*. *Sidereal time* is simply time measured relative to the stars. In our day-to-day lives, we are used to measuring time relative to the position of the Sun because of its obvious position in the heavens. This time scale is referred to as *mean solar time*. As with any time system, time is defined as the angle between the observer and some reference direction. With mean solar time, the reference direction is the direction of the mean sun; with sidereal time, the direction is the vernal equinox – just the direction we need for our calculation. So what causes the difference between these two time scales?

As seen in Figure 4, the position of the Sun moves with respect to the stars because of the Earth's orbit around it. Let's say we noted the position of the Sun relative to the stars when it crosses our meridian (longitude) on one day. By definition, that passage is called local noon. However, when that same position relative to the stars crosses our meridian on the following day, the Sun will not yet have reached our meridian. That is to say, the position will cross our meridian before local noon. The interval of time between two successive meridian crossings of a fixed position in inertial space is referred to as one *sidereal day*. Sidereal midnight occurs when the vernal equinox crosses the meridian. The interval of time between two successive meridian crossings of the mean sun is referred to as one mean solar day. As seen in Figure 4, the Earth must rotate a bit more for a mean solar day than for a sidereal day. In fact, a sidereal day is only $23^h56^m04^s.09054$ of mean solar time. This difference, while small, is extremely important.

While we've covered a lot of ground in this column, we obviously still have a bit more to go before we can answer the questions raised above. For our computer implementation, we will first need to develop a procedure for calculating the Julian Date in our last equation. Then, we will need to refine our conversion from latitude, longitude, and altitude to ECI coordinates to incorporate an oblate (flattened) Earth. When we make this refinement, we will also see the magnitude of error which can occur if this factor is ignored. At this point, we will have finished our first coordinate transformation and will be able to calculate the vector from the Earth observer to the satellite. We will then begin the process of developing our second coordinate transformation, that from ECI to the topocentric-horizon or azimuth-elevation coordinate system. It is this system which will allow us to measure the position of a satellite relative to the Earth's surface.

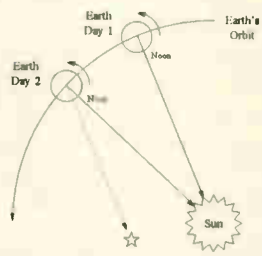


FIGURE 4: ***Sidereal versus SolarTime***

We will also begin to include snippets of computer code to illustrate the theory we're developing here. If you'd like to look ahead, these routines can be found in the file **sgp4-pl2.zip** at **ftp://archive.afit.af.mil/pub/space** or on the *Celestial BBS* at (334) 409-9280.

As always, if you have questions or comments on this column, feel free to send me e-mail at **tkelso@afit.af.mil** or write care of *Satellite Times*. Until next time, keep looking up! **ST**

By Ken Reitz, KC4GQA

Beginner's Guide To The MILSATs

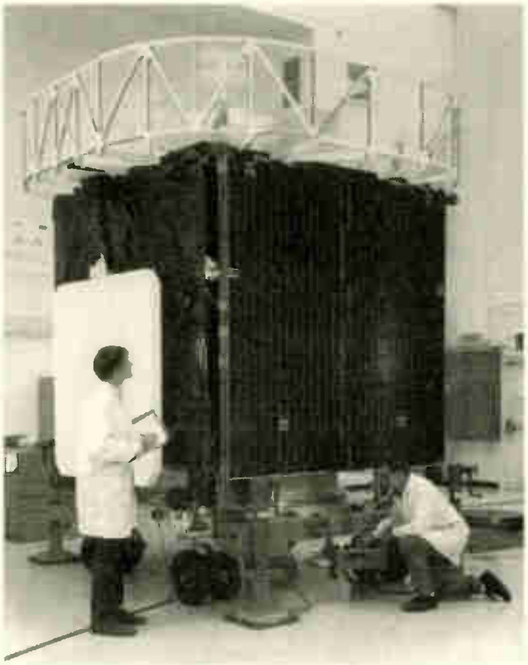
Back in the bad ole days of the Cold War, a terrific amount of money was being spent on the continuous upgrading of America's military superiority. And I'm not just talking about $200 hammers and $500 toilet seats, a certain amount of this outlay went toward the development of military communications. Following the success of early experimental satellites in the late 60's, the first of the modern geostationary satellites went into service nearly ten years later.

The ensuing two decades have brought a continued refinement of this communications capability. Today ships at sea can contact fixed locations, well, like, the Pentagon for example, and find out who's up for promotion without having to wait for the previously approved transmission mode — the message in a bottle.

The advantages should be obvious, but I'll reiterate them just in case you've already fallen asleep this early in the column. "Speed, accuracy and privacy!", barked the Admiral when asked by a Congressional Subcommittee on the desires of the military brass (what he would like to see in the way of improvements over the old system).

By mere coincidence, this is exactly what one gets when one orders up a state-of-the-art communications satellite. Building on the WWII-era scheme concocted by ex-military man Arthur C. Clarke (who by this time was wandering around the Himalayan Mountains, in native attire) a system of three satellites equally spaced about the Equator would provide global coverage for our worldwide military presence.

And, there you have it — a communications system very similar to the broadcast satellites we've talked about so much in previous columns with one or two notable differences. This is two-way communications and it's done on frequencies in the 240-400 MHz band. Actually, the only similarity is that it is a geostationary satellite with a transmission beam which covers the continental United States (CONUS).



The U.S. Navy's UHF Follow-On F-3, undergoes mass property testing in El Segundo, Calif. (Photo courtesy of Hughes Space and Communications)

Reception Requirements

First of all you might as well know that you won't be able to transmit on these satellites. Monitoring the military satellites will not be anything like listening to TVRO SCPC reception, analog TVRO FM subcarriers or even your police scanner. As with any type of monitoring there are basically four components to reception: The antenna, the feed line, the receiver, and the wallet. The most important of all is, of course, the wallet.

The Antenna

Let's look at the antenna first. Right away we're in a quandary. You'd like to be able to use your scanner antenna, but there are a few problems. First, omni-directional antennas are out because our target is a small dot in the sky some 22,300 miles away. Horizontally or vertically polarized antennas are out because these satellites transmit a right hand circularly polarized (RHCP) signals. Also the power output of these satellites is so small that you're going to need all the antenna gain you can get.

Please, wipe those tears from your eyes because *Satellite Times* has, once again, come to your rescue. Author Chuck Morrison wrote a dandy little piece in *ST* called "A Helical Antenna for FLTSATCOM Reception". In case you don't remember this article you will find it in the November-December 1994 issue and a reprint of the article can be obtained for $2.00 and an SASE from Brasstown. Morrison built this antenna for about US$10.00 out of materials from a local builder's supply.

The Feedline

This is critical. I don't want you spending your weekend constructing a chicken wire masterpiece only to blow it by trying to feed the antenna to your receiver with junk wire. You want to use what the pros use, a high grade 50 Ohm feedline such as the Belden 9913 (favored by AMSAT operators). Oh sure, you'll gripe a lot about how expensive it is and reach for some hamfest bargain cable, but DON'T! You can find Belden 9913 in the amateur radio supply catalogs for about 60 cents/foot. Here's a tip that will save you some money on that coax purchase — make the cable as short as possible by placing your antenna as close to the receiver as you can.

The Receiver

You have probably heard the stories like I have. Some guy in his basement in Detroit is receiving all the military UHF satellite signals with full quieting using a hand-held scanner and a rubber stubby antenna. I don't know how. All I know is that your experience will be totally different. You're going to need all the signal you can get. But a great signal is useless without a decent receiver.

