Satellite Times

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Volume 5
Number 1
September 1998

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Satellite Times

Cover Story

Cover Photo: An artist rendition of the Iridium constellation of satellites. The Iridium system is a global personal communications system based on a network of 66 low earth orbit (LEO) satellites orbiting approximately 780 km above the earth as iluustrated by this month's cover. (Artist rendition courtesy of Iridium LLC)

Personal Communications Systems–Anywhere, Anytime

By Dan Veeneman

In the four decades since the first artificial satellite was launched, Earthbound users have benefited from advancements in orbiting communications technology. The family of personal communications satellites has also grown over the past decade. But this growth has only been the tip of the iceberg and PCS is set to expand dramatically in the next fews years. Author Veeneman explores the world of PCS starting on page 10.

Vol. 5, No. 1

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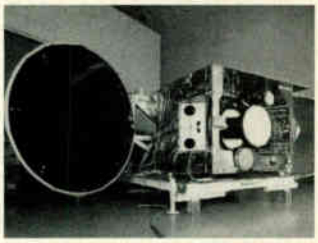


Inmarsat–the First PCS Satellite System

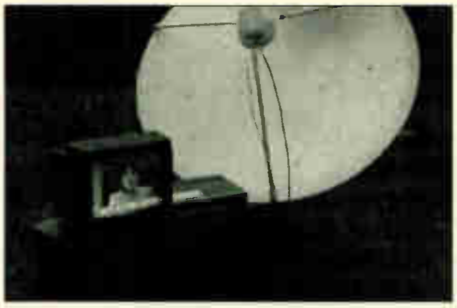
By Philip Chien

Before the era of satellites, ships at sea and aircraft over the open oceans kept in communication via shortwave radio. But the 1970s changed the face of marine and aviation communications with the launch of the thre Marisat spacecraft. In the 1990s, aircraft, ships, vehicles, and portable phones all utilize the Inmarsat 3 satellites and that has brought about a personal communications system revolution. Author Chien looks at the first PCS system in detail starting on page 16

Deploying the Iridium Constellation

By Phillip Clark

When fully operational the Iridium communications satellite constellation will consist of six orbital planes with eleven operating satellites and one spare per plane for a total of 72 satellites. As this issue goes to press Iridium is nearing that goal. But it hasn't been easy. *ST* staffer Phillip Clark at the launch profiles, evolution of the satellite orbits once launched and some of the problems in his indepth article starting on page 20.



How would you like a cheap, 54-inch dish, C-band TVRO for a total cost of about $100.00? Then look no further than this month's *Beginner's Column* where Ken Reitz will show you how to put one together. Ken's column starts on page 50.

DEPARTMENTS

ST

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Special Message from the Publisher of *Satellite Times*

The Uplink Comes Down...The End of a Four Year Experiment

"The operation was a success, but the patient died" is a well-known, whimsical anecdote among physicians. The same may be said of *Satellite Times.*

We began this adventure just four years ago as a service to both the satellite industry and the end users. We were a niche publication, addressing the technical angle of satellite communications, occasionally throwing in a little related astronomy as well.

To do this successfully, we retained some of the best writers in the business, and we addressed topics that were not readily available elsewhere. We didn't concentrate on any one aspect of the satellite industry; rather, we looked at military, domestic communications, weather, entertainment, and amateur as well.

Even with this multifaceted outlook, we discovered that there are precious few readers interested in the "how-to" aspects of satellite radio. We saw the same basic disinterest that is endemic in experimental electronics in general. Our society is accepting high technology just so long as it is plug and play; publications using terms like "resistor" and "frequency" hold about as much interest as a doctoral thesis on quantum mechanics.

And, of course, there are other astronomy magazines with lush photography, aerospace publications of long-standing respect, satellite television guides, and hobby radio/electronics subscriptions to draw from.

Since *ST* is subscriber supported, not advertiser supported like our competitors, we relied on increasing subscription numbers to keep us going. It costs us the same to prepare one magazine as it does 10,000 magazines. And now our printer has told us that our costs are going up again for paper as well as printing. That was the straw that broke the camel's proverbial back.

In order to keep the title *Satellite Times* alive, we attempted to turn the publication over to other responsible entities since it is an excellent medium to propagate information as well as new products. Unfortunately, the businesses we contacted were already under their own pressures and deadlines, and reluctantly turned down the opportunity to take on *ST.*

I would like to take this opportunity to thank our advertisers as well as our subscribers. *ST* has been fun to publish, and our interaction with all of you by letter and in person has been most enjoyable. We have all learned by sharing the pool of informational wealth contained in the pages of *ST.*

And a special thanks to our professional staff of writers and editors who have put their hearts and souls into preparing accurate and comprehensive articles of interest every month. *ST* held the respect of the satellite industry with its unfailing quantity and quality.

But the important thing is that this momentum will not be lost. *Monitoring Times, ST*'s older and bigger sister, will absorb the balance of your subscription. *MT*, already the leading source of monitoring information, will be strengthened even further, offering you many of the popular topics that you have enjoyed in *ST.* And if you are already an *MT* subscriber, you get an added bonus–your *MT* subscription will be automatically extended to include your unexpired subscription to *ST*!

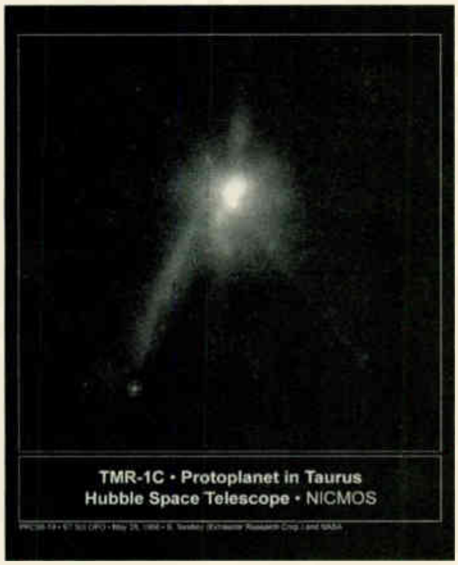
So many thanks for your loyalty; I hope you have enjoyed reading *ST* as much as we have preparing it for you. And now, look forward to receiving *MT* beginning next month, and by the November issue, we will be incorporating exciting and informative articles to satisfy your interest in the satellite communications spectrum.

Bob Grove, Publisher

SATELLITE MONITOR

By Wayne Mishler, KG5BI

Hubble discovers runaway world



NASA's Hubble Space Telescope has discovered what appears to be a runaway planet outside our solar system possibly ejected into deep space by its parent stars.

Located within a star-forming region in the constellation Taurus, the object, called TMR-1C, appears to lie at the end of a strange filament of light, which suggests it was flung from a forming pair of binary stars.

At a distance of 450 light-years from Earth, the same distance as the newly formed stars, the candidate protoplanet may be double or triple the mass of Jupiter, the largest gas giant planet in our Solar System.

The candidate protoplanet is now 130 billion miles from the parent stars and predicted to be hurtling into interstellar space at speeds up to 20,000 miles per hour.

The discovery challenges theories that gas giant planets take millions of years to coagulate from dust in space. Such large, low-density planets may condense out of gas very quickly with their parent star.

"This observation pushes back the clock on planet formation and offers short time scales which allow us to see how things form. This provides valuable new clues to the origin of our Solar System," says Susan Terebey of the Extrasolar Research Corporation in Pasadena, CA.

Astronomers believe the planet may have been flung into space by a gravitational "slingshot" effect from its parent stars. This could have happened if the planet's orbit allowed it to rob momentum from the stars and pick up so much speed that it escaped the system, similar to the way spacecraft perform gravitational "slingshot" maneuvers to pick up speed by flying close by a planet.

"We know that many triple star systems eventually toss out the lowest mass star. And we can predict the speed at which the object should be moving, based on the separation of the binary stars," she added.

"We will just have to wait and see if future observations confirm this picture," said Terebey.

Memorial service held for Alan Shepard

A private memorial service for astronaut Alan Shepard, Rear Adm., USN, Ret., the first American in space, was to be held at NASA's Johnson Space Center, Houston, TX, Aug. 1, in the Teague Auditorium.

Family friends and long-time associates planted a tree in Shepard's honor in the Astronaut Memorial Grove on the Johnson grounds. The observance was concluded with a "missing man" fly-over by NASA astronauts.

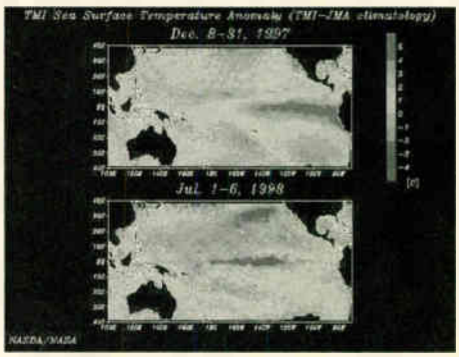
La Niña yields her secrets to satellites

The recently launched Tropical Rainfall Measuring Mission (TRMM) satellite, a joint U.S/Japanese mission, is probing La Niña and measuring temperatures of the sea in her vicinity.

This data is providing new insight into the La Niña phenomenon, by studying changes in sea-surface temperatures, ocean current movement, and the dissipation of El Niño. While it is too early to draw definite conclusions, the data seems to support the onset of La Niña type conditions.

La Niña is essentially the opposite of El Niño and is characterized by unusually cold ocean temperatures in the equatorial Pacific, as compared to El Niño, where ocean temperatures are warmer than normal. During a typical La Niña year, winter temperatures are warmer than normal in the Southeast and cooler in the Northwest.

Several NASA missions study the effects of El Niño and La Niña with orbiting satellites. Instruments measure sea surface height, ocean color, and precipitation and sea-surface temperature. The Tropical Atmosphere-Ocean Array consists of nearly 70 moored buoys in the



tropical Pacific designed by the National Oceanic and Atmospheric Administration (NOAA).

The devices take real-time measurements of air temperature, relative humidity, surface winds, sea surface temperatures and subsurface temperatures down to a depth of 500 meters. Data from these moored buoys is processed by NOAA and then made available to scientists.

Formation of Sky Station Africa Announced

Sky Station International (SSI), an intriguing alternative to satellite based telecommunications, has taken another step forward by forming a subsidiary corporation to provide services in Africa.

SSI technology employs a solar powered lighter-than-air platform held geostationary in the stratosphere to provide high capacity wireless telecommunications services to large metropolitan regions. Platforms can be easily and inexpensively launched and retrieved for maintenance, as compared to satellites.

The first Sky Station platform is scheduled to be launched in 2001.

Lost SOHO spacecraft found on radar

Ground-based radio telescopes have found the Solar and Heliospheric Observatory (SOHO) spacecraft rotating slowly near its original position in space after radio contact was lost on June 24.

Researchers at the U.S. National Astronomy and Ionosphere Center (NAIC) in Arecibo, Puerto Rico, used the facility's 305-meter (990-foot) diameter radio telescope to transmit a signal toward SOHO on July 23. The 70-meter dish of NASA's Deep Space Network in Goldstone, CA, acted as a receiver, locating the spacecraft's echo and tracking it using radar techniques for more than an hour.

The radar data indicates that SOHO is still in its nominal halo orbit near the so-called "L-1" Lagrangian point in space, and is turning about one revolution per minute.

Staff members of NAIC and the Deep Space Network, in cooperation with ESA and NASA, are continuing to analyze the data to extract more precise information on SOHO's location and motion, which in turn could help in future recovery efforts, as SOHO's solar panels turn toward the Sun.

ESA and NASA engineers also are continuing their efforts to reestablish radio data communication with the spacecraft, encouraged by the radar measurement of a slow spin rate, which suggests minimal structural damage has occurred.

International Space Station launch dates revised

Launch dates for components of the International Space Station (ISS) have been revised to November 20, for the Control Module, and December 3, for shuttle mission STS-88 with Unity (Node 1).

Changes in the construction schedule for the third station component, the Russian-provided Service Module, led to rescheduling of the first assembly launches. The Service Module will house the first station occupants and the Data Management System, provided by the European Space Agency.

Although the new dates move the launch of the first station component from June to November, the target dates agreed upon for many major station milestones during the latter portions of the five-year assembly plan have changed little. Several enhancements to the station's assembly have been made, including an exterior "warehouse" for spare parts and a Brazilian-provided carrier for exterior station components launched aboard the Space Shuttle.

The International Space Station partners set an April 1999 target launch date for the Russian Service Module.

The station's first crew will be launched aboard a Russian Soyuz spacecraft in summer 1999 to begin a five-month inaugural stay.

Launch of the U.S. Laboratory module is set for October 1999.

Launches of other laboratory modules, provided by Europe, Japan and Russia, will take place later in the assembly sequence. The Canadian-provided station robotic arm will be launched in December 1999. Scientific research will commence aboard the station early in the year 2000. Expansion from a three-person crew to six people is planned in November 2002. And the final launch in the assembly sequence is set for January 2004, only one month later than in the previous assembly plan.

Some issues in this assembly sequence remain under review and will be resolved at a Space Station Control Board meeting in September.

NASA continues the development of an Interim Control Module (ICM) as a contingency against further delays in the Service Module and as a potential additional propellant capability for a more robust space station. A decision concerning the configuration of the ICM will be made later this year.

SATELLITE MONITOR

NASA facility will seek out dangerous asteroids

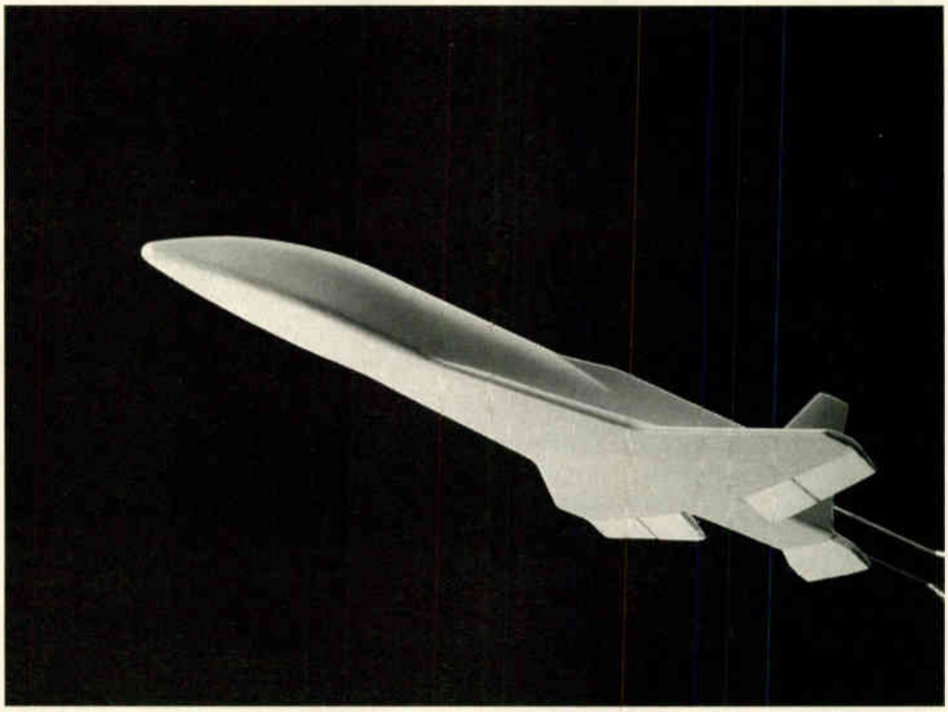
A new facility to detect, track and characterize asteroids and comets that could pose a threat to Earth is being established at NASA's Jet Propulsion Laboratory (JPL), Pasadena, Calif.

NASA's Near-Earth Object Program Office will focus on locating at least 90 percent of the 2,000 Earth-threatening asteroids and comets larger than 2/3-mile (about 1 kilometer) in diameter, by the end of the next decade.

"These are objects that are difficult to detect because of their relatively small size, but are large enough to cause global effects if one hit the Earth," said Dr. Donald K. Yeomans of JPL, who will head the new program office.

"Finding a majority of this population will require the efforts of researchers at several NASA centers, at universities and at observatories across the country, and will require the participation by the international astronomy community as well."

"We determined that, in order to achieve our goals, we need a more formal focusing of our near-Earth object tracking efforts and related communications with the supporting research community," said Dr. B. Carl Pilcher, science director for Solar System Exploration in NASA's Office of Space Science, NASA Headquarters.



"I want to emphasize that science research solicitations and resulting peer reviews, international coordination, and strategic planning regarding future missions will remain the responsibilities of NASA Headquarters."

In addition to managing the detection and cataloging of near-Earth objects, the new NASA office will be responsible for facilitating communications between the astronomical community and the public should any potentially hazardous objects be discovered as a result of the program, Pilcher said.

X-34 passes important milestone

The first wing assembly for NASA's X-34 technology demonstrator has completed qualification tests and has been shipped to the prime contractor, Orbital Sciences Corporation, Dulles, VA, where it has been mated to the X-34 test article under construction there.

Integration of the wing assembly with the test article fuselage marks a major milestone in the program. Flights of the air-launched X-34 are scheduled to begin next year in conjunction with flights of its larger and more advanced sister ship, the X-33.

The newly qualified X-34 wing assembly, intended for flight, has been installed, initially, on a full-scale X-34 test article at Orbital. The test article will be used for X-34 verification and certification. This first wing assembly will ultimately fly aboard one of two flight vehicles also under construction at Orbital.

The sub-orbital X-34 and X-33 vehicles will demonstrate key technologies

– at high speeds and high altitudes – leading toward the development of full scale, commercially operated reusable launch vehicles after the turn of the century. The ultimate objective of these efforts is to dramatically reduce the cost of placing payloads into space.

Nearby star cluster yields insights into early universe

NASA's Hubble Space Telescope has taken a "family portrait" of young, ultra-bright stars nested in their embryonic cloud of glowing gases. The celestial maternity ward, called N81, is located 200,000 light-years away in the Small Magellanic Cloud, a small irregular satellite galaxy of our Milky Way. These are probably the youngest massive stars ever seen in the nearby galaxy.

The nebula offers a unique opportunity for a close-up glimpse of the "firestorm" accompanying the birth of extremely massive stars, each blazing with the brilliance of 300,000 of our suns. Such galactic fireworks were much more common billions of years ago in the early universe, when most star formation took place.