Now, in the satellite biz, when we talk about receivers we usually mean expensive and exotic. You may not consider a scanner very exotic, but the decent ones are expensive. Serious and wealthy MILSAT enthusiasts will head straight for the ICOM R7100-2 which covers nearly everything in the RF spectrum (and for $1,300 does it better than anything else!). The less financially endowed will purchase the new Radio Shack Pro-2035 which covers nearly the same frequencies for $900 less.

Just make sure the receiver can scan between 240-400 Mhz, have both wide and narrow bandwidths in the FM mode, have a digital frequency display reading to three decimal points (four is preferred), and have a BNC, SO-259, or N-connector (preferred) external antenna connector for your homebrew antenna.

Accessories

After spending a few weeks monitoring the MILSATs it may occur to you that certain other accessories would be nice, like well, a uniform or a swagger stick or maybe a pair of those old Cold War style Russian hobnail boots. Anyway, that'll be the easiest and cheapest part.

Who's Up There Anyway?

As you may have imagined, a lot of what you think you might like to hear you can't. Which is to say, the good stuff is encrypted. And why not? This is a National Security issue! We can't allow everybody with a scanner to eavesdrop on our military communications. If this was the case, even our enemies wouldn't need spies. So, if they want to listen in, they'll just have to do it the old fashioned way — bribe a trusted official with a serious drinking, gambling or drug problem.

U.S. citizens must content ourselves with listening to the unencrypted channels, for instance, when ships at sea are involved in a daring sea rescue or ordering pizza. You will also hear a number of other transmissions on these frequencies which are not coming from the military, but other government agencies and contractors as well.

A number of books and publications are available which will help you locate exact frequencies for these little known satellites. Your first stop should be the Grove Catalog which features titles specifically on scanning the military. In addition to this magazine, *Monitoring Times* often feature articles of interest to scanning and military satellite enthusiasts. Look for subscription information elsewhere in this magazine.

Mail Bag

Mohamed Noui of Elgin, IL writes that as an Algerian citizen residing in the States he would like to receive Algerian TV and Radio Services which are carried by the Eutelsat II-F3 and Intelsat I-601 satellites. He would like to know what kind of equipment would be necessary for such reception.

Sadly, we can't receive Eutelsat anywhere in this country. It's just too far away. Worse yet, I can find no reference to Algerian TV on Intelsat I-601. If anyone knows any different please correct me (C-band transponder 24-Larry). At any rate 601 is at 27.5 degrees West which would put it considerably down on the horizon in the Chicago area. I'm not sure you could see the satellite even if it did have the programming you desire.

Joe Thompson of Ft. McCoy, FL, a new TVRO owner, checks in with a number of interesting questions:

1. Why can't Ku-band signals from the Anik satellites be seen in Florida.
2. Is Solidaridad 2 active?
3. What's going on with the various Ku-band formats?
4. Why is Morelos 1 (109.2° West) Ku listed as being in a inclined orbit and the C-band listing is not?
5. Where are the *CNN Live* and Larry King feeds?
6. What's the deal with F5?
7. What happened to *CNN Airport Channel*?
8. With the Drake 1824 and VideoCipher II what would it take to receive digital video now?

Whew! Well, Joe, that's enough questions for an entire column! The deal with Anik E1 and E2 Ku-band is that those channels are spot beamed to Canada and the power of their signals diminishes dramatically as you move south of the border. Footprint maps indicate that North Carolina is about as far south as you can go and get decent signals.

And that's the problem with Solidaridad 2 in your location: you're out of the primary footprint and it would take extraordinary measures to get any kind of signal from that bird at your location.

As to the Ku-band format problem — everything got balled up right at the beginning when there were only a few transponders per satellite and the difference, as well, between the wide and narrowband transponders. On Ku-band there are 27, 36, 54 and 72 Mhz wide transponders. In addition, the horizontal/vertical format may have to be changed to accommodate a nearby Ku bird with the same format.

M1 (which is really Solidaridad 1) is not in inclined orbit.

CNN uses fiber optic land lines for its feeds between New York and Washington and Atlanta. The days are gone when Larry King wold leer at us from his desk in Washington, D.C.

F5 is actually Satcom C5 and has only two active video channels (18 and 24) both of which are spot beamed to Alaska. However, channels 3,4,9,10,16, and 21 are filled with analog SCPC audio services. In addition, all the digital SCPC news networks such as Westwood One, NBC Radio News and dozens more are on channels 15,19, and 23 all of which are not audible to those of us without digital audio receivers. But, you'd better have a nice unobstructed view to the West as this satellite, from Florida it will be only 10 or 15 degrees off the horizon.

The *CNN Airport Channel* is now located on Galaxy 4 channel 10 using a Scientific-Atlanta video compression system and thus lost to the home dish owner. And, finally, what it would take to receive digital video is a digital receiver built into your current analog receiver. The word about a year ago was that by summer 1995, new IRDs would be so equipped. Now, it looks doubtful that such a track will be taken at all. A number of prominent receiver manufacturers have left the market or will do so in the next year or two. Credit the success of the DSS™ system with scaring off TVRO receiver manufacturers. This in spite of the fact that 1994 was the best year for the industry in nearly ten years.

Rhiman Rotz of Gary, IN was interested in a simply written book to help him get up to speed on the subject of TVRO as he is especially interested in international radio broadcasting.

Rhiman, I think you might be interested in the *1995 Satellite Broadcasters Guide* which is published by the same folks who do the *World Radio-TV Handbook*. It's available from Grove Enterprises and you need to order BOK 79. It sells for $24.95 plus shipping. ST