"This is giving us new insights into the physical mechanisms governing star formation in far away galaxies that existed long ago," says Mohammad Heydari-Malayeri, who headed the international team of astronomers who made the discovery using Hubble's Wide Field and Planetary Camera 2.

Because these stars are deficient in heavier elements, they also evolve much like the universe's earliest stars, which were made almost exclusively of the primordial elements hydrogen and helium that were created in the big bang. The Small Magellanic Cloud is a unique laboratory for studying star formation in the early universe since it is the closest and best seen galaxy containing so-called "metal-poor" first- and second - generation type stars.

These observations show that massive stars may form in groups. "As a result, it is more likely some of these stars are members of double and multiple star systems," says Heydari- Malayeri. "The multiple systems will affect stellar evolution considerably by ejecting a great deal of matter into space."

This furious rate of mass loss from these stars is evident in the Hubble picture, which reveals dramatic shapes sculpted in the nebula's wall of glowing gases by violent stellar winds and shock waves. "This implies a very turbulent environment typical of young star formation regions," Heydari-Malayeri adds.

He believes one of the members of the cluster may be an extremely rare and short-lived class of super-hot star (50,000 degrees Kelvin) called a Wolf-Rayet. This star represents a violent, transitional phase in the final years of a massive star's existence - before it ultimately explodes as a supernova.

"If confirmed by future Hubble observations, this finding will have a far-reaching impact on stellar evolutionary models," says Heydari-Malayeri. "That's because the Wolf-Rayet candidate is fainter than other such stars in that galaxy, in contrast with the predictions of these models." The team's work will be shortly submitted for publication in the European journal Astronomy and Astrophysics.

Hubble's resolution allows astronomers to pinpoint 50 separate stars tightly packed in the nebula's core within a 10 light-year diameter – slightly more than twice the distance between Earth and the nearest star to our sun. The closest pair of stars is only one-third of a light-year apart. Before the Hubble observations, N81 was simply dubbed, "The Blob" because its features were indistinguishable by other telescopes.

Space research yields better products at home

Metal products in homes, cars, and aircraft are becoming less expensive, safer, and more durable. And we owe it all to low-gravity space research, NASA tells us.

Auburn University and industry are partnering with NASA to develop computer model predictions of molten metals and molding materials used in industrial casting of metal parts.

For example, Howmet Industries of Whitehall, Mich., is using the predictions to increase precision in designing and casting aircraft turbine blades. Ford Motor Company's casting plant in Cleveland, Ohio, is using information developed by the new computer models to improve casting automobile and light truck engine blocks.

"We're doing the long-range research that industry really needs to improve its final products," said Dr. Tony Overfelt, Director of the Solidification Design Center at Auburn University. "We're benefiting the American public, who pays for the research and uses the products."

Cast metal parts are used in 90 percent of all durable goods such as washing machines, refrigerators, stoves, lawn mowers, cars, boats and aircraft. Sales of cast parts in the United States alone total $25-30 billion a year, according to the American Foundrymen's Society, Des Plaines, Ill.

Auburn University is one of NASA's 10 Commercial Space Centers. These centers serve as a focal point for NASA partnerships with industry and universities to develop new products and services.

And finally...

With all the garbage out there on worldwide television these days corrupting young minds, what's a parent to do?

Soft-shoeing onto stage, with a four part answer, is the U. S. Department of Education.

Their pearls of wisdom: Set limits. Plan. Participate. Monitor.

In other words: Tell your kids what they can watch. Make your kids plan to watch what you tell them to watch. Chaperone your kids while they watch. Spy on your kids while they watch.

Excuse me, but is there something missing in this equation? Let's add (ta da) parental example. That is, don't watch what you don't want your kids to watch.

Admittedly, it's an old concept. But antiques can be priceless.

Sources: European Space Agency, Marshall Space Flight Center, NASA, Pegasus Satellite Television, and Sky Station International.

Get Global E-mail in a Handheld Package: The Magellan GSC-100 is Shipping Soon!

Customers have clamored for the **GSC-100** from the time we first introduced it in *Satellite Times* more than a year ago. Now, 12 of the planned 36 ORBCOMM satellites are in low earth orbit, and the system is scheduled to be switched on by September 1998. **The era of handheld global communications has begun!**

Magellan says users who activate their GSC 100 units with ORBCOMM by Sept. 30, 1998, will receive special pricing for the first six months of service, featuring **no monthly access fee and no limit on the size of the first 10 messages. (See the April '98 ST for more information.)**

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

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

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

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

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

Twelve of the planned 36 ORBCOMM satellites (shown below) are now in place. Read Satellite Times for updates on future launches.

Order yours today—only $999.95 from Grove

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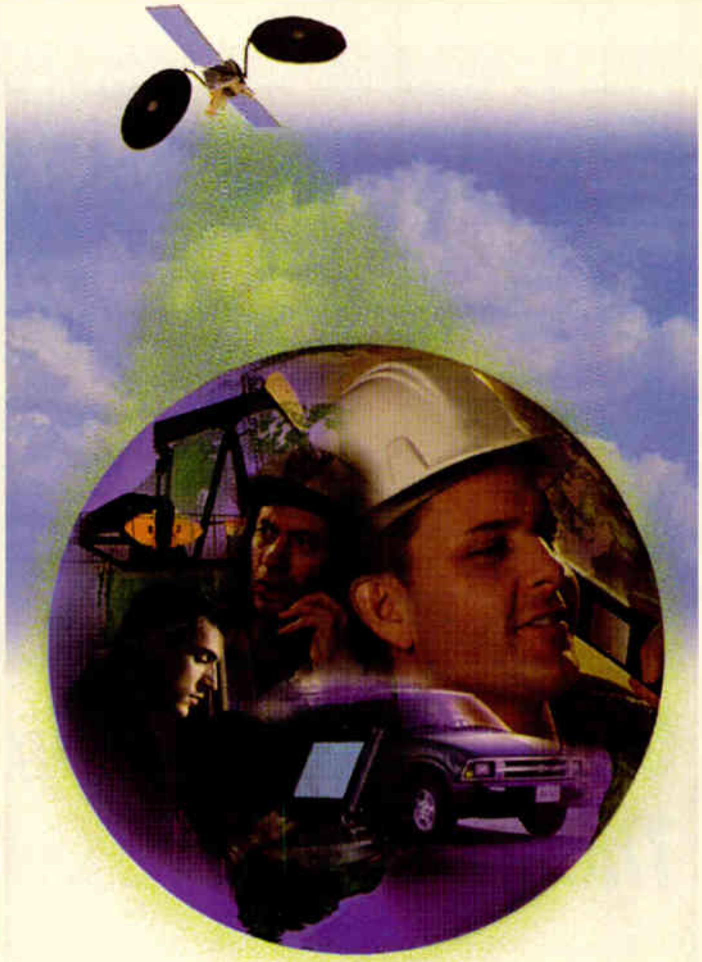


By Dan Veeneman, ST Staff Writer

In the four decades since the first artificial satellite was launched, Earth-bound users have benefited from advancements in orbiting communications technology. Enormous antennas and racks of equipment previously necessary for satellite communication have given way to handheld terminals suitable for personal, portable use anywhere, anytime. The family of personal communications satellites has been growing over the past decade and is set to expand dramatically in the next few years.

Orbits

Exactly where these new satellites will go is a continuing debate among satellite system designers, who must decide among several different orbital configurations, each with its own set of advantages and drawbacks.

For many years the most common type of orbit was *geosynchronous*. A satellite orbiting the earth at an altitude of 19,300 nautical miles will be traveling about 7,000 miles per hour and complete an orbit in 24 hours. If the satellite's orbital path keeps it directly above the equator, to a ground observer it will appears to "hang" in space above a particular spot. These *geostationary* orbits (GEO) are very useful primarily because it's easy to point an antenna and find the satellite, but their distance has some drawbacks. It takes radio signals a quarter of a second to travel all the way up to a geosynchronous satellite and all the way back down, introducing delays that can become noticeable during, say, a telephone call. It also takes a fair amount of transmitter power for radio signals to make the trip.

At the opposite extreme lies the low earth orbit (LEO). Operating at an altitude of a few hundred miles, LEO satellites zip from horizon to horizon in a hour or so, making a complete revolution many times each day. Because these satellites are so much closer to the surface they require much less transmitter power to reach and have much shorter round trip delay, typically on the order of 0.005 to 0.010 second. These characteristics allow the use of low power, relatively inexpensive terminals on the ground, but again there are tradeoffs. For instance, in order to provide continuous coverage, a whole string of satellites is necessary. As one LEO satellite moves out of sight, another LEO better be coming into view or the user on the ground will have only intermittent service. Also, LEOs can't "see" nearly as much of the earth as a GEO. Sitting 19,300 nautical miles up in space, a single GEO can cover about 42 percent of the earth's surface. A LEO zooming along down at 500 nautical miles can only see about 5 percent of the surface at any one time. What all this means is that any kind of real, continuous communications service using LEO satellites will require a whole bunch to be in orbit at once. These *constellations* of satellites must be placed into predetermined orbits and be equally spaced to compete with GEO providers.

The third type of orbital altitude is a compromise between

GEO and LEO. A satellite in Medium Earth Orbit (MEO), sometimes referred to as an Intermediate Circular Orbit (ICO), will fly at an altitude somewhere around 5,000 nautical miles, riding between the inner and outer Van Allen radiation belts. A MEO can see about 30 percent of the earth's surface and experiences radio propagation delays of 0.070 to 0.080 second.

Personal communications services are presently available primarily through geostationary satellites, although LEO, and eventually, MEO constellations will become commercially available.

Inmarsat

The International Maritime Satellite Organization was established in 1979 to provide satellite-based telephone services for seagoing users, and was the first to offer a true mobile satellite service. Headquartered in London with more than 80 members, Inmarsat operates a fleet of geosynchronous satellites providing a number of services to more than 100,000 customers on land, sea, and in the air. Ground stations scattered across the globe link the satellites to the public switched telephone network (PSTN) and other terrestrial communications networks.

Inmarsat-A is the original service, first introduced in 1982. Using a one meter dish and upwards of $30,000 worth of equipment, subscribers can direct dial telephone and fax numbers from almost anywhere on earth. Nearly 18,000 "Standard-A" installations are on board ships, providing analog FM voice and data connectivity at rates of $6 to $10 per minute. For land-based operations, the necessary equipment can be collapsed into a couple of large suitcases and set up when on-site. Viewers of the Cable News Network (CNN) during the Gulf War may have seen pictures of journalists using these types of satellite phones to maintain contact with their television headquarters. Although designed to work with equipment someone has to lug around, Inmarsat-A is also used in remote, self-contained payphones where landline service is not available.

The successor to Inmarsat-A is, logically enough, Inmarsat-B. Introduced in 1993, it provides a digital connection at rates up to 64 kilobytes per second (kbps). Besides the regular voice and fax services, the high data rate channel can be used for remote LAN connectivity and video conferencing. Prices average around $7 per minute.

Enormous antennas and racks of equipment previously necessary for satellite communication have given way to handheld terminals suitable for personal, portable use anywhere, anytime.

The alphabet soup continued with the Inmarsat-C service, also established in 1993. This data-only store and forward service provides a more cost-effective way for less well-heeled customers to move small messages across the Inmarsat network. Terminal equipment costing in the $4000 range allows companies to send and receive short data messages for about a dollar per thousand characters. Ships at sea use it for weather reports and chart updates as well as electronic mail and position reporting. On land, fleet management and remote monitoring top the list of potential applications–the same type of customers that the emerging "little LEO" companies are going after.

The aviation version of Inmarsat-C, named Aero-C, provides two-way data messaging for corporate and commercial aircraft. Messages of up to 32,000 characters are supported, allowing detailed weather and flight plan updates to be delivered to pilots while enroute. Position reporting and other information can also be sent.

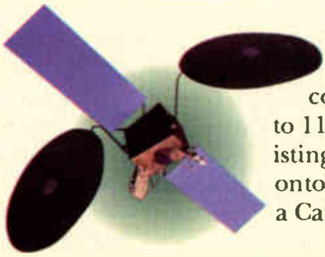
Also making its appearance in 1993 was the Inmarsat-M service, providing telephone, fax, and data connectivity using a $15,000 briefcase weighing about 30 pounds. These portable, personal mobile satellite telephones provide a 2400 bits per second (bps) digital link and having a per minute rate of $4 or $5.

Higher power spot beams aboard the newest generation of Inmarsat spacecraft allowed the introduction of smaller, lighter satellite phones last year. More than 17,000 customers are now making use of these notebook-sized portable terminals under the "Mini M" service. Although users must be stationary, the service provides digital voice at 4800 bps as well as fax and data connectivity at 2400 bps. A number of manufacturers are currently producing lightweight portable terminals, including NEC, Nera, and Westinghouse Wireless. These units come in small briefcases with the antenna built into the lid and provide more than an hour of talk time from an internal battery. Smart cards are used for security and authentication.

AMSC

Established in 1988, American Mobile Satellite Communications (AMSC) currently provides both satellite and terrestrial-based connectivity for mobile subscribers.

AMSC uses a geostationary satellite to



provide service to customers in North America, although the satellite has recently changed. The AMSC-1 satellite is based on the popular Hughes 601 model and contains a communications payload produced by Spar Aerospace of Canada. It measures 70 feet long and weighs nearly two tons. A pair of 17 foot by 22 foot graphite "Springback" antennas, one on each side of the spacecraft body, provide up to 2,000 radio channels in L-band. The satellite was launched on April 7, 1995, into a slot at 101° West, where its six beams provide coverage to the continental United States (CONUS), Alaska, Hawaii, Mexico, Puerto Rico and the Caribbean, and boundary waters within 200 miles of the U.S.

AMSC offers mobile voice, data, digital broadcast dispatch, and position reporting via their headquarters and satellite gateway in Reston, Virginia. Service began in late 1995 under the SKYCELL brand name, providing satellite-only telephone service as well as dual mode satellite/cellular roaming service. Dual mode customers use terrestrial cellular services, where available, but when they're out in the boonies with no cell tower in sight their equipment will automatically switch over to satellite operation.

Customers typically use a vehicle-mounted transportable phone in the 5 to 10 pound range that gives them voice, data, and fax capability. Prices range in the $1 to $2 per minute range, although large customers can often negotiate a discounted deal.

Financial pressures and an excess of unused capacity motivated AMSC in early 1998 to lease their satellite for five years to an African consortium for $182 million. Renamed MSAT-2, the satellite will resume operation over the African continent after being moved to 11.5° East. AMSC's 30,000 existing customers will be moved onto a sister satellite operated by a Canadian partner.

TMI

A twin to AMSC-1 was launched by Ottawa, Ontario-based Telesat Mobile Communications (TMI) on April 20, 1996. Named MSAT-1, this Hughes 601-based satellite was originally placed at 106.5° West, but will move into the 101° West slot vacated by MSAT-2.

TMI serves the same market as AMSC, and the original plan was for each company to back up the other. Neither company has so far achieved the forecasted subscriber usage, and the satellite capacity continues to remain largely unused.

Optus

In the land down under, a pair of Hughes satellites provide services very similar to AMSC and TMI. The Australian Optus "B" generation of satellites provides mobile satellite communications for the continent from geostationary orbit. The 1600-pound Optus B1 was launched from China in 1992 and sits at 160° East. B3 was launched two years later, also from China, and is at 156° East. (In case you're wondering, Optus B2 was lost during the December, 1992, launch when the Chinese Long March rocket exploded 45 seconds into the flight.)

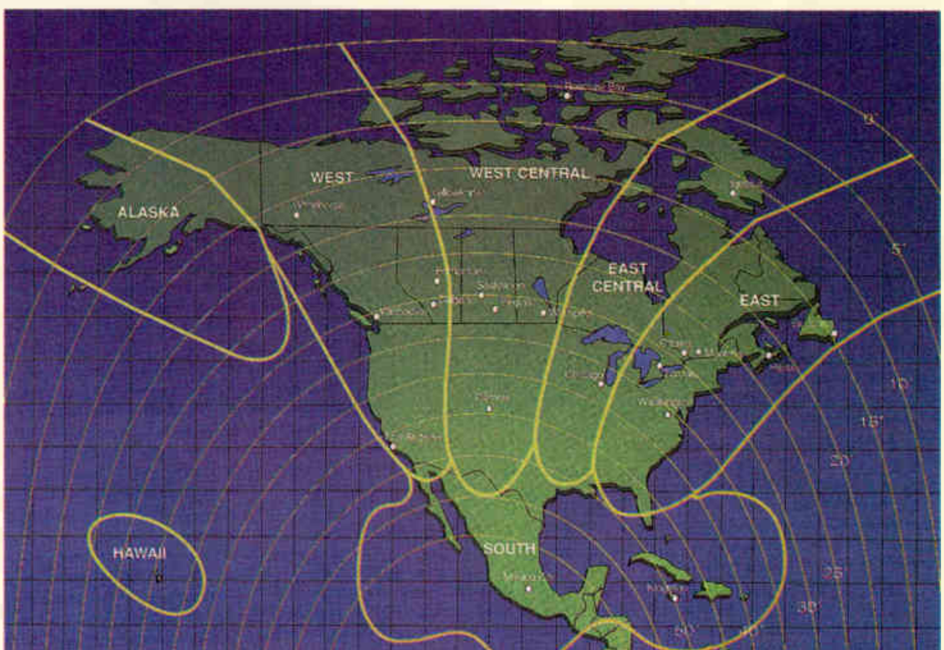
Each Optus satellite, based on the Hughes 601 design, carries a 150 watt L-band transponder capable of supporting 500 full-duplex communications channels. In addition, fifteen 50-watt Ku-band transponders each cover a 54 MHz-wide band across all of Australia, New Zealand, and off-shore areas. A pair of solar panels provide up to 3200 watts of electrical power.

As you might expect, mobile equipment is similar to AMSC and TMI hardware, and is also designed for vehicle and marine installations. The NEC S2 and the Westinghouse series 3000 are two comparable transportable units that provide voice, data, and fax services over the Optus satellites. Airtime is on the order of $1 to $2 per minute.