ST SATELLITE PROFILE

DSP—The Defense Support System

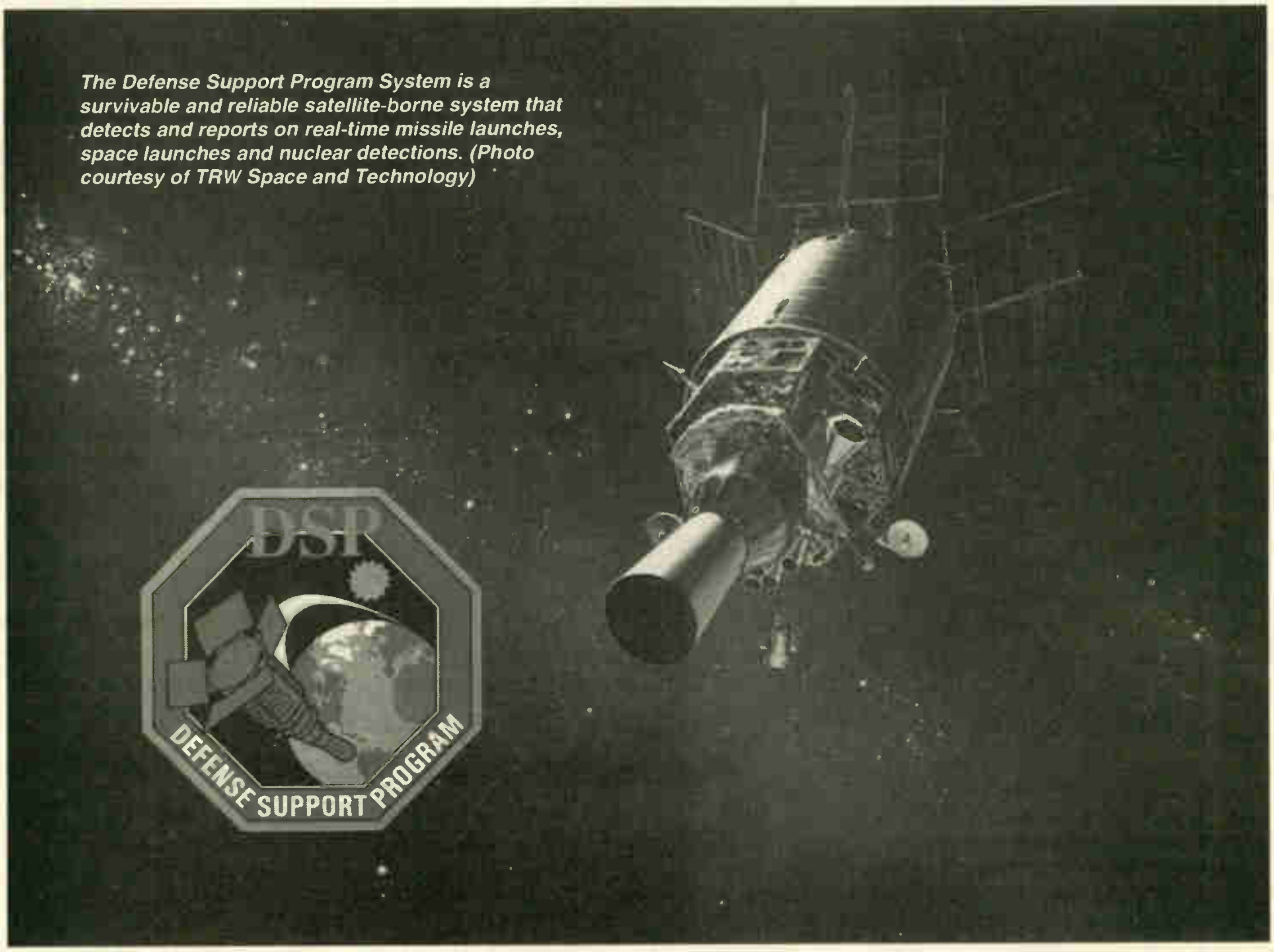
By Philip Chien, Earth News

For a quarter of a century a quiet series of satellites has been protecting the world from the potential of nuclear war. Before 1991 few people had heard of the Defense Support Program-647. Today it's popularly known as DSP, even though there are other DSP satellites and projects. The DSP spacecraft are infrared telescopes, keeping a constant eye out for unexpected missile launches.

In the Gulf War DSP was used extensively for near-real time tracking of Iraqi SCUD missiles. As soon as a SCUD launch was detected its path was calculated, along with an anticipated target area. Controllers quickly notified regional authorities and civilians were able to evacuate the area or go to bomb shelters before the missiles hit.

A DSP spacecraft consists of a Schmitt telescope, with an optical path similar to many backyard telescopes. The detectors were lead-sulfide in early spacecraft, and lead-telluride in later models, arranged as two rows of infrared-sensitive pixels. It's interesting to note that those detectors have been spun-off for non-military applications. They're declassified for astronomical applications and are used for infrared astronomy at many specialized observatories. DSP's telescopes spin at 6 RPM, sweeping across the Earth's hemisphere. A momentum wheel spins the opposite direction to stabilize the spacecraft.

Current DSP models have space allotted for a Laser Communications System (LCS). When operational the LCS will enable the DSP spacecraft to be used as relays to transmit data back to the United States



The Defense Support Program System is a survivable and reliable satellite-borne system that detects and reports on real-time missile launches, space launches and nuclear detections. (Photo courtesy of TRW Space and Technology) from a spacecraft which would normally be blocked by the Earth. The LCS has had many technical problems and on most of the spacecraft that have been launched the LCS has been replaced with ballast. As a secondary function, the DSP spacecraft are also orbital nuclear sentinels, with sensitive detectors to monitor clandestine tests of nuclear weapons.

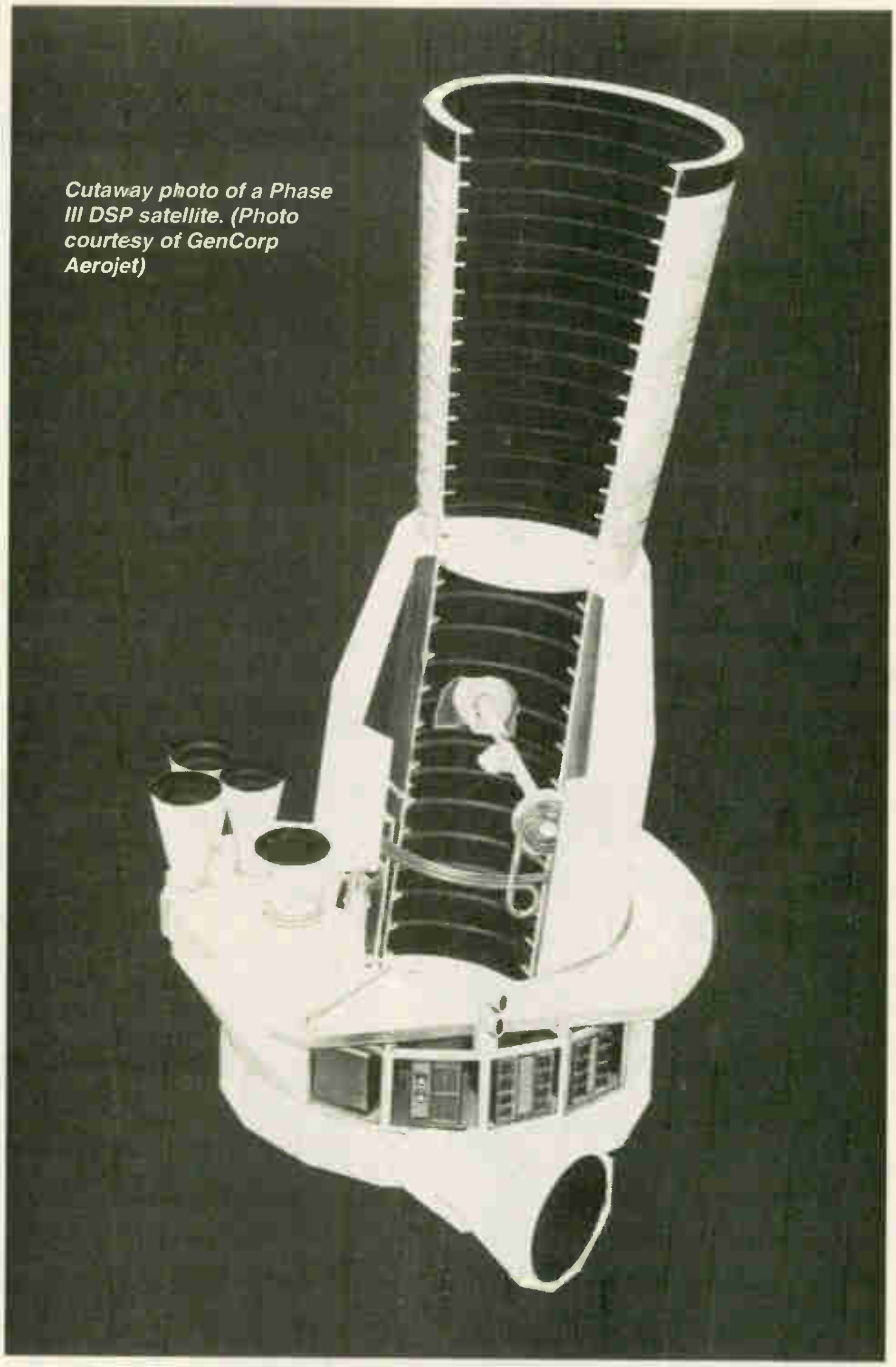
DSP was an outgrowth of an earlier missile warning spacecraft called MIDAS. The MIDAS spacecraft used low earth orbits, which gave them the advantage of higher resolution for a given sensor. Unfortunately a lower orbit also translates in to less time over a particular target. It also results in a predictable schedule where your adversary can easily predict when your spacecraft is in view and schedule missile launches while your spacecraft is on the opposite side of the planet.

The objectives of Program 647 were to put infrared missile warning sensors into geosynchronous orbit. From an altitude of 35,888 km. (22,300 mi.) over the equator a spacecraft can observe almost an entire hemisphere at a time and keep a constant eye on important areas like missile test centers.

Most spacecraft equipped with infrared detectors used tanks of liquid helium to cool the infrared detectors close to absolute zero. For DSP that isn't necessary since missiles have fairly high temperature exhausts and a simple radiator is enough to keep the detector at a reasonable temperature to detect these missiles.

One interesting note about DSP is that there is a lot of public information available on the program — much more than most military spacecraft, especially ones designed to collect strategic and tactical reconnaissance information. One of the reasons DSP works is that everybody around the world realizes that it is always there. If another country knows that its missile launches can easily be detected from orbit, and that those sensors are constantly in place then it's much less likely to try to develop a missile which violates international arms limitations agreements. Third world countries who are developing their own short-range missiles for sale on the world market for terrorists are also aware that the superpowers realize what their missiles capabilities are, and have the information they need to develop countermeasures.

During the Iran-Iraq war DSP spacecraft detected and monitored 166 SCUD missiles launched by both sides during the long war of attrition. That data proved to be invaluable during the Gulf war where Iraqi missiles were constantly monitored by DSP.



Cutaway photo of a Phase III DSP satellite. (Photo courtesy of GenCorp Aerojet)

DSP's telescope constantly views the Earth's surface, with its linear sensor rotating like a radar beam. Any hot-spot, like a missile's exhaust, indicates a potential detection. The spacecraft is smart enough to avoid false hits caused by sunlight reflecting off clouds. Whenever a foreign missile launch is detected it is assumed to be a potential threat to the United States. The missile's trajectory in virtually all cases rules that out and the data is cataloged for future use. DSP's ground stations have stored in their computer the locations of every missile test center around the world, along with the infrared plume signatures of each type of rocket. Even submarine launches of test missiles from unanticipated locations, are monitored by DSP.

DSP's infrared detectors are extremely sensitive. It's been reported that they can detect high performance aircraft operating on afterburners. There have been false alerts, and concerns about an adversary purposely blinding DSP's detectors. On October 18, 1975, a DSP spacecraft over the Indian Ocean was blinded by a bright flash of infrared energy. At least four additional flashes were recorded over the next two months. At first it was thought that a Soviet laser was aimed at the spacecraft to purposely disable its sensors. It turned out that the blinding was actually caused by natural gas pipeline fires, which was verified by photographic reconnaissance satellites. Nevertheless more recent DSP spacecraft have additional protection to detect impacts and close a shutter if a bright source is detected.

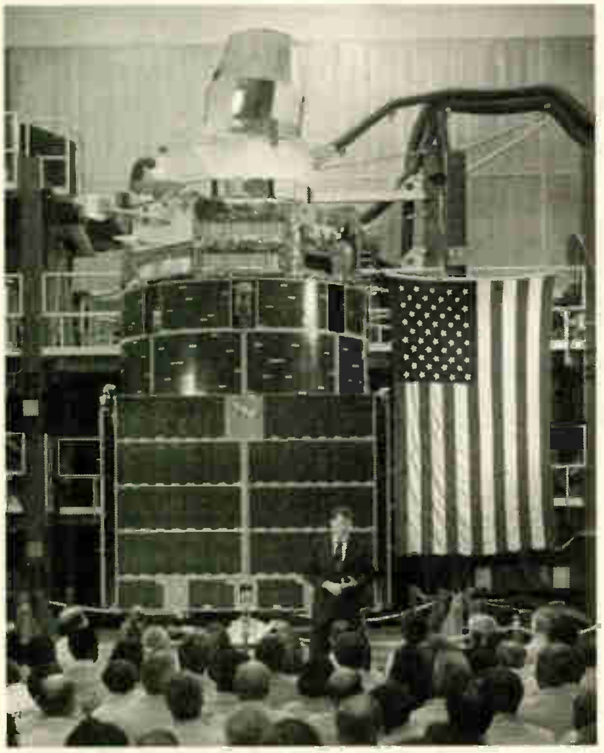
In the late 1970s Strategic Air Command bombers were launched in one instance, based on DSP data about a potential Soviet attack. The scramble was canceled when additional data showed that there was no Soviet attack underway.

TRW builds the DSP spacecraft under contract to the USAF. Gencorp Aerojet builds the sensor payload and the infrared sensors come from Hughes Santa Barbara.

A total of four Phase I spacecraft were built, one test article and three flight spacecraft. At launch each spacecraft weighed 945 kg (2100 lbs). Its solar arrays produced 400 watts, the infrared sensor included 2000 hand-wired detectors, and the spacecraft had a planned lifetime of 3 years, although most exceeded their planned lifetimes.

The very first DSP-647 spacecraft was launched on November 6, 1970, on a Titan IIIC launch vehicle. It's been reliably reported that the launch vehicle's upper stage malfunctioned and the spacecraft was put into an elliptical orbit, below its operational altitude. Industry sources have speculated that only some engineering data was returned from that mission.

Phase I was only supposed to be a series of tests, with Phase II as operational spacecraft, however, the two Phase I spacecraft which were put on station were so successful that DSP was declared operational in 1972 and command authority for the spacecraft was turned over to the Air Defense Command.



The DSP Program served as a backdrop for Vice President Al Gore during a visit to TRW's Space and Electronics Group facility in Redondo Beach, Calif. (Photo courtesy of TRW)

The Phase 2 spacecraft were launched from 1973 to 1987 and weighed 1,782 kg (3,960 lbs) at launch. The larger solar arrays generated 1250 watts and the number of infrared detectors was increased to 6000. The length of the spacecraft was 660 cm (22 feet) and it fit within the Titan IIIC's 300 cm (10 feet) diameter faring. The spacecraft had planned 3 to 5 year lifetimes.

Phase II DSP spacecraft have also included other payloads including the MOS/PIM (Multi-Orbit Satellite / Performance Improvement) and Phase II Upgrade - SED (Sensor Evolutionary Development).

Sources are contradictory in terms of the actual number of spacecraft launched in conjunction with the program, ranging from 11 to 13. It is certain that no DSP Phase II was launched from the space shuttle, even though many sources claimed that one was the primary payload for the 51-C space shuttle mission in January 1985. On the average spacecraft have lasted six years, significantly longer than their design lifetimes.

It appears that the current DSP constellation consists of four to five spacecraft and at least three Phase II spacecraft remain in operation. Operational locations are classified, but it has been widely reported in the aerospace press that the five orbital slots are located at 70° West, 86.5° West, 135° West, one DSP satellite over the Indian Ocean and one over the western Pacific. Downlink frequencies for the DSP satellites are located in the S-band (tracking, telemetry and control) and X-band (7.2 to 8.4 GHz for data information).