ACeS

The Asia Cellular Satellite system (ACeS) is designed to provide voice, fax, and paging services for Southeast Asia, India and China. This joint venture between companies in Indonesia, the Philippines, and Thailand will use a pair of high powered Lockheed-Martin A2100 satel-

TMI serves the same market as AMSC, and the original plan was for each company to back up the other.



The Iridium first launch took place on May 5, 1997, when five satellites were lifted into orbit aboard a McDonnell-Douglas (now Boeing) Delta II rocket from Vandenburg Air Force Base in California.

lites, each capable of handling at least 11,000 telephone conversations. Three national gateways will provide GSM services for both cellular and satellite telephones.

Big LEO

Voice services are currently the driving force in personal communications satellites. In the United States there are currently four companies licensed to build and launch constellations of low earth orbiting satellites designed to provide voice services in the L- and S-bands. In addition, a London-based spin-off of Inmarsat has also entered the fray.

Iridium

Backed primarily by Motorola, this system is arguably the most expensive and most complicated of the Big LEO constellations. Sixty-six satellites will orbit the earth in six planes, each containing 11 space vehicles at an altitude of 420 nautical miles. Dual-mode subscriber phones will use Iridium satellites when a terrestrial Global System for Mobiles (GSM) cellular network is not available or out of range.

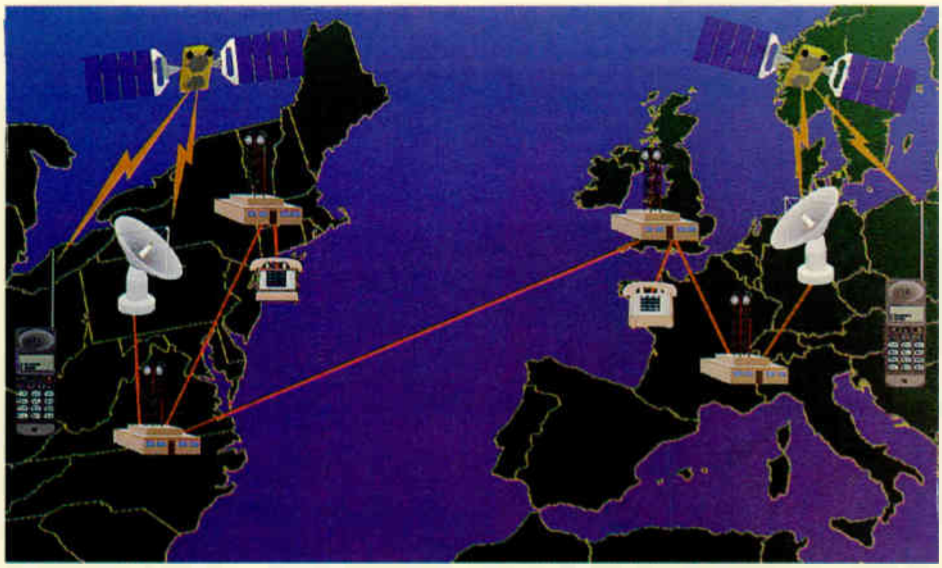
Part of Iridium's complexity arises from the design decision to use on-board processing. Unlike most other satellites, which simply repeat back (transpond) what they receive, Iridium space vehicles will process transmissions from consumer handsets. Depending on the destination, the call may be routed to other space vehicles using *inter-satellite links*, hopping from one satellite to the next until being downlinked to the proper ground station.

The Iridium first launch took place on May 5, 1997, when five satellites were lifted into orbit aboard a McDonnell-Douglas (now Boeing) Delta II rocket from Vandenburg Air Force Base in California. Subsequent launches from Vandenburg, Baikonur Cosmodrome in Kazahkstan, and Taiyuan Launch Center in China placed a total of 72 satellites in orbit, including six spares. At the time of writing seven space vehicles have failed for one reason or another, but by the time you read this replenishment launches should have filled any gaps in coverage.

Globalstar

Globalstar, a partnership between a number of high technology companies including Loral, Qualcomm, AirTouch and Alcatel, plans to provide voice service from 48 satellites in eight planes of six birds each. Code division multiple access

In remote areas with little or no existing wireline telephony, the introduction of affordable Globalstar™ satellite-based telephony kiosks will rapidly advance telecommunications in the developing world and bring the progress necessary for effective internal and external development.



Globalstar™ routes a subscriber's wireless phone call up through one of 48-low-Earth orbiting satellites, down through a gateway connected to the Public Switched Telephone Network (PSTN), and on to the calling party or the party called. If the call is destined for another portable Globalstar™ phone, the call continues through a second gateway, up to a satellite, and back down to the receiver.

(CDMA) technology will be used for the L-band and S-band transmissions between satellites and ground terminals. There has been some concern from within the industry that the Globalstar satellites, built by Loral, will have insufficient electrical power to serve the anticipated number of subscribers.

User terminals will transmit digitized voice signals up to the spacecraft at L-band frequencies between 1610 and 1626.5 MHz and receive the downlink in S-band between 2483.5 and 2500 MHz. Sixteen L-band and 16 S-band beams on each satellite will support several thousand simultaneous calls, with transmitters running at a peak output of 2000 watts. On-board GPS receivers will provide navigation and position information to controllers for orbit maintenance.

Globalstar plans on selling capacity to local service providers, who will use the satellite service as an extension to their terrestrial telephone networks. Additional markets include rural fixed operations (the solar-powered phone booth in the middle of nowhere), vehicles, and international travelers.

Eight satellites are currently in orbit from launches in February and April, 1998. Additional launches using Delta, Zenit, and Soyuz Ikar vehicles will populate the constellation for a commercial start date in 1999.

Ellipso

Ellipso hopes to beat its Big LEO rivals by using orbital mechanics to its advantage. Rather than place LEO satellites in circular orbits, Ellipso plans to operate two "sub-constellations" in elliptical orbits. One sub-constellation would have their highest altitude (called *apogee*) above the more populous and wealthy northern hemisphere countries, giving the satellites a longer "hang time" over these anticipated customers. Satellites would move quickly through their lowest point (called *perigee*) over the southern Atlantic and Pacific Oceans, where few paying customers reside. The other constellation will have a somewhat more circular orbit near the equator, providing coverage for the tropics. Believe it or not, the U.S. Patent Office has issued patents for these particular orbital schemes, which Ellipso hopes will give them comparable service capabilities with lower spacecraft and launch costs.

In May of this year Boeing announced it would invest as much as $200 million in the $1.4 billion Ellipso project. Boeing is slated to build the satellites, perform at least two launches, and provide the telemetry, tracking and control (TT&C) once Ellipso is in orbit.

Constellation

The fourth U.S.-licensed Big LEO hopes to operate 46 satellites in four orbital planes, offering similar services as the others. The first phase will involve 12 satellites in equatorial orbit serving tropical regions by late 2001. Subsequent launches would place an additional 34 satellites in inclined orbits to serve the remainder of the globe.

Orbital Sciences Corporation (OSC) has signed on to build at least a dozen ECCO spacecraft under a $450 million contract, after having been replaced on the Ellipso project by Boeing.

ICO

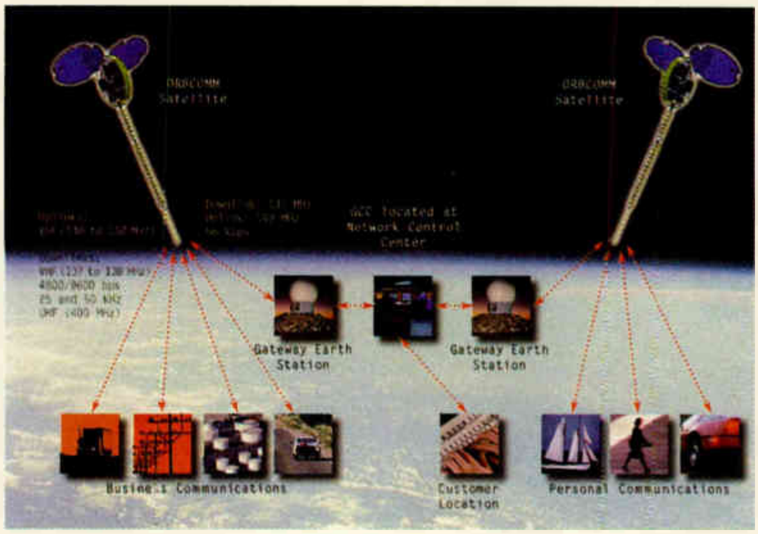
ICO, a spin-off of Inmarsat and also headquartered in London, plans on

System	ECCO	Ellipso	Globalstar	Iridium	ICO
Orbit	LEO	MEO	LEO	LEO	MEO
Altitude (nm)	1080	4356, 4237 to 281	763	421	5591
Orbital period (minutes)	127	varies	114	100	359
Operational Satellites	46	14 to 18	48	66	10
Orbital planes	4	3	8	6	2
Satellites per plane	11 / 5	4 / 4 / 6	6	11	5
Beams per satellite	24 and 32	61	16	48	163
Access Scheme	CDMA	CDMA	CDMA	TDMA	TDMA
Life Expectancy (years)	4 to 5	5	7.5	5 to 8	15
Relay Type	bent pipe	bent pipe	bent pipe	on-board processing	bent pipe
Primary Backer(s)	E-Systems	Mobile Communications Holdings, Inc. Boeing	Loral Qualcomm Alcatel	Motorola	TRW Teleglobe
Satellite Contractor	Orbital Sciences	Boeing	Loral	Motorola	Hughes

launching a constellation of 12 satellites by 2000. These Hughes-built satellites will orbit in two planes at an altitude of about 5600 nautical miles, making it a MEO system. Digitized voice and data will be transmitted and received in S-band from handheld terminals and specialized ground equipment using TDMA. The satellites, based on the Hughes 601 design, will support as many as 4,500 simultaneous calls in 163 spot beams. A dozen ground stations (what ICO calls satellite access nodes–SAN), will be scattered around the globe to route satellite calls into and out of the public switched telephone network (PSTN).

ICO has signed contracts with NEC, Samsung, and Mitsubishi for design and manufacture of consumer handsets. Since ICO is also a signatory to the GSM Memorandum of Understanding (MoU), dual-mode handsets are expected to operate within a terrestrial GSM cellular network as well as over satellite.

The first ICO spacecraft, F-1, underwent environmental testing at Hughes Space and Communications in Los Angeles in June. ICO expects to offer commercial service from six satellites as early as 1999.



Little LEO

Although the voice services promised by Big LEO systems garner headlines, the market for data transmission may be much larger. Five companies in the United States have been licensed to provide two-way data and position reporting. The FCC describes these "little LEO" systems as non-voice, non-geostationary mobile satellite service (NVNG MSS). Uplink frequencies for these constellations are in the 148 to 149.9 MHz band, and downlink frequencies run from 137 to 138 MHz. Because the available space in these bands is limited and currently occupied by other users, a rather complicated spectrum sharing plan is in place to allow these five systems to operate without interfering with each other. How well this works in such a competitive marketplace remains to be seen.

Orbcomm

Headquartered in Herndon, Virginia, Orbcomm is jointly owned by Orbital Sciences Corporation, Canada-based Teleglobe, and the Malaysian company Technology Resources Industries Bhd. Orbital has approval from the FCC to build and launch a constellation of 48 satellites in low earth orbit, providing messaging and position reporting via small, low powered VHF and UHF transceivers. Orbcomm currently has 12 satellites in orbit, and plans to have 16 more overhead by the end of the year.

Although long delayed, one of the most anticipated products is the Magellan GSC 100 handheld subscriber communicator. This paperback-sized terminal will send and receive electronic mail messages via the orbiting spacecraft, which serve as relays for strategically located ground stations. Ground-based computers will route these messages between customers and terrestrial networks such as the Internet. The GSC 100 will sell for less than $1000 and charges will be billed on a per character basis rather than per minute.

VITA

Volunteers in Technical Assistance (VITA) is currently licensed by the FCC to operate two little LEO satellites. These will presumably be used to further their non-profit, humanitarian operations in third world countries. Using these satellites they hope to deliver educational, health, environmental, and technical services to developing countries.

LEO One USA

LEO One plans to offer two-way messaging, vehicle tracking, remote meter reading and other services using 48 LEO satellites operating FDMA/TDMA.

Final Analysis

Final Analysis is working to create a LEO constellation of 30 operational satellites plus six in-orbit spares, although their FCC license of April 1, 1998, allows only 26 active and four spares. They plan to operate from a 1850 nautical mile orbit.

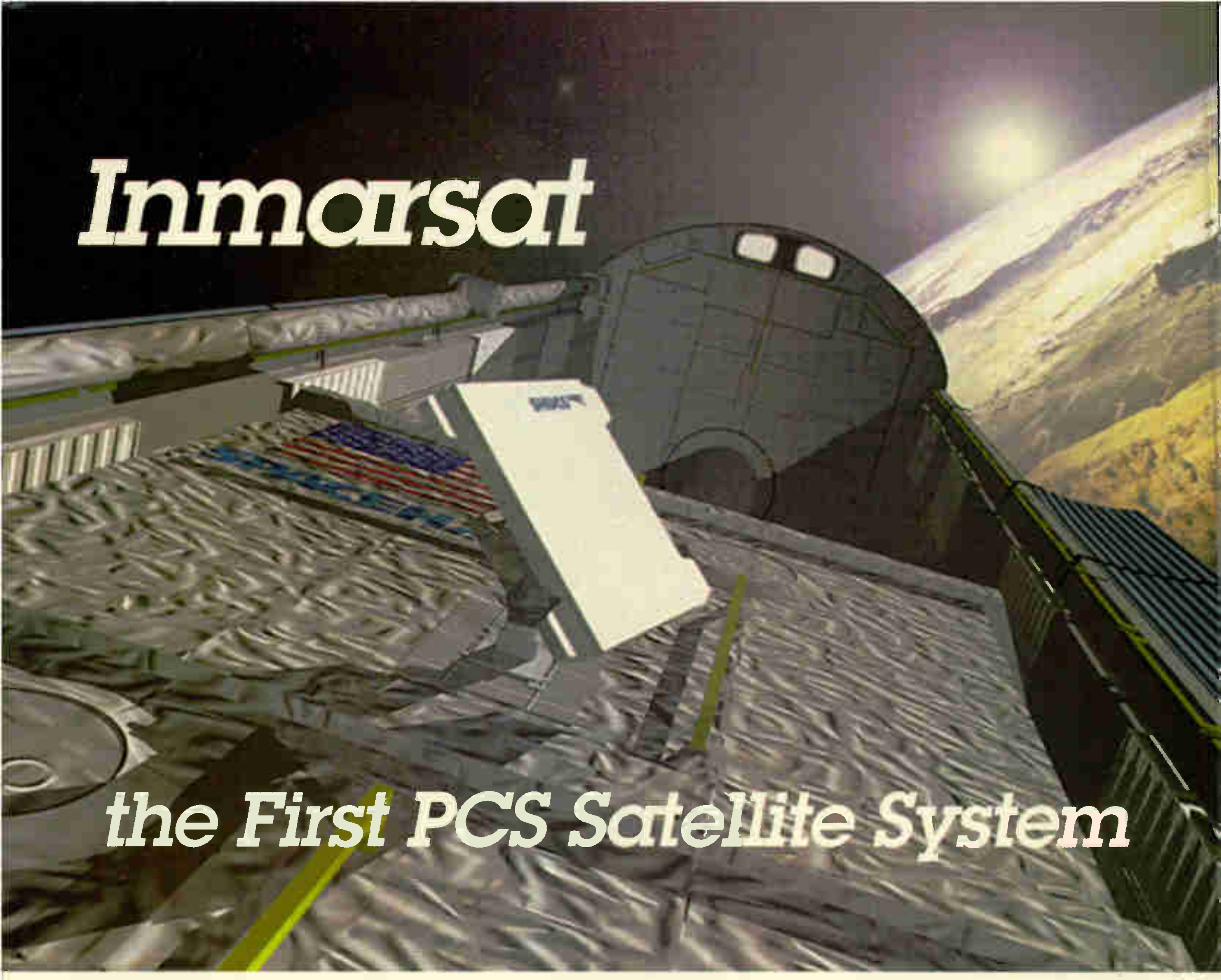
E-Sat

Owned by EchoStar Communications Corporation and DBS Industries, this system is envisioned to support automated meter reading applications. DBS Industries previously demonstrated the use of LEO satellites to collect meter information from remote sites. The planned constellation will have six satellites transmitting and receive spread spectrum signals at an altitude of 1655 nautical miles.

Falling prices

Mobile satellite services are following a traditional technology curve. In the early 1980's the Inmarsat Standard-A service provided satellite-based telephone service from a $30,000 terminal at rates of $10 per minute. The introduction of Inmarsat-M a decade later brought the terminal size down from a shipboard mount to a briefcase or two costing $10,000, with a $5 per minute airtime charge. The Inmarsat-3 satellites have made possible the Mini-M service, accessible through $3,000 notebook-sized terminals running at $3 per minute or less. Regional competitors such as AMSC, TMI, and Optus offer $5,000 terminals and $1.50 per minute rates for geographically limited but no less capable service.

The imminent availability of Big LEO service from Iridium, Globalstar, Ellipso and others will further drive down size and cost, making possible a handset costing less than $1,000 and airtime rates less than $1 per minute. Competition will continue to bring prices down to earth for the anywhere, anytime personal communications satellite services.



Inmarsat the First PCS Satellite System

by Philip Chien, ST Staff Writer

Before the era of satellites, ships at sea kept in communication via shortwave radios. Shortwave was responsible for the rescue of the survivors from the *Titanic*, and countless vessels in distress at sea. But shortwave is also unreliable, dependent on the atmospheric conditions.

In the 1970s NASA launched three Marisats–Maritime satellite systems which established the first satellite communications specifically intended for ships at sea. In 1979 Inmarsat–the International Maritime Satellite organization–was established, using Intelsat as its model. Any nation could join Inmarsat, and a country's participation was based on how much funding it provided.

The Soviet Union had shunned Intelsat, preferring its own Inter-Sputnik system, but it chose to join Inmarsat. Inmarsat started with 22 countries and now includes 82. The most recent signatory is VietNam, this past April. All of the major countries with shipping and maritime interests are members of Inmarsat, and some land-locked countries too. The top participants are the U.S., UK, Norway, and Japan. Inmarsat's world headquarters are located in London, England.

The European Space Agency planned to launch two Marecs satellites. Marecs A was launched on December 20, 1981. Marecs B was lost in an early Ariane failure and eventually Marecs B2 was built as a replacement. The Marecs satellites were leased to Inmarsat, similar to the way Comsat leased its Marisat satellites. These early, pre-Inmarsat assets had extremely limited capabilities; Marisat could handle 10 two-way voice circuits, Marecs up to 75. But no matter–only the major ocean-going vessels could afford or justify the costs of a shipboard transceiver.

When Inmarsat decided to obtain its own on-orbit resources it took a rather unusual route. Instead of purchasing their own satellites, they rented space on other satellites. An arrangement was reached with Intelsat where four Intelsat V series satellites would carry Inmarsat Maritime Communications Subsystem (MCS). The MCS could support 50 two-way voice circuits. The parent Intelsat satellite would supply power and other support functions to the MCS system when it was in use and Intelsat would be paid for the use of the system, just like any other Intelsat customer. If the MCS payload wasn't in use, then Intelsat could use the power for other purposes (e.g. additional transponder power, battery charging, etc.) The arrangement was beneficial for all of the parties–Intelsat had another paying customer, Inmarsat had its own on-orbit transponders without most of the overhead costs of operating its own satellites.

By the mid 1980s Inmarsat was growing rapidly with more and more demand for its services. At this point the organization decided it was ready to obtain its own satellites. Just to confuse everybody these were called the "Inmarsat 2" series. Inmarsat 1 was the MCS payloads on the Intelsat satellites even though they were never referred to by that name. The contract to build the five satellites went to British Aerospace, with launches by Delta and Ariane 4 vehicles. These satellites had the capability to support 250 two-way voice circuits. The effective isotropically radiated power (EIRP) is 39 dBW.

These improvements led to new operating modes and less expensive air time charges. More and more ships were Inmarsat equipped, and eventually it became an international regulation for many classes of vessels. Many cruise ships even have public pay-phones installed, connected via Inmarsat satellites, and luxury cabins even have their own direct-dial telephone numbers! By this point satellite maritime communications has become more of a necessary and operational tool than just a high tech toy for only the largest ships.

In addition, Inmarsat was starting to branch out. While the organization was started primarily to serve the maritime community, aircraft transceivers were developed and even transportable suitcase-size transceivers for world travelers without any other reliable form of communications. Some managers even kidded that the name of the organization should be changed to InMOBsat to reflect its new focus.

One of the most famous Inmarsat users was CNN reporter Peter Arnett, covering the Gulf War from Baghdad with a transportable Inmarsat-A terminal.

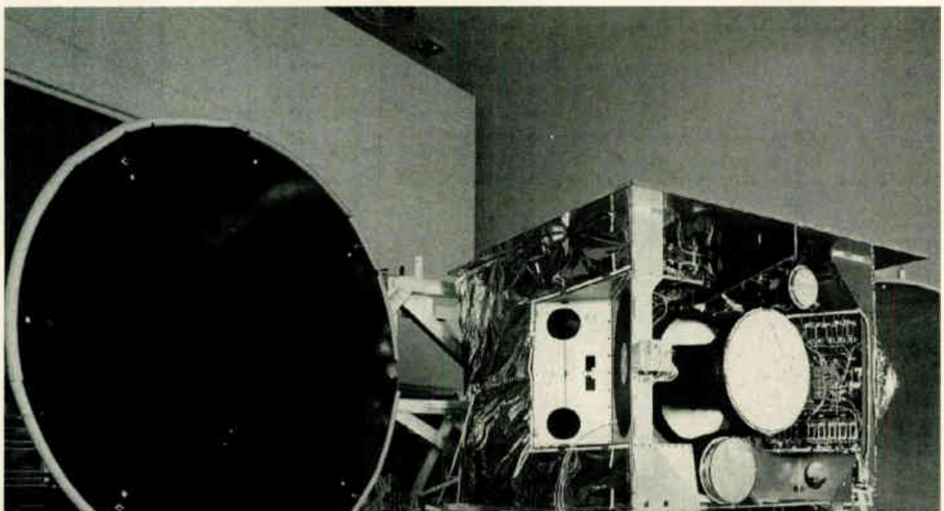
The current Inmarsat satellites are the Inmarsat 3 series, with the Inmarsat-2s available for additional capacity and as backups. The Inmarsat-3s have an EIRP of up to 48 dBW–eight times the power density of the Inmarsat 2 series. The transponders can handle up to 2000 two-way voice circuits. GE Astrospace (later Lockheed-Martin Astrospace) built the GE-4000 satellite bus while Matra Marconi built the communications transponders.

In remote areas beyond the reach of telephone links, or in places of natural disaster where telephone lines are down, the Inmarsat-A transportable communications terminal is a vital link for rescue workers and the media.

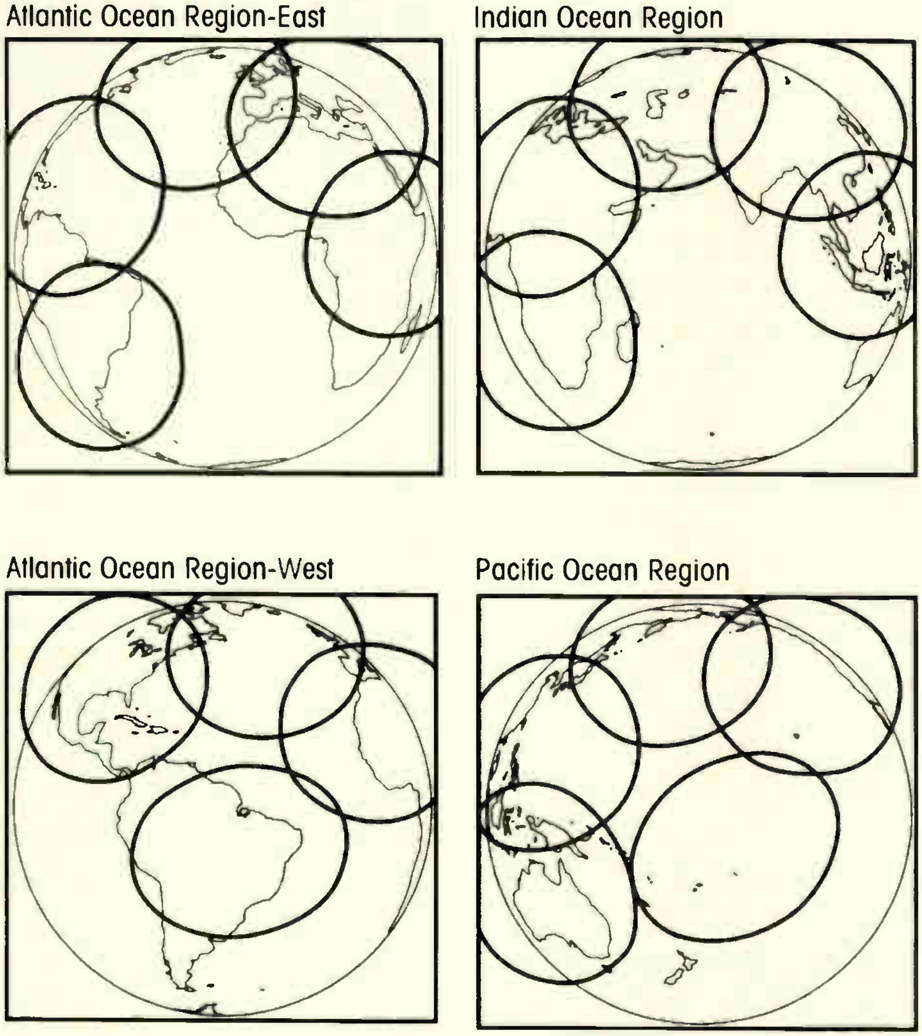
Three types of launch vehicles were used to launch the Inmarsat-3 series–Atlas, Ariane, and Proton launch vehicles. The commercial Proton launch was procured directly from Khrunichev before International Launch Services was established to sell Proton launches for western satellites. Due to the high latitude of the Proton launch site the Block DM upper stage is used to take the satellite directly to a geostationary orbit. In comparison, Atlas and Arianes only go to a geosynchronous transfer orbit and the satellite uses its own on-board propellant to circularize the orbit in to a geostationary orbit. Normally the GE-5000 bus is built around a Thiokol Star 37 apogee kick motor (AKM). For the Proton launch of Inmarsat 3-F2 the AKM was not used and the spacecraft bus was modified for use with the Proton.

One of the more subtle improvements is direct, user-to-user capabilities. In the past, if one ship wanted to contact another ship in the same ocean, the call would have to be relayed via a ground station, doubling the price of the call and the length of the timelag. The call would

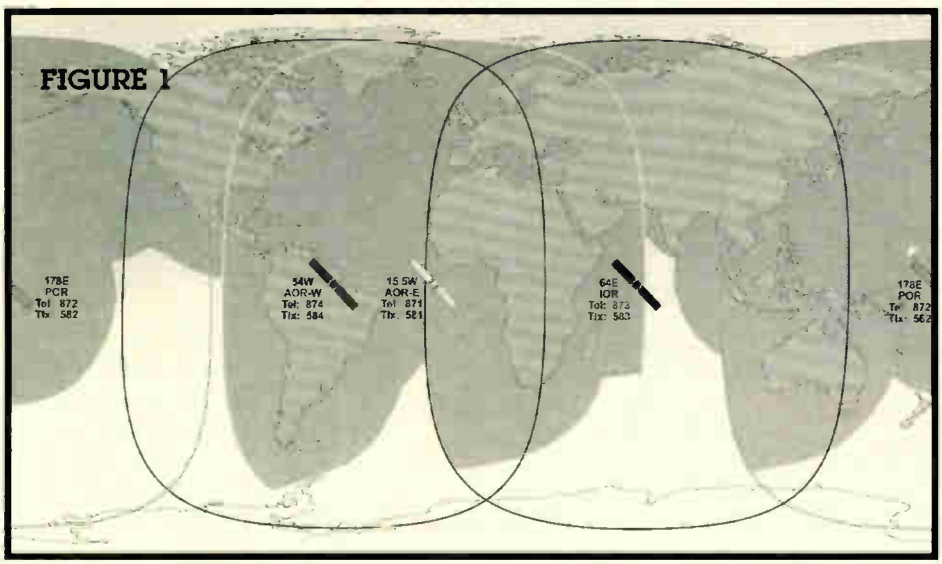
The world's most advanced mobile communications payload is designed and manufactured by Matra Marconi Space at its Portsmouth, England facility for the Inmarsat 3 satellite. (Photo credit: Matra Marconi Space)



Inmarsat-3 Spot Beam Coverage



Inmarsat-3 Spot and Global Beam Coverage



go from ship to satellite to ground station to satellite to ship. The Inmarsat 3 series have enough onboard intelligence to route a direct ship to satellite to ship call without requiring a link through a ground station.

The key Inmarsat 3 improvement is high power spot beams aimed towards continental areas and some heavily traveled ocean regions. Spot beams work on the same principles as megaphones and directional antennas–aim the signal where you want it to go rather than everywhere. The spot beams supplement the hemispheric coverage antennas which cover from about 65 degrees North to 65 degrees South.

Figure 1 shows the various footprints from the four operational locations around the world. Note that in the case of the Atlantic satellites many areas are only covered by one particular satellite but not the other. For example, Venezuela in South America is served by the Atlantic East satellite while Liberia in Africa is served by Atlantic West. The key regions not covered by spot beams include New Zealand, Sri Lanka, and portions of the Indian, Pacific, and South Atlantic oceans.

In comparison with other PCS systems Inmarsat has various advantages and disadvantages. The MSAT / AMSC geosynchronous satellites are limited to only the North American continent plus coastal areas. Lower altitude satellites have the advantage of no geosynchronous time lag, lower power requirements, and many can use omnidirectional antennas. Inmarsat can reach Palmer station in Antarctica at 65 degrees South; however, many LEO constellations can communicate with every spot on the Earth, including the poles. On the other hand the four Inmarsat satellites plus one spare are enough to cover all of the populated areas of the world and all of the major ocean regions while LEO constellations require many more satellites and launches to cover as much area.

The current Inmarsat 3 satellites will reach the ends of their useful lifetimes about 2010. It's too early to tell what the Inmarsat 4 series will look like. Much of it will depend on the success of the Low Earth Orbit (LEO) and Intermediate Circular Orbit (ICO) constellations. Among other thoughts, Inmarsat is considering leasing services, developing piggyback payloads similar to the Inmarsat MCS transponders, or a fourth-generation satellite from scratch.

Inmarsat mobile services are available in several flavors.

Inmarsat-A, still in use, is the original analog voice bandwidth (phone, fax, data, telex) service. It requires fairly large (50-100 kg.) and expensive ($30,000) terminals.

Inmarsat-B is the digital version with lower user charges.

Inmarsat-C is a specialized low data-rate (600 bits per second) mode with briefcase size terminals in the $5000 price range. It's suitable for worldwide portable email applications. Inmarsat calls e-mail received on a ship via satellite, "Sea-mail" (pronounced C-mail).

Inmarsat-M is a digital communications system using the Inmarsat-3 spot beams. Terminals are about the size of a laptop computer and cost about $10,000.

Other versions of Inmarsat are available for aircraft operations and simple one-way messaging (e.g. pagers or remote data collection) modes. Since pager-type applications require very low bandwidth, they can use very low power, indoor, omnidirectional antennas with very small receivers.

Inmarsat reached 100,000 users in December 1997 and the numbers continue to climb.

The first portable global satellite communications unit was Comsat's Planet 1. The $3000 terminal is about the size of a notebook computer. The antenna needs to be pointed towards an Inmarsat satellite. Indoors the unit will only work if it's positioned by a window facing the correct direction. Comsat quotes rates of $3 per minute usage charges. Secure communications are available as an option. STU-III (Secure Telephone Unit Version III) is available with four levels of security. Type 1 can only be used by government contractors working on top secret classified projects and has the strongest encryption techniques. Type 2 is for government sensitive information and limited to companies with U.S. government sponsorship. Type 3 is available for any U.S. corporation and is limited to use by U.S. citizens. Type 4 is available to domestic and international corporations, except prohibited countries where U.S. export restrictions apply.

COMSAT's PLANET 1 offers portable anywhere-anytime digital voice, fax, data and paging communications via satellite to international business travellers and individuals who live, work and travel outside of cellular coverage.

One of the most unusual Inmarsat users has to be the space shuttle. On the STS-91 shuttle-*Mir* mission, a Lynxx Inmarsat terminal was flown as a "protoflight" experiment–SpaceHab Universal Communications System (SHUCS). The key modification was software to compensate for the shuttle's speed and to determine which way to point the antenna. A 31 inch (79 cm.) square external flat antenna was mounted on top of the Spacehab pressurized module. The antenna was connected to a pan and tilt unit, basically a spare shuttle cargo bay camera mount.

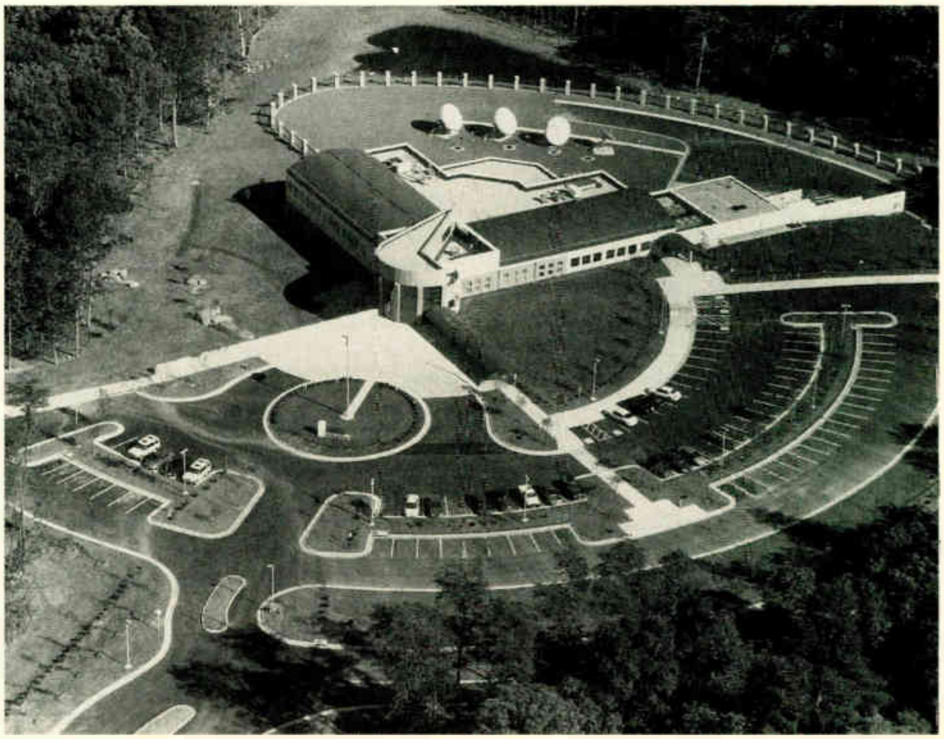
In addition, the antenna had four GPS patch antennas which were used to determine the shuttle's attitude without requiring any interface with the shuttle's avionics. Once the GPS data was acquired, the on-board computer could determine the shuttle's location and which direction it was pointed. It then sent commands to the pan and tilt unit to point the antenna towards on of the Inmarsat satellites. At that point the shuttle astronaut could make a call from the Spacehab module to anybody in the world.

It turns out a loose cable prevented any possibility of high speed modes and there wasn't enough time to diagnose the problems. The SHUCS team is confident that if they had additional time they would have succeeded in completing a voice-mode call. The SHUCS team hopes to refly the experiment on the STS-96 space station logistics flight.

SpaceHab also investigated the possibility of placing an Inmarsat terminal aboard *Mir* to increase communications capability with the Russian space station. Currently the company is investigating offering its SHUCS as a subsystem for commercial and government satellites, including the International Space Station, to permit high speed communications at a lower cost than NASA's Tracking and Data Relay Satellite.