PHASE III - DSP SATELLITE LAUNCHES

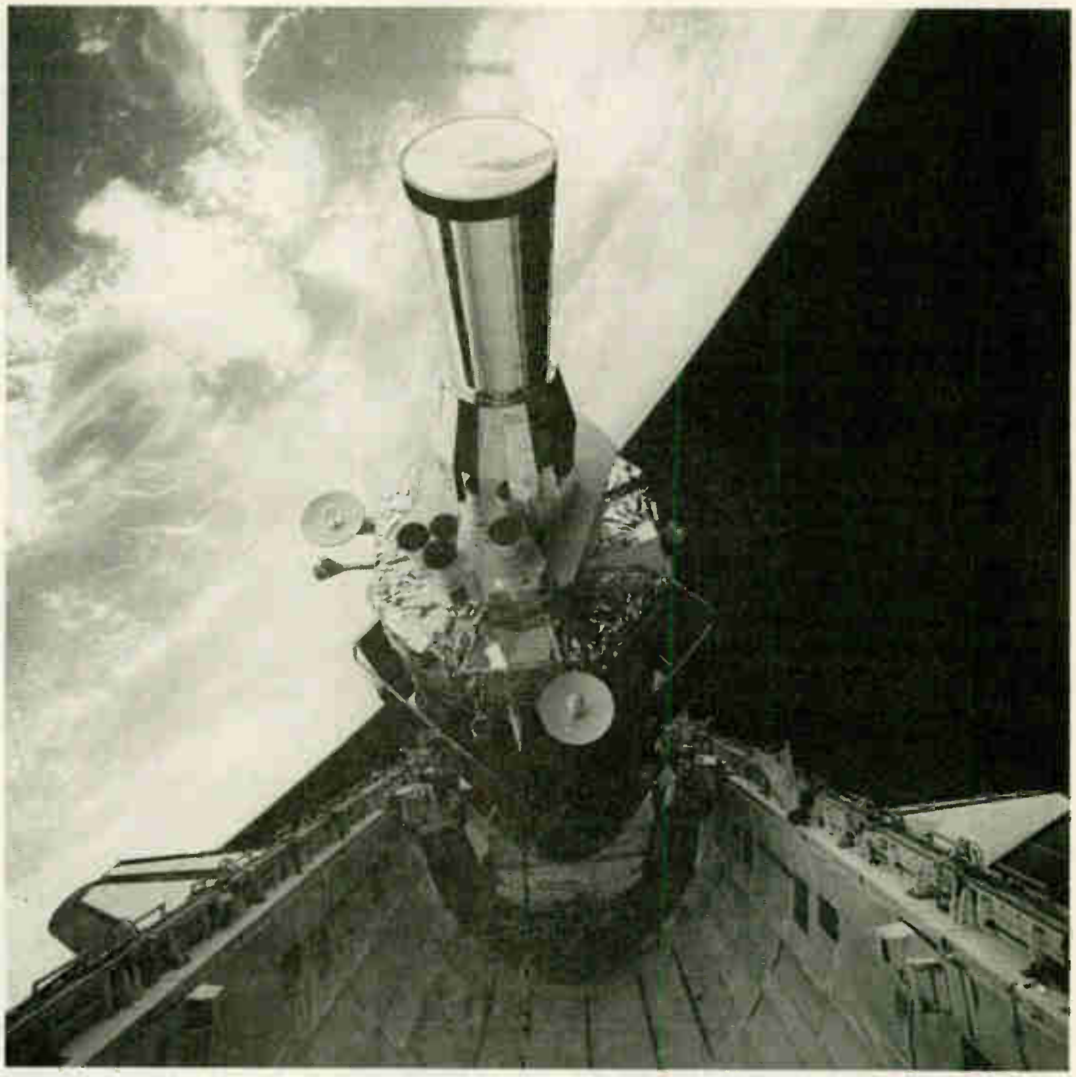
Norad #	Intl Desig	Name	USA DesigLaunch Vehicle	Date of Launch	Pad
20066	1989-46A	DSP-14	USA 39Titan IV-IUS LV-1 (1)	6/14/89	41
20929	1990-95A	DSP-15	USA 65Titan IV-IUS LV-6 (3)	11/12/90	41
21805	1991-80B	DSP-16	USA 75STS-Boeing IUS-14	11/24/91	39A
	1994-84A	DSP-17	USA 107?Titan IV-IUS LV-? (11)	12/22/94	40

The new Phase III DSP spacecraft has marked a major increase in the system's performance. The weight was increased to a staggering 2,340 kg (5,200 lbs) with solar power upgraded to 1250 watts. The most significant statistical increase is the anticipated lifetime which has been raised to 7-9 years. The spacecraft are 990 cm (33 feet) high and 420 cm (14 feet) in diameter.

TRW proudly notes in public literature that the evolutionary approach of upgrading the existing DSP design has reduced the price, permitting the Air Force to purchase five spacecraft for the price of four. It's estimated that each of the five spacecraft will cost, on the average US$148 million, plus the launch vehicle. Due to the spacecraft's size and weight the only compatible launch vehicles are the Titan IV and space shuttle. In either case an Inertial Upper Stage is required to place the spacecraft on station in geosynchronous orbit.

The first third-generation DSP spacecraft, DSP-14, was launched on June 14, 1989 on the first flight of the Titan IV launch vehicle. DSP-15 was launched on November 12, 1990 also on a Titan IV.

DSP-16 marks the only time any DSP has been launched on any launch vehicle besides a Titan. As part of the original agreement between NASA and the Air Force for the space shuttle the Air Force would support the development of the shuttle. In exchange the Air Force would receive a discount price for launches. When NASA upgraded its flight control systems in 1990 the Air Force realized that it would not be cost effective to upgrade the necessary hardware for 'controlled mode' operations needed for the highly classified shuttle missions. Consequently it was decided to use the final Air Force shuttle slots for payloads which could be at least partially declassified without compromising their missions. In March 1990 the decision was made to declassify the STS-44 mission and the Air Force revealed that the primary payload was to be a DSP spacecraft with an Inertial Upper Stage.



DSP prior to deployment aboard the STS-44 mission of the Space Shuttle. (Photo courtesy of NASA)

STS-44 was launched on November 24, 1991. Two people got to watch Atlantis's launch from a unique perspective. Cosmonauts Alexander Volkov and Sergei Krikalev aboard the Mir station were informed about the upcoming shuttle launch by friends at the Goddard Spaceflight Center via amateur radio. They decided to stay up late and got an excellent view of Atlantis's ascent through the solid rocket booster separation. They passed on their regards for their fellow space travelers, and the STS-44 crew was informed that their launch had been seen from space.

For the most part the mission looked like a normal NASA mission which deploys the civilian Tracking Data and Relay Satellite (TDRS) or another IUS payload. The notable exception was a set of special protective covers for the DSP's star sensors. The shuttle's payload bay is a relatively dirty place and DSP engineers were concerned about contamination. A set of cloth covers were developed which covered the sensors through the shuttle's launch. Once on orbit a set of lines, similar to a fishing reel, dragged the covers off the sensors before the IUS and DSP were rotated up to the deployment proper angle. The six person astronaut crew, Fred Gregory, Tom Hendricks, Story Musgrave, Jim Voss, Mario Runco, and Tom Hennen, nicknamed the DSP spacecraft "Liberty". Officially it has an international designation of 1991-80B (e.g. the primary payload deployed by the shuttle which was the 80th launch of 1991), and NORAD number 21805. It's also known as USA 75.

It turns out that, due to the high cost of launching a spacecraft from the shuttle and the unnecessary risk to the shuttle and the astronauts's lives, no future DSP are scheduled for shuttle launches. When the Titan IV program was delayed there were rumors that the Air Force was going to ask NASA to launch another DSP on the shuttle as a high priority payload, but that plan was never implemented. DSP-17 was launched on December 22, 1994 on a Titan IV.