Deploying *the Iridium Constellation*

By Phillip Clark, ST Staff Writer



The fully operational constellation of Iridium communication satellites comprises six orbital planes of satellites, each orbital plane containing eleven operating satellites plus at least one spare satellite. A rapid-fire series of launches starting in May 1997 and ending a year later using United States, Russian and Chinese vehicles resulted in the initial deployment of satellites being completed after fifteen clusters of satellites had been successfully launched, although some of the satellites were non-operational: a total of 72 satellites had been placed into orbit.

This article will review the launch profiles used by the three different launch vehicles used during the initial deployment of the Iridium satellites and also look at the evolution of the satellite orbits once launched. Table 1 provides an overview of the launches which took place through to the end of May 1998.

In the discussions which follow, unless specified otherwise all orbital data are derived from the U.S. Space Command (USSPACECOM) two-line orbital elements. The satellites numbered 1-3 were ground test vehicles, explaining why the numbering system begins with satellite number 4. The satellite designators used in this article are those which are assigned by USSPACECOM, but it appears that as the satellites have maneuvered in orbit USSPACECOM has subsequently misidentified some of the satellites.

TABLE 1: IRIDIUM LAUNCHES, MAY 1997–MAY 1998

Launch Date and Time	Launch Site	Vehicle	Satellites	Plane
1997				
May 5/1455	Vandenberg	Delta-2 (7920)	4 5 6 7 8	D
Jun 18/1402	Baikonur	Proton-K (4)	9 10 11 12 13 14 16	E
Jul 9/1304	Vandenberg	Delta-2 (7920)	15 17 18 20 21	F
Aug 21/0038	Vandenberg	Delta-2 (7920)	22 23 24 25 26	B
Sep 1/1400	T'ai Yuan	CZ-2C/SD	Test payloads (2)	–
Sep 14/0136	Baikonur	Proton-K (4)	27 28 29 30 31 32 33	C
Sep 27/0123	Vandenberg	Delta-2 (7920)	19 34 35 36 37	D
Nov 9/0134	Vandenberg	Delta-2 (7920)	38 39 40 41 43	F
Dec 8/0716	T'ai Yuan	CZ-2C/SD	42 44	F
Dec 20/1316	Vandenberg	Delta-2 (7920)	45 46 47 48 49	B
1998				
Feb 18/1358	Vandenberg	Delta-2 (7920)	50 52 53 54 56	E
Mar 25/1701	T'ai Yuan	CZ-2C/SD	51 61	D
Mar 30/0602	Vandenberg	Delta-2 (7920)	55 57 58 59 60	C
Apr 7/0213	Baikonur	Proton-K (4)	62 63 64 65 66 67 68	A
May 2/0916	T'ai Yuan	CZ-2C/SD	69 71	B
May 17/2122	Vandenberg	Delta-2 (7920)	70 72 73 74 75	A

Note: The Chinese launch on September 1, 1997, was a test flight of the new variant CZ-2C/SD launch vehicle with two dummy payloads carried: "SD" is the Smart Dispenser which acted as a third stage of the launch vehicle.

Launches Using the Delta-2

Nine launches of Delta-2 (7920 variant) launch vehicles from Vandenberg AFB were used to launch 45 satellites into orbit in clusters of five. It was originally planned that the first Iridium cluster would be only three satellites, but the launch failure of the first Navstar 2R satellite aboard a Delta-2 (7925) on January 17, 1997, and the subsequent delay in launching the first Delta-2/Iridium mission meant that the number of satellites carried was increased to what was to be the standard Delta-2 complement.

The first launch of an Iridium cluster finally took place on May 5, 1997, with five satellites being successfully placed into orbit: the initial constellation deployment was completed May 17, 1998, with the ninth launch of a Delta-2 carrying a cluster of Iridium satellites.

Table 2 provides a summary listing showing the Iridium parking orbit parameters for each Delta-2 launch: only one representative of each cluster has been used for this listing (usually cataloged "A") and usually satellites which appear to have slightly anomalous orbital altitudes (slightly above or below the norm) are ignored since these might reflect bad data in the two-line orbital element sets.

The satellites were planned to maneuver to near-circular 86.4°, 100.4 minutes, 775-780 km orbits. It will be noted that the first two Delta-2 launches used the operational orbital inclination, but starting with the fourth launch a higher inclination of 86.6-86.7° was used. This was probably so that any launch/deployment failures would have a slight orbital inclination difference, reducing the chances that such failures could interfere with the operational satellites.

Table 2 also shows that two altitude regimes were used for the parking orbits. When the first flights at the slightly-increased orbital inclination took place (clusters 4 and 6) a lower orbital altitude was used–both perigees and apogees were typically 80 km below the altitudes seen on the first two launches. The launch of cluster 7 (fifth Delta-2 launch) saw a return to the original orbital altitudes. The mean orbital periods and altitudes for each of the two orbital regimes were:

Regime 1 (7 launches, 35 satellites)
Period: 97.38 ±0.03 minutes
Perigee: 624 ±4 km
Apogee: 642 ±3 km

Regime 2 (2 launches, 10 satellites)
Period: 94.87 ±0.03 minutes
Perigee: 502 ±2 km
Apogee: 523 ±1 km

The rational behind the different orbital regimes is that the first two clusters launched on the Delta-2 carried satellites with light battery packs and full propellant loads, each satellite having a mass of 657 kg. The third and fourth Delta-2 clusters carried heavier battery packs (adding 10 kg to each satellite) and the full propellant load, and thus a lower deployment orbit was called for.

Starting with the fifth Delta-2 launch the heavier battery packs were retained, but about five kg of propellant was off-loaded, giving a mass for each satellite of

TABLE 2: INITIAL ORBITAL DATA FOR DELTA-2 LAUNCHES OF IRIDIUM SATELLITES

Cluster	Satellite	Incl Deg	Period min	Perigee km	Apogee km
1	Iridium 8	86.40	97.41	626	643
3	Iridium 15	86.40	97.29	619	639
4	Iridium 26	86.69	95.66	544	557
6	Iridium 19	86.69	95.65	542	558
7	Iridium 43	86.58	97.38	626	641
9	Iridium 45	86.57	97.38	623	644
10	Iridium 52	86.57	97.38	624	643
12	Iridium 55	86.58	97.36	624	641
15	Iridium 70	86.57	97.41	627	643

TABLE 3: ORBITAL DATA FOR DELTA-2 SECOND STAGES

Orbit Epoch	Incl Deg	Period min	Perigee km	Apogee km	Argument of Perigee Deg
Cluster 1 (MS-1A)		Still in orbit on Jul 1, 1998			
1997 May 5.80	86.92	100.29	596	949	211
Cluster 3 (MS-2)		Decayed Mar 30, 1998			
1997 Jul 12.12	82.73	93.52	266	628	342
Cluster 4 (MS-3)		Decayed Oct 15, 1997			
1997 Aug 21.13	86.69	95.78	519	593	176
1997 Aug 21.19	82.64	92.09	209	545	350
Cluster 6 (MS-4)		Decayed Apr 18, 1998			
1997 Sep 27.29	86.85	95.61	489	608	171
1997 Sep 29.61	83.61	92.80	278	545	340
Cluster 7 (MS-5)		Decayed Apr 26, 1998			
1997 Nov 9.56	83.56	93.40	255	628	351
Cluster 9 (MS-6)		Decayed Jun 24, 1998			
1997 Dec 20.78	83.61	93.46	262	627	352
Cluster 10 (MS-7)		Still in orbit on Jul 1, 1998			
1998 Feb 18.81	83.67	93.52	269	625	351
1998 Feb 19.02	86.57	97.39	627	641	222
1998 Feb 20.76	83.68	93.49	267	624	345
Cluster 12 (MS-8)		Decayed May 11, 1998			
1998 Mar 30.42	86.58	97.36	624	641	232
1998 Mar 30.81	83.02	92.77	194	626	351
Cluster 15 (MS-9)		Still in orbit on Jul 1, 1998			
1998 May 18.12	84.16	94.06	319	627	352

The "MS" designators are those used by Boeing for the Iridium deployment missions: the status of the second stage (in orbit or decayed) is correct through to the end of June 1998.

662 kg and permitting a return to the higher orbital regime.

Material issued by Boeing with the Delta-2 press kits for the Iridium launches gives the typical launch profile for missions in the first orbital regime just noted. After launch a dog-leg maneuver would be used to reach an orbital inclination of 86.4° (the same value is quoted for the missions which reached 84.6-84.7° inclinations). The first burn of the second stage would place the assembly into a 170-647 km transfer orbit (Second Stage Engine Cut-Off, SECO-1, 674 seconds after launch), while a second burn of the stage (SECO-2, 3,516 seconds after launch) circularizes the orbit at 639 km for the deployment of the satellites. About 6,350 seconds after launch the second stage engine once more re-ignites (SECO-3) to take the stage out of the Iridium orbital regime: a burn to the depletion of the propellant lowers perigee well below the deployment altitude to ensure that the stage is only in orbit for a few months.

It is interesting to compare this standard profile with orbital data from USSPACECOM (see Table 3). With these data one has to bear in mind that the second stage is in the deployment orbit for a relatively short time and therefore USSPACECOM might not produce an element set until the stage has performed the burn to depletion.

There was a problem with the deployment of the first Iridium cluster. Following deployment of the third satellite there was a pressure drop in the gaseous nitrogen tank of attitude control system of the second stage and by the time that the fourth satellite had been deployed the nitrogen was virtually depleted. After deployment of the fifth satellite the second stage did not back away as it should have done and when the planned depletion burn was completed the fifth satellite was pushed into a slightly lower orbit. Meanwhile, the second stage was not correctly aligned when the depletion burn took place, and instead of entering the planned 332-630 km orbit it went into a 595-950 km orbit from which it has yet to decay.

Table 3 shows that this was the only such malfunction of a Delta-2 second stage during the Iridium deployments, with all of the other missions having the second stages maneuvered to orbits below the Iridium deployment altitude.

The majority of Iridium launches using the Delta-2 vehicle have resulted in unexplained, additional pieces of debris being tracked in orbit. The pieces which have been cataloged are listed in Table 4. It will be noted that the epoch dates for these initial orbits are normally a few days or even weeks after the launches took place: this simply reflects the time taken before the debris was officially cataloged, rather than the time when the debris was created.

Looking at the orbital data and in particular the orbital inclinations, these appear to reflect the initial orbital inclinations of the deployment orbits. If the fragments had all originated from the satellites then one would expect some or all to be the operational inclination of 86.4°, but this is not the case.

There is some evidence which points to the source of the debris being acoustic/thermal blanket material from the fairing interior. The problem was supposedly rectified for subsequent launches. However, debris continued to appear, and therefore either the problem was not properly solved or there was a second source for the debris on the later Delta-2 launches. Enquiries with Boeing concerning this matter received no response.

TABLE 4: CATALOGED DEBRIS FROM DELTA-2/IRIDIUM LAUNCHES

Cluster	International Designation	Orbit Epoch	Incl Deg	Period min	Perigee km	Apogee km
3	1997-034G	1997 Jul 31.81	86.34	97.05	579	656
	1997-034H	1997 Aug 4.85	86.38	97.40	620	648
	1997-034J	1997 Aug 15.29	86.34	97.12	581	660
4	1997-043G	1997 Aug 29.72	86.63	94.02	445	497
	1997-043H	1997 Aug 29.15	86.67	95.02	503	536
	1997-043J	1997 Aug 29.43	86.69	95.48	529	555
9	1997-082G	1998 Jan 14.74	86.54	96.63	581	613
10	1998-010G	1998 Mar 2.22	86.55	95.22	503	556
	1998-010H	1998 Mar 2.47	86.56	96.31	573	590
12	1998-019G	1998 Apr 20.33	86.62	95.60	535	560
	1998-019H	1998 Apr 20.55	86.61	94.73	500	511
15	1998-032G	1998 May 18.53	86.60	97.27	617	640

Launches Using The Proton-K

Three launches of the four-stage Proton-K vehicle were purchased for the initial Iridium deployments, each launch carrying seven satellites. The basic three-stage Proton-K was manufactured by Khrunichev in Moscow and the fourth stage was a derivative of the Block DM family of fourth stages, manufactured by Energiya. As noted in an earlier *Satellite Times* article (*Russian Proton Rocket Program*, January 1998, pp 16-21, 55), the Block DM2 fourth stage variant was specifically developed for the deployment of Iridium satellites, and it included a specially-manufactured Khrunichev multiple payload mount to carry the seven satellites.

The initial orbital data for the three clusters of satellites launched using the four-stage Proton-K are summarized in Table 5 which follows.

Table 5: Initial Orbital Data for Proton-K (4) Launches of Iridium Satellites

Cluster	Satellite	Incl Deg	Period min	Perigee km	Apogee km
2	Iridium 14	86.35	94.86	501	523
5	Iridium 29	86.63	94.91	505	523
13	Iridium 62	86.66	94.84	500	522

It should be noted that like the first two Delta-2 launches the parking orbit inclination was 86.35° for the first launch and approximately 0.3° higher for the later launches. The mean values of the other parameters for all 21 satellites are as follows:

Period: 94.87	±0.03 minutes
Perigee: 502	±2 km
Apogee: 523	±1 km

The first Proton-K launch carried a cluster of Iridium satellites with the light battery packs and a full propellant load (mass 657 kg each), but the second and third launches carried satellites which had both the heavier batteries and a full propellant load (mass 667 kg each).

As described in the *Satellite Times* article noted above, a completely new launch profile was used by the Proton-K for launching Iridium satellites. The third stage placed the fourth stage/satellites assembly into an initial 73°, 170 km circular orbit (approximate parameters) where the third stage and the shroud covering the fourth stage were separated. The Block DM2 fourth stage then performed a maneuver 2,224 seconds after launch to reach a ~73°, 170-516 km orbit and at the first apogee pass 4,832 seconds after launch the stage performed a circularization burn and changed the orbital place to 86.4°. It was in this orbit that the satellites were deployed. A third Block DM2 maneuver 7,046 seconds after launch deorbited the stage. (These are the nominal values for the first launch.)

On the Cluster 2 launch, the first aboard a Proton-K, USSPACECOM did not catalog the third stage, fourth stage shroud or the fourth stage before they decayed from orbit: one assumes that they were tracked, but USSPACECOM did not get any fixes which were good enough to allow orbital data to be released to the public.

On the Cluster 5 launch only one low-orbit object was cataloged, presumably the third stage since this normally stays in orbit longer than does the fourth stage shroud. The first set of orbital data was for more than 8.6 hours after launch and showed a rapidly-decaying object in a 72.58°, 124-143 km orbit. The fourth stage was not cataloged.

Finally, no rocket stages nor the shroud were cataloged from the Cluster 13 launch.

There appear to have been no anomalies on any of the three Iridium launches aboard the four-stage Proton-K vehicle.

Launches Using the CZ-2C/SD

Iridium Inc purchased ten launches aboard a modification of the Chinese CZ-2C ("Chang Zheng"–Long March), each launch carrying two satellites. Launches would be from the T'ai Yuan site which had previously only been used for the two Sun-synchronous Feng Yun-1 meteorological satellites in 1988 and 1990.

The CZ-2C is a successful modification of the original CZ-2A which failed on its only launch in November 1974: the CZ-2C flew 14 successful missions during 1975-1993 with no launch failures. For the Iridium launches it is reported that a stretched second stage is used: the Chinese developed a third stage, the Smart Dispenser (SD), for the vehicle, and this would be used for in-orbit maneuvering and the deployment of satellites in orbit.

All of the Chinese launches of operational Iridium satellites have used the heavy battery variant with the full propellant load (mass 667 kg).

Table 6 provides a summary of the deployment orbits from the first four CZ-2C/SD launches.

TABLE 6: INITIAL ORBITAL DATA FOR CZ-2C/SD LAUNCHES OF IRIDIUM SATELLITES

Cluster	Satellite	Incl Deg	Period min	Perigee km	Apogee km
–	MFS 1*	86.34	97.26	623	632
8	Iridium 42	86.29	97.34	626	636
11	Iridium 51	86.42	97.27	622	635
14	Iridium 69	86.35	97.38	625	641

* Mass Frequency Simulator: this is the test launch of the CZ-2C/SD with two mock-up Iridium satellites.

Taking all four launches and eight satellites (including the two Mass Frequency Simulators on the first CZ-2C/SD flight), the mean orbital data were:

Period: 97.32	±0.05 minutes
Perigee: 624	±2 km
Apogee: 637	±3 km

It is interesting that these launches were all using virtually the same orbital inclination as the operational constellation.

The Chinese have also published launch announcements for these launches, giving the nominal (target) orbital parameters and the actual parameters (flight data): these are summarized in Table 7.

TABLE 7: CHINESE ORBITAL DATA FOR CZ-2C/SD LAUNCHES OF IRIDIUM SATELLITES

Cluster	Test Flight		Cluster 8		Cluster 11		Cluster 14	
	Target	Actual	Target	Actual	Target	Actual	Target	Actual
Incl (Deg)	86.5	86.38	86.4	86.29	86.4	86.4	86.4	86.35
Perigee (km)	630	626.2	630	628.8	630	626.7	630	632.5
Apogee (km)	630	638.8	630	632.0	630	628.2	630	634.5

It should be noted that the orbital altitudes differ from those given elsewhere in this article, and this is because the Chinese are using a different Earth model for the calculation of the orbital altitudes.

The Chinese launches resulted in a lot of objects being placed into orbit, including pieces which USSPACECOM identifies as "debris."

The orbits of the CZ-2C second and third stages from each mission are summarized in Table 8. Looking at the orbital parameters from the four missions it would appear that USSPACECOM or GSFC have assigned the second and third (SD) stages from the September 1997 test flight the wrong way around.

The launch profile was for the CZ-2C to place the second stage and the SD/satellites assembly into an initial 84.3°, 180-660 km orbit and as the SD approached apogee for the first time it would fire to circularize the orbit. This is the orbit listed in Table 6 where the two Iridium satellites were deployed. Shortly after deployment the SD would once more fire its motor to reduce perigee to an altitude of around 200 km to ensure orbital decay within about 1-2 months.

Each of the Chinese launches produced debris in orbits which suggest that they are produced prior to the SD maneuvers. The number of additional pieces from the flights are as follows:

Test flight	2 pieces
Cluster 8	4 pieces
Cluster 11	4 pieces
Cluster 14	4 pieces

Continued on page 74

The View From Above

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Eventful Summer for Weather Sats (and Weather!)

Summer 1998 has so far proved to be one of the most eventful seasons for the weather satellite scene that I can recall. As I write this column, the new Russian Resurs-O satellite started transmitting APT (low resolution images) on 137.300 MHz–and then stopped transmitting them just 24 hours later!

Prior to that, some form of beacon telemetry from the satellite was first heard on (or near) 137.225 MHz, shortly after launch from Baikonur cosmodrone. Designated 1998-043A (number 25394 in the US Space Command catalog), the launch of Resurs had been anticipated for some weeks, though the proposed frequency of the APT transmission was uncertain. As of July 15, APT imagery had resumed broadcasting on 137.300 MHz at 1300 UTC.

Although I work at home six days of the week (and usually have two scanners operating), the one day that I was out teaching (information technology) was the first day that Resurs was active on APT. I was therefore grateful to receive some of the first Resurs images transmitted from several people around the world–especially since the only image I obtained from the satellite at 2016 UTC on the first day, was a blank image because it was night over Europe!

Olga Tarakanova of the R&D Center at ScanEx in Russia, tells me that image transmission from Resurs is from the visible channel of the onboard device MR-900M. An engineer who apparently works within the Resurs project told me that systems will be checked out for at least two months, and will involve different operations. I hope to include further details in future editions.

FIGURE 1: ***RESURS-O July 13 image of West Coast at 1720 UTC from Dale Ireland (USA)***

Other weather satellite activity

Meteor 3-5 recommenced APT activity on July 10 on its usual frequency of 137.850 MHz. The satellite's orbital plane had previously passed through conditions of low solar illumination (therefore a power constraint) and had apparently been deactivated for a few weeks. The satellite is passing northbound in daylight and stops transmitting when entering the earth's shadow (local night). During northern hemisphere summers, the north pole remains in daylight, so Meteor 3-5 continues to transmit during this part of its orbit. After crossing the pole it passes southbound into local night and switches off–see figure 4.

FIGURE 2: ***RESURS-O July 13 image of Central America at 1538 UTC from Milan Konecny (USA)***

FIGURE 4: ***Meteor 3-5 short southbound, night-time pass over Britain on July 15.***

Meteor 2-21 has been in a sorry state. The satellite is an old one that has not been used for some years. It restarted transmissions on 137.850 MHz in early June, but after a few weeks, the APT signal failed and only an RF (radio frequency) carrier with partial data, but no subcarrier has been received. Meteor 3-5's reactivation was therefore welcome by many weather satellite monitor enthusiasts.

NOAA-15 transmitting high quality images

I was amazed to see a perfect image from NOAA-15 on June 17 at 0755 UTC. Unknown to me at that time, NOAA-15's antenna had flipped into its correct position (or at least nearly-so) just two hours earlier. NOAA scientists had been monitor-

FIGURE 3: ***RESURS-O July 13 image at 1025 UTC of western Europe from Brian Dudman (UK)***

NASA engineers successfully performed a series of over 300 on-orbit verification tests since the May 13, 1998, launch to establish a satellite performance baseline designed to characterize all aspects of instrument and spacecraft operation.

ing a slow movement of the antenna and were relieved when telemetry improved so rapidly. "An early problem with the deployment of the VHF real-time antenna has almost completely corrected itself and the antenna is now fully functional and is providing excellent imagery to the ground."

"The NOAA-15 satellite is working beautifully and the mission has been an outstanding success," stated Harry McCain, the project manager for the Polar-orbiting Observational Environmental Satellite (POES) program. "This success is due to the professionalism of a large team of NASA, NOAA and contractor personnel. Our primary contractors are Lockheed Martin, ITT, Aerojet, Ball Aerospace, Panametrics and L3 Communications. We also have international partners from the U.K., France and Canada. All are to be congratulated for their significant ontributions in achieving our joint goal of success for the NOAA-15 mission."

NASA engineers successfully performed a series of over 300 on-orbit verification tests since the May 13, 1998, launch to establish a satellite performance baseline designed to characterize all aspects of instrument and spacecraft operation. My thanks to Patricia Viets, Public Affairs Officer at NOAA's National Environmental Satellite, Data, and Information Service at Suitland Federal Center for providing this information.

One of the best pre-antenna correction images that I have seen came from Chuck Vaughn–see figure 5. This shows the APT image with both visible-light channels active.

The other two polar orbiting weather satellites NOAA-12 and -14 have continued to transmit reliably (on 137.500 and 137.620 MHz, respectively). The two CIS (Russian) imaging spacecraft OKEAN-4 and SICH-1 make scheduled, but rare transmissions on 137.400 MHz, and these tend to be restricted to the vicinity of Russia. So far I have logged just one such transmission in July.

FIGURE 5: ***NOAA-15 May 16, 1622 UTC from Chuck Vaughn***

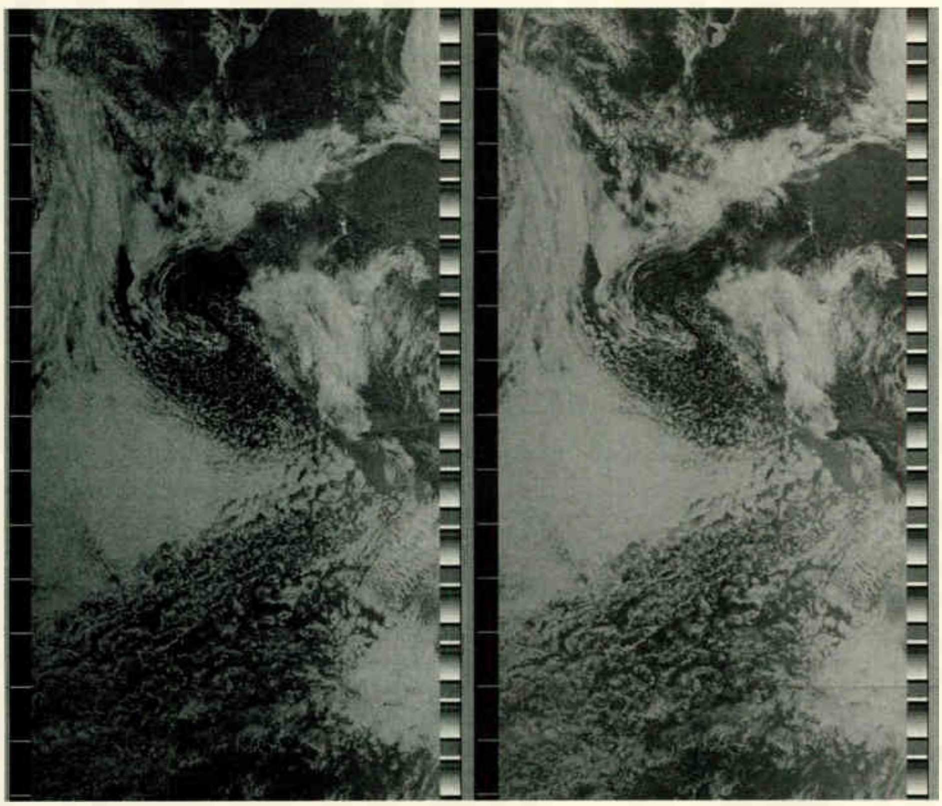
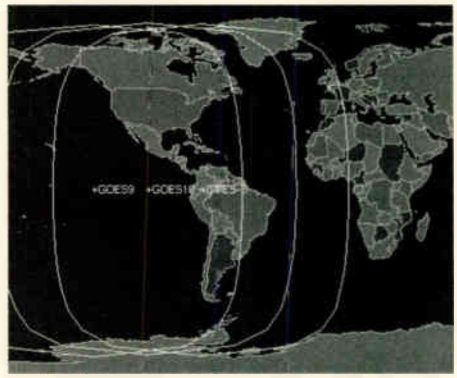


FIGURE 6: ***GOES-8, 9, 10 footprints***



GOES-9 replaced on orbit

The Commerce Department's National Oceanic and Atmospheric Administration announced on July 9 that NOAA's geostationary GOES-9 is failing as it reaches the end of its planned life. "Both momentum wheels on GOES-9 have exhibited problems," said Kathleen Kelly, director of NOAA's Satellite Operations Control Center. "Momentum wheel 2 failed and was turned off in June, and now the other is experiencing extremely high current levels. We need at least one wheel in operation to maintain pointing accuracy. Though we expect it to fail at any time, we are doing our best to keep GOES-9 transmitting until GOES-10 becomes fully operational ..."

GOES-10 is America's newest geostationary weather satellite, which was put into a storage orbit. It completed operational testing in June and is now being activated in its present position over the central United States (at 105 degrees West). GOES-10 will then replace GOES-9. Following activation, it can provide useful data within 72 hours. The satellite will be repositioned after consultation with the National Weather Service. GOES satellite images are best known to television viewers as the cloud images and movies that are broadcast on TV weather forecasts.

Gerald Dittberner, NOAA's GOES program manager said, "Having a GOES satellite stored on orbit ready to back up the other two GOES satellites turned out to be an excellent idea. It's the first time we had ever had a backup satellite in place. Without such a satellite, we would have had to wait as much as 12 to 15 months to get a

NOAA's new GOES series has produced an excellent set of real-time weather data for weather forecasters and researchers. Combined with data from Doppler radars and automated surface observing systems, these satellite data have proved to be crucial in improving weather forecasts and numerical models.

launch time slot. Now we can have GOES-10 transmitting data within 72 hours after activation, meeting our program needs without any loss in data continuity."

GOES-8 and GOES-9 were the first in a new series of satellites that had projected, planned lifetimes of three years. GOES-8, launched over four years ago, continues to function with no significant changes in the past 18 months. GOES-9, launched in May 95, had reached its projected planned life. The planned mission life for GOES-10 is five years. The next satellite in the series, GOES-L, is scheduled for launch in May 1999 and will also be stored on orbit.

NOAA's new GOES series has produced an excellent set of real-time weather data for weather forecasters and researchers. Combined with data from Doppler radars and automated surface observing systems, these satellite data have proved to be crucial in improving weather forecasts and numerical models. Better warnings of thunderstorms, winter storms, flash floods, hurricanes, and other severe weather has helped to save lives, preserve property, and benefit commercial interests. NASA's Goddard Space Flight Center manages the design, development, and launch of the GOES spacecraft for NOAA.

July 4–the views from GOES

Figures 7 and 8 are official GOES-8 and GOES-9 images respectively for July 4, for which I am grateful to NASA's Goddard Space Flight Center.

The variety of images from the GOES-8 (GOES-east) weather satellite, positioned over longitude 74 degrees west, should be enough to persuade anyone who has an interest in technology to set up a direct WEFAX receiving system. I find the images tremendously interesting, especially given the challenge of the difficult reception conditions!

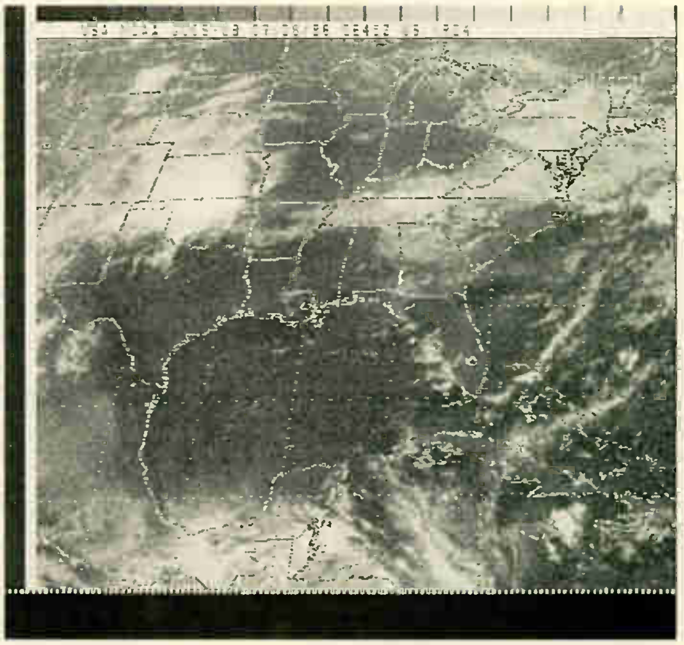


FIGURE 9: ***GOES-8 my image (from Plymouth, UK) of July 8, 0845 UTC***

Pointing a 45-element yagi through a neighbor's garden bush and adjusting for best reception at an elevation of three degrees is only worthwhile when you know the images are really worthwhile! My own GOES-8 image–see figure 9–has been slightly smoothed to reduce the inherent noise level seen at low elevations.

FIGURE 7: ***GOES-8 visible-light image 1745 UTC on July 4***

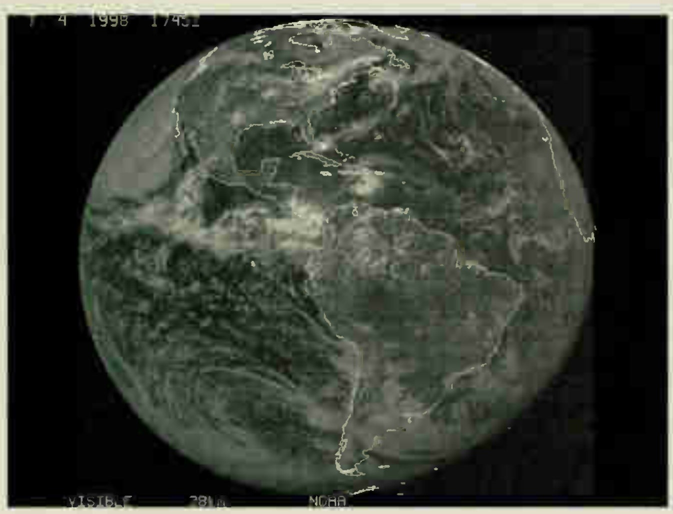
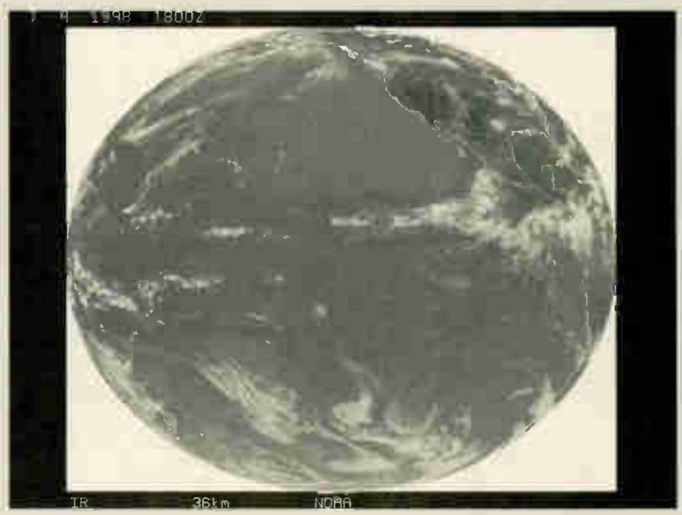


FIGURE 8: ***GOES-9 infra-red image 1800 UTC on July 4***



The variety of images from the GOES-8 (GOES-east) weather satellite, positioned over longitude 74 degrees west, should be enough to persuade anyone who has an interest in technology to set up a direct WEFAX receiving system.

Fires on the fourth

Some dramatic images were received in the USA from NOAA-12 on July 4 as fires burned along the eastern coast of Florida. Figure 10 is an HRPT image from NOAA-12 received at 1103 UTC and made available by the Operational Significant Event Imagery support team. The image is a one km resolution multichannel color composite of Florida. This morning pass of NOAA-12 shows the heat signatures as bright red spots on the land in eastern Florida. Plumes of dense smoke (light blue in the original) can be seen rising from these hot spots and extending south-eastward along the coast and over the Atlantic Ocean. The reddish color of the water at the right of the image is due to reflected solar energy seen by AVHRR channel 3, which is the first channel that makes up this composite.

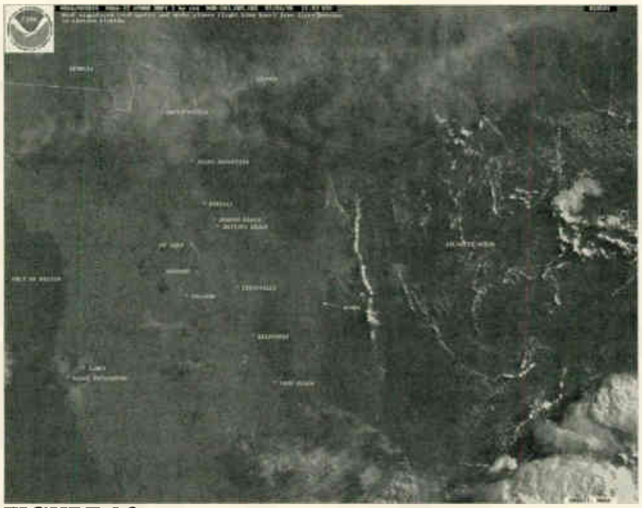


FIGURE 10: ***NOAA-12 image of Florida fires on July 4 courtesy George Stephens of the OSEI Support Team.***

For more information on special events images from NOAA, visit: **http://www.osei.noaa.gov/**

Weather Satellite Status Report

NOAA-14 transmits APT on 137.620 MHz
NOAA-12 and 15 transmit APT on 137.500 MHz
NOAAs transmit beacon data on 136.770 or 137.770 MHz
METEOR 3-5 transmits APT on 137.850 MHz when in sunlight
RESURS-O (1-4) new satellite transmitting APT on 137.300 MHz
OKEAN-4 and SICH-1 sometimes transmit briefly on 137.400MHz
GOES-E and GOES-W use 1691.0 MHz for WEFAX

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http://www.njin.net/~magliaco/

A New Era in Amateur Radio Satellites

After several delays in June, both the TMSAT-1 and TECHSAT-1B amateur radio satellites were successfully launched from Baikonur on Friday July 10, 1998. They were launched along with the Resurs 1-4 satellite and placed into sun synchronous circular orbits approximately 817 kilometers above the earth's surface. These two new microsatellites usher in a new era in amateur radio satellite communications as they push far beyond the present constellation of amateur radio satellites in capabilities and functionality. Let's take a look at some of the unique features possessed by these new amateur spacecraft.