The cold war has ended, but the need for DSP has not decreased. Instead of concentrating on worldwide strategic concerns, military resources - including satellites - are now more oriented towards regional conflicts. The DSP satellite was originally intended to warn the U.S. if there was an ICBM attack and to monitor ICBM tests, but has also proved that it can track medium-range missiles, proving its value to world peace. ST

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: **Astronomical League**

This astronomical special-interest group was formed to promote the science of astronomy by fostering astronomical education, providing incentivies for astronomical observation and research, and assisting communication among amateur astronomical societies The Astronomical League has over 11,000 members and over 200 clubs member societies across the United States. They even sponsor a page on the worldwide web on the Internet at http://bradley.bradley.edu/ dware/al.html

The Astronomical League sponsors five observing programs for its members. These are the Meteor Club, the Binocular Club, the Messier Club, the Herschel Club, and the Sunspotters. Each of these observing projects is based on a *Observe* manual published by the Astronomical League. The equipment required for these various programs ranges from the unaided eye to telescopes with solar filters. The objects of study range from very near solar system to very deep sky. Likewise, there are observing programs to challenge both beginning and experienced observers.

For More Information

The *Observe* manuals, containing detailed information and forms needed to complete these programs, are available from Astronomical League Sales. The address and current price are listed in the current issue of the League's quarterly newsletter, the *Refflector* Each of the observing programs, except the Herschel Club or the Binocular Messier Club (as a class activity), require that the observer be a member of the Astronomical League, either through an affiliated club or as member-at-large.

If you have further questions, send a self-addressed, stamped envelope to the appropriate person:

Binocular Messier and Deep Sky Binocular Clubs: John Wagoner, 1409 Sequoia Dr. Plano, TX. 75023.
Herschel Club: Brenda Branchett, 515 Glen Haven Dr., Deltona, FL. 32738.
Messier, Meteor or Sunspotter clubs: Kathy Machin, 4845 N. Smalley, Kansas City MO. 64119

If you want to become a member of the League, contact your local astronomy club or you can become a member-at-large for $25.00 a year and that includes a subscription to the Astronomical League's quarterly publication and a copy of the proceedings from their national convention held annually. For more information on the League itself write to: Astronomical League, Science Service Building, 1719 N. Street N.W., Washington, D.C. 20030

Amateur Satellite Corporation (AMSAT)
P.O. Box 27
Washington, DC 20044
(301)-589-6062

British Interplanetary Society
27/29 South Lambeth Road
London SW8 1SZ
ENGLAND
Membership: No dues information available at present.

Canadian Space Society
43 Moregate Crescent
Bramalea, Ontario
CANADA L6S 3K9
Answering Machine: (416)-626-0505
CSS BBS: (905)-458-5907 (8N1, up to 2400 buad)
Membership: Annual dues are $25/year ($15/year for full-time students, $100/year for corporate members).

National Space Society
Membership Department
922 Pennsylvania Avenue, S.E.
Washington, DC 20003-2140
(202)-543-1900
Membership: $20 (youth/senior) $35 (regular).

The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106
(818)-793-5100
email psociety@delphi.com
Membership: $5/year

Sky Report — Freehold, NJ
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(908) 866-8808, (908) 918-1000, (908) 957-8700, (908) 505-8011 and (908) 545-6000.

The Society of Amateur Radio Astronomers (SARA)
c/o Hal Braschwitz
3623 W. 139th Street
Cleveland, OH 44111.

Space Access Society
4855 E Warner Rd #24-150
Phoenix, AZ 85044
(602)-431-9283 voice/fax
hvanderbilt@bix.com
Membership: $30/year, $1000/lifetime; includes email updates. $50 for email plus mailed hardcopy ($25 extra outside the US).

Space Station Future Fighters
16582 Space Center Blvd
Houston, TX 77058-2039
Fax: (713) 488-7903
Membership: All volunteer, No formal membership or dues. Presently conducting a national petition drive in support of the international space station. Send a stamped self-addressed envelope for free information and a blank copy of the petition.

Space Studies Institute
258 Rosedale Road
PO Box 82
Princeton, NJ 08540
Membership: $25/year. Senior Associates ($100/year and up) fund most SSI research.

United States Space Foundation
PO Box 1838
Colorado Springs, CO 80901
(719)-550-1000
Membership: Charter $50 ($100 first year), Individual $35, Teacher $29, College student $20, HS/Jr. High $10, Elementary $5, Founder & Life Member $1000+

World Space Foundation
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South Pasadena, California 91030-1000
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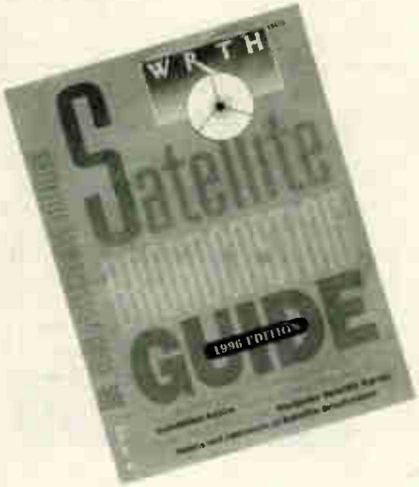

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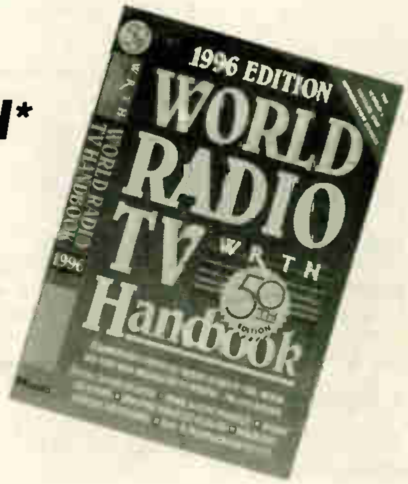

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SPACE GLOSSARY

The following are some terms used in the satellite business and are described in layman's terms.

ALTITUDE (ALT): The distance between a satellite and the point on the earth directly below it, same as height.

AQUISITION OF SIGNAL (AoS): The time at which a particular ground station begins to receive radio signals from a satellite.

APOGEE: The point in a satellite's orbit farthest from the Earth's center.

ARGUMENT OF PERIGEE: This value is the number of degrees from the ascending node the perigee point occurs. The perigee point is the point where the satellite is the closest to the earth (assuming an orbit which is elliptical to some degree). This number may be entered as a real value between 0.0 and 360.0.

ASCENDING NODE: Point at which the satellite crosses the equatorial plane from the southern hemisphere to the northern hemisphere. (See RIGHT ASCENSION OF THE ASCENDING NODE.)

AZIMUTH (AZ): The angle measured in the plane of the horizon from true North clockwise to the vertical plane through the satellite.

CATALOG NUMBER: A 5-digit number assigned to a cataloged orbiting object. This number may be found in the NASA Satellite Situation Report and on the NASA Two Line Element (TLE) sets.

COORDINATED UNIVERSAL TIME (UTC): Also known as Greenwich Mean Time (GMT). Local time at zero degrees longitude at the Greenwich Observatory, England. Uses 24 hour clock, ie. 3:00 pm is 1500 hrs.

CULMINATION: The point at which a satellite reaches its highest position or elevation in the sky relative to an observer. (Known as the Closest Point of Approach)

DECAY RATE: This is the rate of decay of the orbital period (time it takes to complete one revolution) due to atmospheric friction and other factors. It is a real number measured in terms of Revolutions per Day (REV/DAY).

DECLINATION (DEC): The angular distance from the equator to the satellite measured positive north and negative south.

DIRECT BROADCAST SATELLITE (DBS): Commerical satellite designed to transmit TV programming directly to the home.

DOPPLER SHIFT: The observed frequency difference between the transmitted signal and the received signal on a satellite downlink where the transmitter and receiver are in relative motion.

DOWNLINK: A radio link originating at a spacecraft and terminating at one or more ground stations.

DRAG: The force exerted on a satellite by its passage through the atmosphere of the Earth, acting to slow the satellite down.

EARTH-MOON-EARTH (EMR): Communications mode that involves bouncing signals off the moon.