TMSAT-1

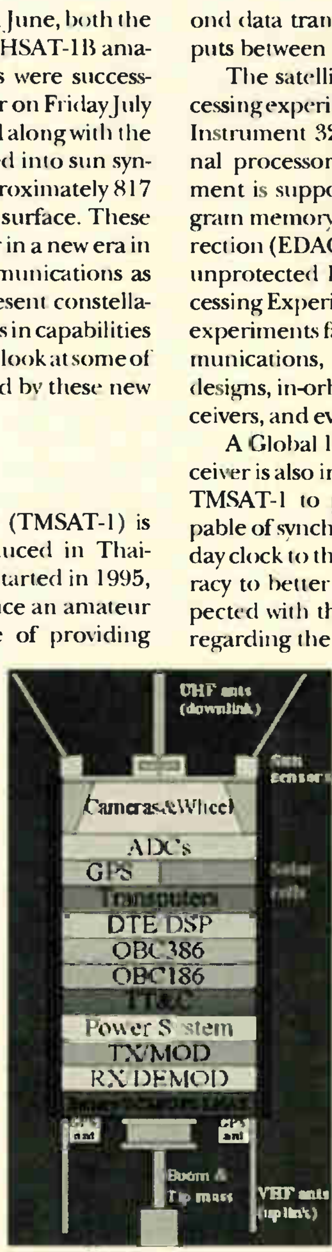
The Thai Micro Satellite (TMSAT-1) is the first microsatellite produced in Thailand. The TMSAT-1 project started in 1995, and its purpose was to produce an amateur radio microsatellite capable of providing earth observation and digital store-and-forward communication services to the worldwide amateur radio community.

The TMSAT-1 satellite carries a high resolution multi-spectral earth imaging camera system, scanning communications receivers, digital signal processors, a GPS receiver, and digital store-and-forward communications payloads.

For reception, TMSAT-1 carries three redundant uplink receivers, four monopole antennas, three FSK data demodulators, and a 9600 baud data uplink capability. TMSAT-1 also carries two redundant downlink transmitters, four monopole antennas, two FSK data modulators with support for 9600 and 38400 bit per second data transmission rates. RF power outputs between two and 10 watts are possible.

The satellite carries a digital signal processing experiment designed around a Texas Instrument 32-bit floating point digital signal processor (TMS320C31). The experiment is supported by 128 kilobytes of program memory with error detection and correction (EDAC), along with one megabyte of unprotected RAM. The Digital Signal Processing Experiment is expected to be used in experiments facilitating real time voice communications, experimental digital modem designs, in-orbit signal analysis, scanning receivers, and even a digital voice broadcaster.

A Global Positioning Satellite (GPS) receiver is also included as a payload on-board TMSAT-1 to provide a real-time clock capable of synchronizing the satellite's time of day clock to that of the groundstation. Accuracy to better than one microsecond is expected with this arrangement. Information regarding the satellite's position will also be obtained with the GPS receiver to help determine the satellite's orbit to a high degree of accuracy.



Basic structure of TMSAT-1 showing placement of the satellite's various subsystems. (SSTL Web site photo)

Like many UoSAT satellites carrying CCD earth imaging cameras, TMSAT-1 employs a gravity-gradient boom, sun sensors, magnetometers, and magne-torquers for achieving and maintaining spacecraft attitude control. TMSAT-1 also carries a momentum wheel as part of its attitude determination and control subsystem (ADCs).

The TMSAT-1 spacecraft has an on-board data handling (OBDH) system designed around an Intel 80C186 microprocessor. The microprocessor supports a one megabyte program address range, a 64 kilobyte I/O address range, a pair of DMA channels, three independent 16-bit timers, a 16 MHz system clock, 768 kilobytes of EDAC (error correcting) memory, and a 16 megabyte RAM disk. The data handling system is used for conducting housekeeping tasks on board the satellite, handling store-and-forward communications, managing the power budget of the satellite, and handling uplink and downlink communications.

Two different communication networks are used within the satellite to facilitate communications between the spacecraft's subsystems. A Control Area Network (CAN) is used between all spacecraft subsystems and provides communications at a rate of one megabit per second. A Data-sharing Network (DASH) that communicates at 9600 bits per second is also available. Each communication network has a redundant path and is also mutually redundant. Both the Control Area Network and Data-sharing Network connect to spacecraft subsystems via CAN peripherals and DASH interfaces, respectively.

The earth imaging subsystem contained on TMSAT-1 consists of one wide-angle camera, three narrow-angle cameras (infrared, red, and green), one CCD (charge coupled device) camera, and a 10 or 20 megabit per second direct link to two redundant transputers supporting four megabytes of EDAC memory that are capable of providing image scheduling and pre-processing of images taken by the on-board cameras. The cameras provide a wide field of view of 1500x1500 kilometers, a narrow field of view of 100x100 kilometers, a wide resolution of 578x576 pixels, and a narrow resolution of 1024x1024 pixels.

Techsat-1B

Techsat-1B (also known as Gurwin-II Techsat) was launched along with TMSAT-1 aboard the RESURS-O1 spacecraft from the Baikonur Cosmodrome on July 10, 1998. Techsat-1B is a microsatellite designed by a group of students from the Faculty of Aero-

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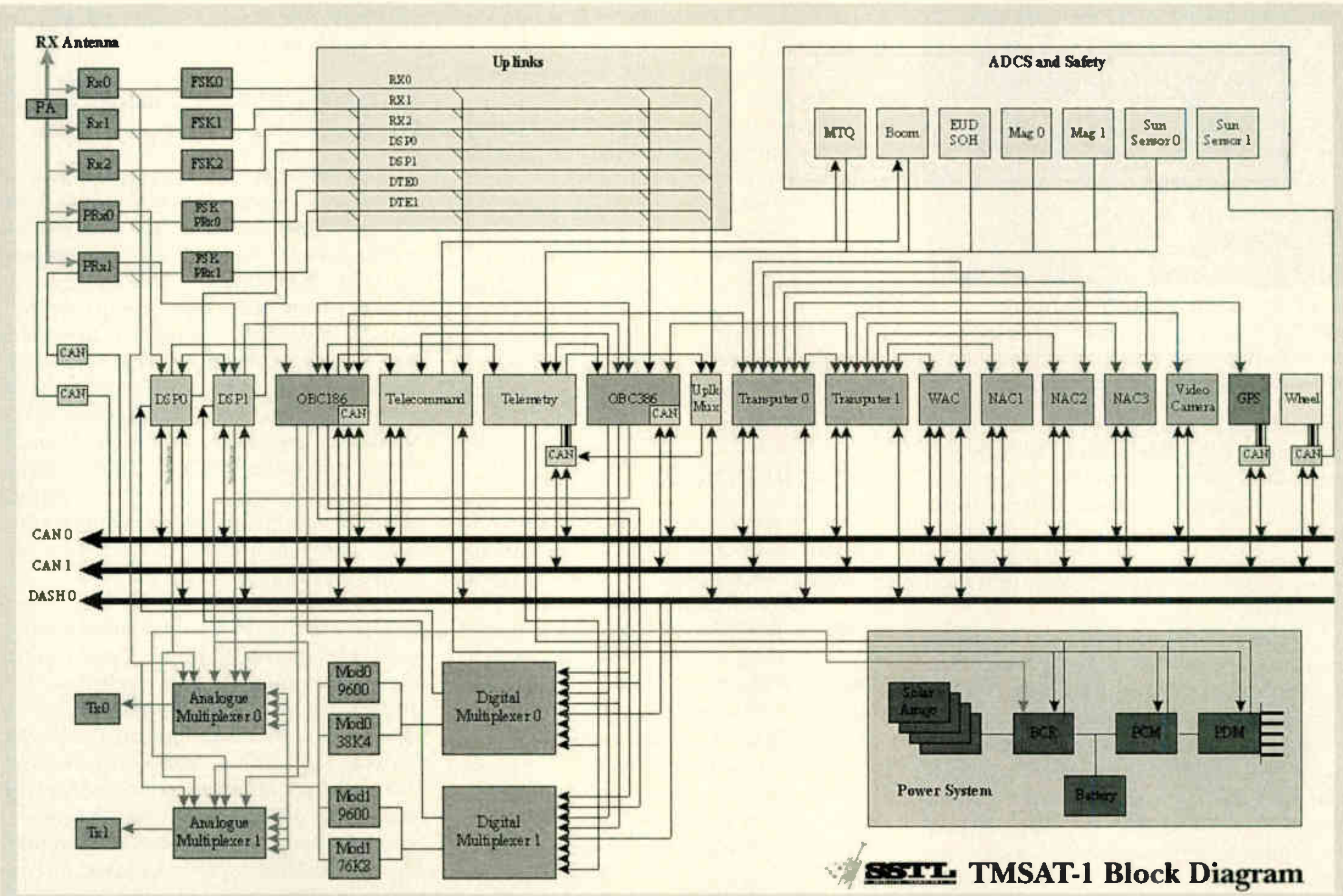


Operational block diagram of the TMSAT-1 satellite. (SSTL Web site photo)

space Engineering under the guidance of Professor Haim Eshed.

Techsat-1B is the second attempt by this group to launch a satellite into space. The first attempt ended in failure when a newly converted Russian intercontinental ballistic missile that was used to launch the satellite failed, plunging the satellite back to earth.

Techsat-1B carries an amateur radio communications payload, an earth imaging CCD camera, an X-ray detector experiment, an ultraviolet spectro-radiometer for the detection and measurement of ozone concentration in the earth's atmosphere, a charged particle detector, a superconductivity experiment, and a laser retroreflector for ranging experiments.

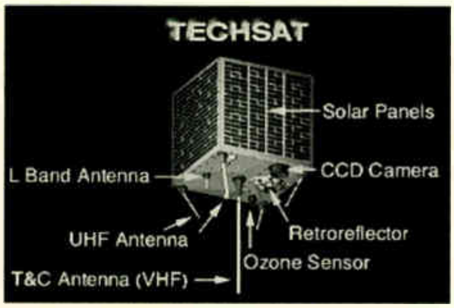
The satellite weighs 48 kilograms and is constructed in the shape of a cube with six aluminum plates. Solar panels adorn four facets of the satellite, while the panel that faces the earth contains an array of antennas, the laser retroreflector, the ozone detector, and the earth imaging camera.

The amateur radio communications package carried on-board Techsat-1B consists of a multi-user digital store-and-forward communication transponder not unlike those carried on previous "pacsat" satellites. The satellite has three uplinks in the 145 MHz band, three uplinks in the 1270 MHz band, and one downlink in the 435 MHz band. Downlink signals may be transmitted at either 1200 baud using bi-phase shift keying (BPSK), or at 9600 baud using frequency shift keying (FSK). This is consistent with the conventions used on previous amateur microsatellites carrying digital store-and-forward communication transponders.

The earth imaging camera is expected to take panchromatic views of selected areas of the Earth for display at suitably equipped groundstations. The earth imaging experiment carried on-board Techsat-1B consists of a CCD video camera video unit (VCU), and an image processing and control card (IPC). In operation, a video image taken by the camera can be captured, digitized, compressed, and stored in an image buffer for later transmission. The compressed image is then transferred to the on board computer (OBC), and transmitted to groundstations where it may be captured, uncompressed, and displayed on a video display monitor.

An array of laser retroreflectors installed on the earth-facing side of TechSat-1B allows the use of the satellite in satellite laser ranging (SLR) experiments. The goal of experiments utilizing this feature of TechSat-1B will be to measure the time it takes for laser pulses

An array of laser retroreflectors installed on the earth-facing side of TechSat-1B allows the use of the satellite in satellite laser ranging (SLR) experiments. The goal of experiments utilizing this feature of TechSat-1B will be to measure the time it takes for laser pulses originating from the earth's surface to be reflected off the satellite and returned to earth.



Basic structure of the Techsat-1B satellite showing placement of solar panels, antennas, and experiment sensors. (Techsat Web site photo)

originating from the earth's surface to be reflected off the satellite and returned to earth. Data gathered from this experiment could also be used to precisely determine the orbital characteristics of the TechSat-1B satellite and determine its exact position at any point in time down to a certainty of 5 to 10 centimeters.

TechSat-1B also carries X-ray detectors, the purpose of which will be to gather data for the future design of an astronomical telescope capable of performing X-ray detection and imaging of gamma-ray bursts in space. This type of experiment is ideally suited to the microsatellite environment, since microsatellites such as Techsat-1B produce much lower amounts of X-rays as compared to larger spacecraft.

A superconductivity experiment is also carried on-board Techsat-1B to investigate the operation and survival of a thin film superconductive device in space. The experiment is powered by a K-508 cryocooler made by Ricor, Inc., and will help explore future power generation techniques in space.

Upper atmosphere ozone depletion has been the subject of much scientific study over the past 30 years, and Techsat-1B will be contributing to the research in this subject through the use of its ultraviolet spectro radiometer. Data gathered from this experiment is also expected to be used towards the development of an new ozone meter with improved accuracy, lower weight, and smaller power consumption over the ozone detectors currently in use.

Techsat-1B also carries a Soreq single event monitor to study the proton and heavy particle environment around the earth's poles. This experiment is part of an international effort to better understand the changing near-earth radiation environment that affect the life and operation of all satellites in earth orbit that carry sensitive electronics prone to radiation-induced single event upsets (SEUs).

At press time, both TMSAT-1 and Techsat-1B were undergoing testing and attitude stabilization by their groundstation controllers. Once initial testing is complete, the satellites are expected to be commissioned and released for general amateur radio use.

You can get more information on Techsat-1B at the Technion website: http://www.technion.ac.il. Also the latest frequency chart for TMSAT-1 and Techsat-1B can be found in the *Satellite Services Guide* on page 43 of this issue of *ST*.

Phase III-D News

The prospects of having the Phase III-D amateur radio communications satellite launched this year from a European Space Agency Ariane flight have slipped from slim to nil. On June 15, 1998, it was announced that a dummy satellite representative of Eutelsat's W2 spacecraft would be flown along with ESA's Atmospheric Reentry Demonstrator (ARD) on Ariane flight 503, now officially targeted for mid-October. The Phase III-D satellite will not be carried on flight 503, despite the numerous assurances given to AMSAT over the past several months that it would be.

According to a recent "go-Ariane" report, when questioned as to the reasons that had led to broken promises to AMSAT, Arianespace Chairman Jean-Marie Luton fully explained the situation in terms of urgency. "We had to constitute a pairing, the ARD and another payload within the allowable mass limits. After the fire that damaged W1 which had been scheduled on 503, the fact that the sister craft W2 would not be ready and our inability to find an alternative commercial passenger, we decided to have a dummy satellite that was as dynamically representative as possible of a W series satellite–and that without having to start all the studies from scratch which would have pushed back the launch. If AMSAT had been accepted, the launch could not have taken place before the end of the year."

AMSAT was officially notified that AMSAT Phase III-D could not fly on Ariane flight 503 "because it would take 8 months to fulfill the necessary studies." AMSAT is now considering its future options for the Phase III-D spacecraft, and does not exclude a solution to be found with Arianespace.

SEDSAT-1 Passes Vibration Tests

SEDSAT-1 passed its vibration test in June, and reports indicate that tests on all three axes went fine. For each axis, an up/down sine diagnostic sweep, a body dynamics sine test, a random vibration test, and another up/down sine diagnostic sweep was performed. The tests showed that all modes were at constant frequency before and after the vibration (within a few Hz), and that no modes had center frequencies below 65 Hz. The lowest frequency mode in the X and Y directions appears to have been rocking on the PAF, although there was not enough instrumentation to prove this. Assuming that is the case, all SEDSAT body modes are above 95 Hz.

In the Z vibration test, which was expected to maximally excite internal components, designers could hear some distinct internal "buzz" and "hum" sounds at particular frequencies. Despite this, everything passed functional tests afterward. During the functional tests, two anomalies were observed. First was unstable current readings from the internal main bus current sensor. This spontaneously disappeared after some operation. The second was reduced brightness and contrast in the PAL images after the X shake. It is possible this was due to a lens iris problem. Designers will analyze the problem, but do not plan to open the satellite.

MIREX News

Astronaut Andy Thomas is safely back on earth after being the USA/NASA representative on *Mir* since January 22, 1998. The remaining crew onboard *MIR* are Russians Talgat Musabayev and Nikolai Budarin. They speak and read Russian only. Therefore, any messages addressed to R0MIR will not be understood by any of the crew members unless it is in Russian. According to Dave Larsen, N6CO, the messages that are sent up to the crew are not being read. Word as of mid-July is that the PMS has been shut down and may remain so for several months.

SAREX on STS-95 Canceled

Frank H. Bauer, KA3HDO, of the SAREX Working Group reports that the Space Ama-

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teur Radio Experiment (SAREX) payload originally scheduled to fly on shuttle mission STS-95 this October has been removed, along with nine other payloads from the flight manifest due to tight constraints on the crew's payload activity time line.

Flight managers, after reviewing all of the planned STS-95 activities, concluded that there was a need to reduce the overall manifest and took the action of removing SAREX and some other secondary payloads to insure sufficient time to accomplish the major objectives of the flight and the overall success of the busy mission.

NASA expressed regret at having to take the action, in particular, at having to delete educational activities from STS-95. NASA, SAREX, ARRL and AMSAT were in the throes of planning the activities for STS-95 when official word came concerning the mission. Four US schools that had been selected for SAREX QSOs will now be first in line for consideration on future missions, such as STS-93 and the International Space Station.

All future shuttle missions are heavily loaded with activities that revolve around building the International Space Station. But SAREX has a place in NASA's future plans for the few shuttle missions that will support it, such as January's STS-93. The SAREX Working Group is looking at another mission for 1999 that may be suitable, too. SAREX also continues to have a big place within NASA's International Space Station plans, which involve a temporary and a permanent amateur r3adio station onboard.