ECCENTRICITY (ECC): This is a unitless number which describes the shape of the orbit in terms of how close to a perfect circle it is. This number is given in the range of 0.0 to less than 1.0. An perfectly circular orbit would have an eccentricity of 0.0. A number greater than 0.0 would represent an elliptical orbit with an increasingly flattened shape as the value approaches 1.0.

ELEMENT SET: (See ORBITAL ELEMENTS.)

ELEVATION (EL): Angle above the horizontal plane.

EPHEMERIS: A tabulation of a series of points which define the position and motion of a satellite.

EPOCH: A specific time and date which is used as a point of reference; the time at which an element set for a satellite was last updated.

EPOCH DAY: This is the day and fraction of day for the specific time the data is effective. This number defines both the julian day (the whole number part of the value) and the time of day (fractional part of the value) of the data set.
The julian day figure is simply the count of the number of days thatparticular date is from the beginning of the year. (January 1 would have a julian day of 1. Feb 28 would be 59.) This number may range from 1.0 to 366.999999999 (taking into account leap years).

EPOCH YEAR: This is the year of the specific time the rest of the data about the object is effective.

EQUATORIAL PLANE: An imaginary plane running through the center of the earth and the Earth's equator.

EUROPEAN SPACE AGENCY (ESA): A consortium of European governmental groups polling resources for space exploration and development.

FOOTPRINT: A set of signal-level contours, drawn on a map or globe, showing the performance of a high-gain satellite antenna. Usually applied to geostationary satellites.

GROUND STATION: A radio station, on or near the surface of the earth, designed to receive signals from, or transmit signals to, a spacecraft.

INCLINATION (INC): The angle between the orbit plane and the Earth's equatorial plane, measured counter-clockwise. 0 (zero) degrees inclination would describe a satellite orbiting in the same direction as the Earth's rotation directly above the equator (orbit plane = equatorial plane). 90 degrees inclination would have the satellite orbiting directly over both poles of the earth (orbit plane displaced 90 degrees from the equatorial plane). An inclination of 180 degrees would have the satellite orbiting again directly over the equator, but in the opposite direction of the Earth's rotation. Inclination is given as a real number of degrees between 0.0 and 180.0 degrees.

INTERNATIONAL DESIGNATOR: An internationally agreed upon naming convention for satellites. Contains the last two digits of the launch year, the launch number of the year and the piece of the launch, ie. A-indicates payload, B-the rocket booster, or second payload, etc.

LATITUDE (LAT): Also called the geodetic latitude. the angle between the perpendicular to the Earth's surface (plane of the horizon) at a location and the equatorial plane of the earth.

LONGITUDE (LONG): The angular distance from the Greenwich (zero degree) meridian, along the equator. This can is measured either east or west to the 180th meridian (180 degrees) or 0 to 360 degrees west. For example, Ohio includes 85 degrees west longitude, while India includes 85 degrees east longitude. But 85 degrees east longitude could also be measured as 275 degrees west longitude.

LOSS OF SIGNAL (LoS): The time at which a particular ground station loses radio signals from a satellite.

MEAN ANOMALY (MA): This number represents the angular distance from the perigee point (closest point) to the satellite's mean position. This is measured in degrees along the orbital plane in the direction of motion. This number is entered like the argument of perigee, as a value between 0.0 and 360.0.

MEAN MOTION (MM): This is the number of complete revolutions the satellite makes in one day. This number may be entered as a value greater than 0.0 and less than 20.0. (See DECAY)

NASA: U.S. National Aeronautics and Space Administration.

ORBITAL ELEMENTS: Also called Classical Elements, Satellite Elements, Element Set, etc. Includes the catalog Number; epoch year, day, and fraction of day; period decay rate; argument of perigee, inclination, eccentricity: right ascension of ascending node; mean anomaly; mean motion; revolution number at epoch; and element set number. This data is contained in the TWO LINE ORBITAL ELEMENTS provided by NASA.

OSCAR: Orbiting Satellite Carrying Amateur Radio.

PERIOD DECAY RATE: Also known as Decay. This is the tendency of a satellite to lose orbital velocity due to the influence of atmospheric drag and gravitational forces. A decaying object eventually impacts with the surface of the Earth or burns up in the atmosphere. This parameter directly affects the satellite's MEAN MOTION. This is measured in various ways. The NASA Two Line Orbital Elements use revolutions per day.

PERIGEE: The point in the satellite's orbit where it is closest to the surface of the earth.

POSIGRADE ORBIT: Satellite motion which is in the same direction as the rotation of the Earth.

RETROGRADE ORBIT: Satellite motion which is opposite in direction to the rotation of the Earth.

REVOLUTION NUMBER: This represents the number of revolutions the satellite has completed at the epoch time and date. This number is entered as an integer value between 1 and 99999.

REVOLUTION NUMBER AT EPOCH: The number of revolutions or ascending node passages that a satellite has completed at the time (epoch) of the element set since it was launched. The orbit number from launch to the first ascending node is designated zero. thereafter the number increases by one at each ascending node.

RIGHT ASCENSION OF THE ASCENDING NODE (RAAN): The angular distance from the vernal equinox measured eastward in the equatorial plane to the point of intersection of the orbit plane where the satellite crosses the equatorial plane from south to north (asecending node). It is given and entered as a real number of degrees from 0.0 to 360.0 degrees.

SATELLITE SITUATION REPORT: A report published by NASA Goddard Space Flight Center listing all known man-made Earth orbiting objects. This report lists the Catalog Number, International Designator, Name, Country of origin, launch date, orbital period, inclination, beacon frequency, and status (orbiting or decayed).

TLM: Short for telemetry.

TRANSPONDER: A device aboard a spacecraft that receives radio signals in one segment of the radio spectrum, amplifies them, translates (shifts) their freuency to another segment and retransmits them.

TELEVISION RECEIVE ONLY (TVRO): A TVRO terminal is a ground station set up to receive downlink signals from 4-GHZ or 12-GHZ commerical satellites carrying TV programming.

TWO LINE ORBITAL ELEMENTS (TLE): See ORBITAL ELEMENTS.

UPLINK: A radio link originating at a ground station and directed to a spacecraft.

VERNAL EQUINOX: Also known as the first point of Aries, being the point where the Sun crosses the Earth's equator going from south to north in the spring. This point in space is essentially fixed and represents the reference axis of a coordinate system used extensively in Astronomy and Astrodynamics.

UPLINK

By Bob Grove, Publisher
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Internet: The Future of Global Intercommunication

Many of us old-timers resent the intrusion of computers into our traditional methods of intercommunication. We enjoy picking up a microphone or grasping a key and hearing a friendly voice or "fist"–familiar or not–coming through the speaker. The notion of a length of wire radiating an electromagnetic signal thousands of miles carries with it a mystique. The ancient glow of tube filaments was warm and reassuring. Ours was almost a secret society, admired with awe by outsiders (or so we fantasized).

With the advent of solid state devices, the hypnotic radiance of the vacuum tube disappeared and, with the arrival of the computer, personal contact grew more distant. Keyboards replaced the human voice, monitors replaced eye contact. And flame mail replaced tolerant dialogue.

But as with any new birth, maturity (barring death) is inevitable, and the disjointed E-mail/BBS interconnection is giving way to the Internet, a high-level intercommunication and informational exchange system with great promise. Still an infant in spite of its decades of previous existence before the computer hacks caught on, the Internet highway conveys more discipline and respect than many other digital avenues. Most manufacturers are placing their futures in the Internet, the on-line service of choice.

It is quite probably that there are no absolute experts on the contents of the Internet; its growth is explosive with millions joining worldwide each month. And the impersonal digital insulation between users is breaking down as well, with real-time voice telephone now available globally at a dollar an hour.

Personal Communications System (PCS) accessories are revolutionizing the concept of the work place and individual intercommunication. Constellations of low-earth-orbiting satellites (LEOs) will allow shirt-pocket radiotelephones to reach anywhere with their permanently-assigned numbers. The portable office will encourage telecommuting, saving time and costs of work travel. Offices and workers will be tied closely by cable and wireless Internet links. Our obsolescent postal system will pale in the efficiency of instant informational exchange. Education, entertainment, real estate transactions, banking, marketing, shopping–you name the challenge, and the Internet can meet it.

Depending upon how long you have been involved with communications, you have seen many changes in technology and the quality of life. In the past, these changes were largely limited by the finite time it took for informational interchange: postal mailings in the earlier days, fax and limited computer access more recently. With on-line services worldwide, information is now exchanged at a blinding rate; we can expect change much faster in the future. ST

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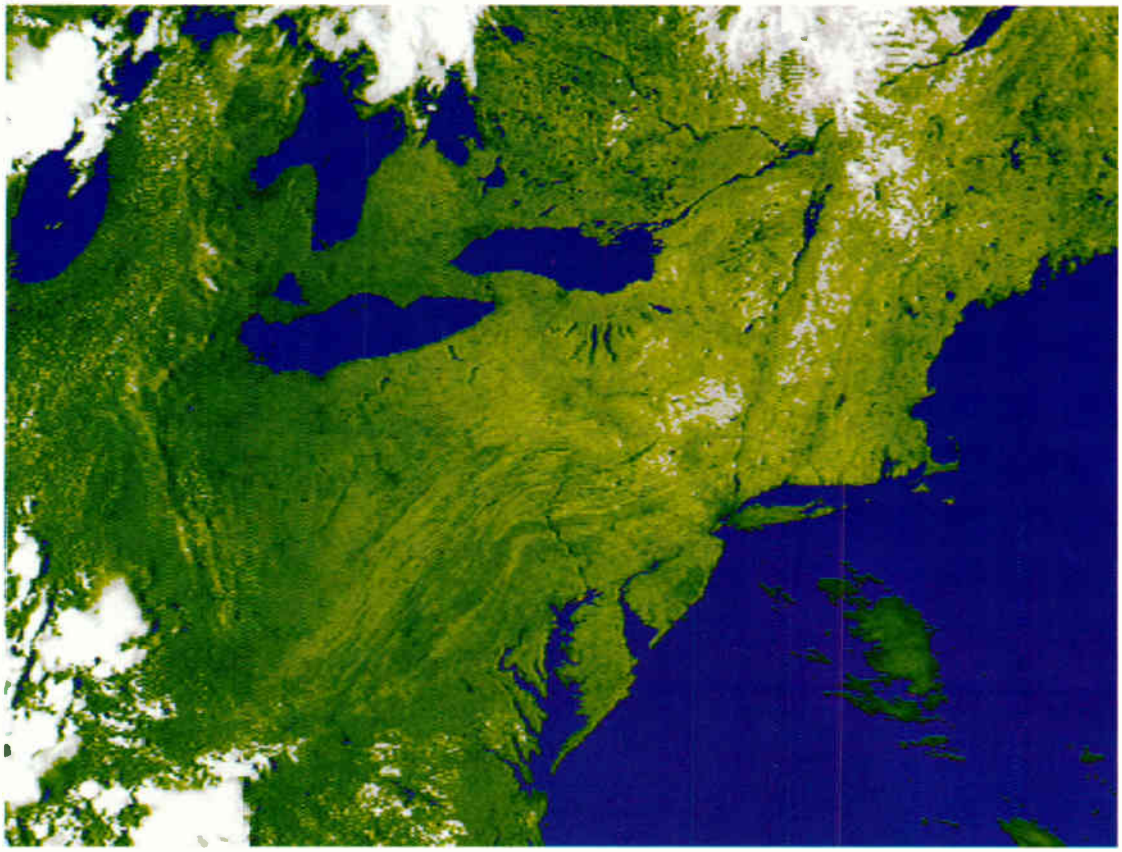

◄ Section of zoomed (4X) and false-colorized NOAA APT image of North East US. This SVGA image created directly from saved image file.

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- ☐ New DDS for 1 Hz Resolution
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- ☐ 10 designated Satellite Memories
- ☐ Data Jack for Packet Ops. (9600 bps)
- ☐ New Modulation Limiter Circuit
- ☐ 2 VFO's each for VHF and UHF Bands
- ☐ 50 Memory Channels
- ☐ Stereo Headphone Jacks
- ☐ 2 Antenna Connectors
- ☐ Noise Blanker
- ☐ RIT Function
- ☐ Memory Allocation Function
- ☐ Attenuator
- ☐ Programmed/Memory/Mode Select Scan
- ☐ CW Semi-Break In and Side Tone
- ☐ AF Speech Compressor (audio)
- ☐ Auto Repeater and One-Touch Functions
- ☐ Separate Main and CW Filters
- ☐ CW Narrow Filter (optional)
- ☐ Tone Scan (optional)
- ☐ 45 W (FM, CW), 35/6 W (SSB) VHF
- ☐ 40 W (FM, CW), 30/6 W (SSB) UHF
- ☐ Microphone Optional

IC-820H 2 M/440 MHZ Dual Band All Mode Transceiver

The IC-820H isn't your typical base station transceiver. This all mode dual bander has compact and lightweight dimensions offering operating versatility other base stations just can't match. Mobile and field operations are ideal with this rig. But don't let its size fool you. This is a high performance transceiver with state-of-the-art construction, circuit design and cutting edge features.

ICOM's **Newly Designed I-loop DDS** (digital direct synthesizer) is employed in the PLL circuit of the IC-820H. Previous PLL circuits for 10 Hz resolution transceivers contained 2-loop circuits. The new I-loop has a single loop and **Generates a Signal with Superior 1 Hz Resolution**. ICOM's DDS PLL also contains a normal PLL as the main-loop and a DDS as the sub-loop.

Satellite operation with the IC-820H's **Built-In Satellite Functions** has never been this easy. These include **Normal and Reverse Tracking** for different modes of satellite communications; **Independent Uplink/Downlink Control** for Doppler shift compensation; **Separate Satellite VFO** and **10 Dedicated Satellite Memories** provide quick switching from normal to satellite operation as well as easy recall of satellite and downlink frequencies.

With **Independent Controls and Indications for Both Bands**, this dual bander is as easy to operate as most single band transceivers – and exchanging the main and sub bands is just a switch away. **Separate S-Meters** simultaneously indicate each band's respective signal strengths.

The **Sub Tuning Function** can be assigned to the **RIT** or **SHIFT** control and allows you to tune automatically at variable tuning speeds. This is especially useful when searching for signals over a wide frequency range – eliminating the need for excessive rotations of the main dial.

The IC-820H's **Compact Size** enables easy installation in a shack as well as a vehicle. Overall dimensions may be small, but important points such as LCD size and space between switches are more than adequate.

An important consideration in all mode transceivers is the interference reduction circuit. The IC-820H's **IF Shift Circuit** electronically shifts the center frequency of the receiver passband to evade interfering signals.

The IC-820H's **DATA Terminal** (in ACC socket) is connected to its modulator circuit directly. This **Data Jack supports Packet Operation** at up to **9600 bps**. A newly designed **Modulation Limiter Circuit** prevents you from exceeding the maximum deviation – even with large amounts of data.

For more information about the IC-820H, visit your local ICOM dealer, contact ICOM Technical Support in the Hamnet forum on CompuServe® @ 75540,525 (Internet: 75540.525 @ compuserve.com) or

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