UoSAT-OSCAR-11 News

Clive Wallis reports that a potential problem with UoSAT-OSCAR-11 occurred at the end of June, after a long period of uneventful operation. OSCAR-11's telemetry status blocks showed that the magnetorquer firing counters had stopped incrementing, and the spin period was steadily increasing, implying that the satellite rotation was slowing down. Normally, the +Z spin counter increments at about ten counts per day, and the -Z spin counter about five counts per day. These firings maintain the spin period at approximately 360 seconds to produce one revolution every six minutes, thereby keeping the satellite pointing towards the earth. The Z-axis counter got stuck at 1024 and the minus spin counter froze at 486. After six days, the spin period rose to 640 seconds.

Ground controllers reset the counters on July 1 and started a new Whole Orbit Data (WOD) telemetry survey of the magnetometer channels. After three days, the spin period returned to its nominal value.

As it turns out, UoSAT-OSCAR-11's magnetorquer control system stops working when a counter reaches 1024. This is designed to protect the satellite from a malfunctioning of the magnetorquer control system. This is apparently what happend toward the end of June.

See you on the birds!

ST

By Keith Stein
kstein@erols.com

New VHF/UHF Satellites Launched

Russia successfully launched six new VHF/UHF satellites aboard a Ukrainian built Zenit 2 booster on July 10. The launch took place at 2:30 a.m. eastern time (0630 UTC) from the Baikonur Cosmodrome in Kazakhstan. All payloads were placed in a 821-km high sun-synchronous orbit.

The two-stage Zenit 2 vehicle carried the 2,800-kg Resurs remote sensing satellite built by VNII Elektromekhaniki (VNIIEM) of Moscow for NPO Planeta of Dogoprudni, Russia. Five piggyback payloads were carried on the primary spacecraft, four of which will separate once in orbit. Two of these payloads are UoSat microsatellites built by Surrey Satellite Technology Ltd. of Guilford, England: the 50-kg Fasat-Bravo for Chilean Air Forces and the 50-kg TMSat 1 for the Thai Microsatellites Co.

Also on this flight was the 52-kg TechSat 1b built by Technion University in Haifa, Israel. OHB-Systems GmbH of Bremen, Germany, will provide the 60-kg Safir 2 messaging satellite for its subsidiary OHB Teledata, as well as the 40-kg Litte LEO Messaging System (LLMS) payload for SAIT-Systems SA of Brussels, Belgium, which will remain attached to the Resurs satellite.

TABLE ONE: ZENIT-2/RESURS LAUNCH PROFILE

0630 UTC	Liftoff
0643 UTC	Separation of Resurs from Zenit 2nd stage.
0804 UTC	First communications pass over Moscow with Resurs. Parameters reported to be "stable".
1400 UTC	Resurs panel deployment, ADCS and sun acquisition.
1830 UTC	Separation of secondary payloads over Moscow.

TABLE TWO: CATALOG NUMBERS AND INTERNATIONAL DESIGNATOR

Satellite Name	Catalog Number	International Designation
RESURS 01-N4	25394U	1998-043A
FASAT-B	25395U	1998-043B
TMSAT	25396U	1998-043C
TECHSAT-1B	25397U	1998-043D
WESTPAC	25398U	1998-043E
SAFIR-2	25399U	1998-043F
SL-16 R/B	25400U	1998-043G

TMSAT-1 has a downlink on 436.925 MHz, and TechSat has a downlink on 435.325 MHz. The beacon transmitters for both may be switched on and off at times while the satellites are tested and prepared for general use. Both are amateur radio communication satellites carrying digital store-and-forward transponders.

Telemetry showed that TMSAT-1 was operating normally after launch, so controllers loaded the flight software to the OBC186 and then started to stabilize the attitude of the spacecraft. Current output power is approximately 1.7 to 2 watts. Announcements will be made as to when the satellite will be made available for general use.

TechSat-1B is a digital store-and-forward satellite using 9600 baud, frequency shift keying (FSK). The satellite does not have a continuous beacon, but does transmit a 9600 baud burst every 30 seconds (about 3 seconds in length). The satellite appears healthy and is currently being stabilized after experiencing cold temperatures during the launch phase.

The German SAFIR-2 satellite will transmit data at 300, 600, 1200, 2400 and 4800 baud on 137.225 MHz and between 400.6-400.9 MHz.

The Intercontinental Retrieval of Information Via Satellite Transmission (IRIS) payload, attached to the Resurs-O downlinks 4800 bps data on 400.6 MHz.

New NASA Ground Station Opens in Guam

Guam Island was the site for a ribbon-cutting ceremony on July 15 to officially open a new terminal that will effectively complete NASA's vital communications and data-gathering support for NASA Earth-orbiting missions.

Providing global, full-time and real-time communications support for NASA's Space Network customers, including the Space Shuttle, International Space Station and Hubble Space Telescope (HST), the new ground terminal will be capable of communicating with geosynchronous tracking and data relay satellites stationed out of view of the existing Cacique and Danzante ground stations in White Sands, New Mexico. NASA's Goddard Space Flight Center, Greenbelt, Maryland, manages the overall system.

Cost of funding the Guam station will be provided by NASA's Space Network operations budget and mitigated in part by the deactivation of the Canberra station.

The Guam Remote Ground Terminal (GRGT) was conceived after NASA's Compton Gamma Ray Observatory suffered an onboard tape recorder failure in March 1992 and required full-time, real-time communications support. NASA established a limited capability ground terminal in Canberra, Australia, in late 1993 to provide continued support for the observatory's science mission. Goddard project officials quickly realized that an enhanced ground station was needed in the Pacific Ocean to better serve NASA's Space Network customers who traverse the Indian Ocean area.

Electronic Sciences Supplies S-band Transponders to AlliedSignal

Electronic Sciences, Inc., announced July 21 that the Canadian unit of its Space Division, CAL Space Systems, has received an order from AlliedSignal Defense and Space Systems of Teterboro, New Jersey, to provide five fourth-generation compatible TDRSS, TT&C (Telemetry, Tracking and Control) transponders for the Kistler Aerospace reusable launch vehicle program.

Each of the five S-band transponders, which are compatible with the NASA's Tracking and Data Relay Satellite system, will be part of the avionics suites supplied by Allied Signal, and will be used for spacecraft control and telemetry. The state-of-the-art, high performance, dual-standard transponder was developed by CAL Space Systems with support from the Canadian and European Space Agencies.

Ham Equipment for International Space Station

Delivery of the first element of the International Space Station (ISS) amateur radio station is expected about six months from now. This element is scheduled to include contributions from Germany, Russia and the US. First crew operations are about one year away according to the current ISS schedule.

In addition, three new astronaut hams received their amateur radio license:

Michel Tognini	KD5EJZ
Eileen Collins	KD5EDS
Catherine Coleman	KC5ZTH

Shuttle May Get Two Ku-band Antennas in the Future

NASA's Johnson Space Center in Houston, Texas, has advised that they are looking at a proposed shuttle integrated communications system to replace the current S- and Ku-band systems. A Ku-band capability is being considered which would have two new antenna systems with one for launch/landing and a second for on-orbit communications. The change would be a major impact to the ground network sites which may require extensive and costly upgrades.

Spartan 201-5 Mission

The Spartan 201 project is a solar physics spacecraft designed to perform remote sensing of the hot outer layers of the sun's atmosphere or corona. The objective of the observations is to investigate the mechanisms causing the heating of the solar corona and the acceleration of the solar wind which originates in the corona.

Spartan 201 carries a pair of complementary instruments which perform observations of the sun's corona: the Smithsonian Astrophysical Observatory, Ultraviolet Coronal Spectrometer, and the Goddard White Light Coronagraph.

The Spartan 201-5 mission is a reflight of the unsuccessful SP201-04/STS-87 mission. The solar science mission is coordinated with the ongoing NASA/ESA SOHO mission. But in late June NASA/GSFC lost contact with SOHO after a attitude maneuver was performed. The SP201-05 mission includes a number of spacecraft enhancements and secondary experiments.

SP201-05 is also a test flight of the TEXAS RF communication system baselined for future Spartans (TEXAS stands for Technology/Experiments Augmenting Spartan). The RF communication S-band system (TEXAS) provides very limited command and telemetry services after Spartan is deployed from the shuttle. Solar images will be downlinked on 2,272.500 MHz through a five watt transmitter, and pointing corrections will be uplinked on 2,092.500 MHz.

The 2,978 pound spacecraft will be deployed on the fourth day of mission STS-95 for about 50-55 hours.

STS-95 OVERVIEW

Launch Vehicle	*Discovery* (OV-103)
Launch Date	October 29, 1998
Orbital Altitude	300 Miles
Orbital Inclination	28.45 Degree Inclination
Mission Duration	9 Day Mission
Payloads	Spacehab, Host, SP201-05, IEH-3, Cyrotsu, SEM, GAS

SPARTAN FLIGHT HISTORY

Mission	Objective	Flight	Date
Spartan 201-01	Solar Physics	STS-56	4/93
Spartan 201-02	Solar Physics/Ulyssess S. Pass	STS-64	9/94
Spartan 201-03	Solar Physics/Ulyssess N. Pass	STS-69	9/95
Spartan 201-04	Solar Physics/SOHO/Secondaries (No Science Data Due to Deploy Anomaly)	STS-87	11/97
Spartan 201-05	Solar Physics (Includes VGS, SEM, TAS-BE, OSVS)	STS-95	10/98

Pre-launch Details Released for Classified Launch

Once again the *Satellite Listening Post* has obtained the following unclassified details for a classified launch August 4, 1998, from the U.S. Air Force, Cape Canaveral Air Station, Florida.

Name	Titan 4/A-20/K-17/TC-09
Launch Agency	5 Space Launch Squadron
Launch Site	Eastern Range, SLC-40
Launch Azimuth	99.4 degrees
Launch Window	Tuesday, August 4, 1998, 0915 to 1530 UTC
Launch Vehicle	Titan 4A

SEQUENCE OF EVENTS

Event	HH:MM:SS
Liftoff	00:00:00
Solid Rocket Motor Separation	00:02:03
Payload Fairing Separation	00:03:54
Titan/Centaur Separation	00:09:01

Centaur Main Engine Start (MES 1)	00:09:22
Centaur Main Engine Cutoff (MECO 1)	00:12:45
Park Orbit Injection	00:12:55
Centaur MES 2	01:50:53
Centaur MECO 2	01:55:13
Transfer Orbit Injection	01:55:38
Centaur MES 3	07:17:05
Centaur MECO 3	07:19:02
Spacecraft Separation	07:23:37
Centaur Blowdown	08:06:17

OBJECTS TO ACHIEVE ORBIT

Payload is 40 feet by 15 feet.
Centaur Rocket Body is 29 feet by 14 feet.

The Titan 4 will place the classified payload in a deep space orbit at the time of Centaur separation.

Titan 4	Downlink Frequency Assignments
Titan Core	2287.5 MHz 20 watts (S-band)
	2255.5 MHz 7.5 watts (wideband Instrument)
Centaur	2272.5 MHz 13 watts

SLP Trivia Time

Trivia Question: In a past issue of *ST* in the *Satellite Listening Post* Intercepts section, there was a report about hearing three NASA aircraft "conducting joint water vapor measurement research with a Lidar Atmospheric Sensing Experiment (LASE)." In which issue of *Satellite Times* did this appear? Hint: The frequency they used was M121.950.

The first person to send in the correct answer wins a Defense Support Program (DSP) satellite hat pin. You can send in your answer to Keith Stein via e-mail at **kstein@erols.com**. Please include your name and address so we can mail you your prize.

Satellite Listening Post Intercepts

AM	Amplitude Modulation
APT	Automatic Picture Transmission
ATC	Air Traffic Control
CEETA	Communications Electronics Evaluation and Test Activity
CO	Commanding Officer
K	kHz
M	MHz
NASA	National Aeronautics and Space Administration
NBFM	Narrowband FM
STS	Space Transportation System
USB	Upper Sideband
VFR	Visual Flying Rules

All times are in UTC.

K10780	Outbound Navy Vessel (ONV) working Cape Radio (CR). ONV wishes to know what time the shuttle is launching. CR replies back there isn't a shuttle launch scheduled for today. A few moments pass by and ONV calls again and states that his CO thinks there is a shuttle launch sometime *this week* and he wants to be sure of the launch time. Cape Radio replies back again and states that the next launch is several weeks away. ONV copied and was out. This might have been a sub leaving Kings Bay, Georgia, or surfacing for a bit (Clay Gibbs-Valdosta, GA)
M124.1000	NASA 995 heard at 2129, AM mode, chatting with Miami Center ATC about Sen John Glenn's upcoming shuttle launch. (Al Stern-Satellite Beach, FL)
M128.5500	NASA 902 (T-38A aircraft from Johnson Space Center) 1847 inbound VFR to Shuttle Landing Facility (Runway 15). (Al Stern-Satellite Beach, FL)
M133.7500	NASA 4 (G-159 Gulfstream I aircraft from Kennedy Space Center, tail number N4NA) inbound to Patrick AFB at 2237. (Al Stern-Satellite Beach, FL)
M134.9500	NASA 914 (T-38A from Johnson Space Center) inbound at 2123, AM mode. Switched to NASA Shuttle Landing Facility Tower on M128.550. (Stern-FL)
M137.2300	Heard telemetry signal from Russian Resurs-O satellite and APT on M137.300. (Lawrence Harris-United Kingdom)
M137.5000	Heard new U.S. weather satellite NOAA-15 at 1930. It was a low pass with maximum elevation of 3 degrees. (Costas Krallis, SV1XV-Athens, Greece)
M143.6250	Heard Russian voice from the *Mir* space station, 0647, NFM mode. (Steve Ralston-Escondido, CA)
M235.4000	NASA 931 (KC-135 "Vomit Comet") returned to Ellington Field after performing zero-g parabolas over the Gulf of Mexico. Called in and reported 40 parabolas and a write up on number 1 engine with a compressor stall. (Chris Parris-Conroe, Texas)
M235.4000	NASA air-to-air (nationwide) and air-to-ground at Ellington Field for the T-38 crowd. AM mode (Larry Van Horn-Brasstown, NC)
M255.4000	Heard NASA 992 (T-38A aircraft) regarding weather. Aircraft was cleared to NPA–NAS Pensacola. (Chris Parris-Conroe, Texas)
M261.8500	Eagle working Eagle Alfa at 2100 UTC. Fair to good signal levels into the Pacific Northwest. (Tony-Willamette Valley, OR)
M429.9800	Monitored HealthSat 1 at 1615. The signal sounds like fast alternating high and low tones with uneven period. (John David Corby-Canada)
M468.8250	GOES West timing data received here. (Chris)
M468.8375	GOES East timing data received here. (Chris)
M468.8625	GOES 10 dead carrier received here. (Chris)
G12.045	The ABC feed from Toronto for Molson Indy was up on Telstar 4 Ku-band at 1500. (Bob Lyle)

Keith Stein is the Associate Technical Editor for Launchspace Publications, Inc. (http://www.launchspace.com).

Satellite Services Guide

INTRODUCTION

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

How to Use the Satellite Service Guide

The various sections of the SSG include:

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

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

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

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

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

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

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

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

Satellite Radio Guide

By Robert Smathers and Larry Van Horn

AUDIO SUBCARRIERS

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

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

Classical Music

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

Satellite Computer Services

Superguide	G5, 7	5.48

Contemporary Music

Radio Desjardins 1	T5, 14	6.80
Radio Desjardins 2	T5, 14	6.20
SuperAudio–*Light and Lively Rock*	G5, 21	5.96, 6.12 (DS)
WPHZ-FM (96.9) Bremen, IN (South Bend market)	G6, 15	6.48, 7.30 (DS)

Country Music

SuperAudio–*American Country Favorites*	G5, 21	5.04/7.74 (DS)
WSM-AM (650) Nashville, TN	C4, 24	7.38, 7.56

Easy Listening Music

IAM Radio-easy listening music	G6, 6	7.69
SuperAudio–*Soft Sounds*	G5, 21	5.58/5.76 (DS)
FCC mandated safe-harbor program audio-easy listening music	G3R, 9	6.80
	G5, 2	6.80
United Video–easy listening music	C4, 8	5.895 (N)

Foreign Language Programming

Antenna Radio (Greek)	S4, 14	7.80
Apna Sangeet Radio India	GE1, 16	7.38
Arab Network of America radio network	GE2, 22	5.80
La Cadena CNN Radio Noticias (CNN Radio News in Sp.)	G5, 17	7.56
KAZN-AM (1300) Pasadena, CA–Radio Chinese (Chinese)	GE1, 22 (Ku-band)	5.80
Radio Maryja–religious programming (Poland)	G7, 10	5.80
Radio Maria	G7, 10	8.03
Radio Tropical	GE1, 4	7.60
SRC AM Network	E2, 1	7.38
SRC FM Network	E2, 1	5.41/5.58 (DS)
Unidentified station-foreign language	GE-1, 22 (Ku-band)	7.78
WCRP-FM (88.1) Guyama, PR–religious (Spanish)	G6, 6	6.53
XEWA-AM (540) San Luis Potosi, Mexico (Spanish)	M2, 8	7.38
XEW-AM (900) Mexico City, DF Mexico (Spanish), ID-*La Voz de la America Latina*–contemp. music	M2, 14	7.38

Jazz Music

KLON-FM (88.1) Long Beach, CA., ID-*Jazz-88*	G5, 2	5.58/5.76 (DS)
Superaudio–*New Age of Jazz*	G5, 21	7.38/7.56 (DS)

News and Information Programming

Broadcast News	E2, 1	5.78
Business News Network	C4, 10	8.06 (N)
Cable Radio Network	G5, 2	7.24 (N)
	C1, 21	7.30
CNN Headline News	G5, 22	7.58
CNN Radio News	GE3, 9	5.62
	G5, 5	7.58
	G5, 22	6.30
USA Radio Network–news, talk and information	GE3, 13	5.01 (ch 1), 5.20 (ch 2)
Virginia News Service	G5,11	5.90
WCBS-AM (880) New York, NY–news	G7, 19	7.38
WCCO-AM (830) Minneapolis, MN	GE3, 6	6.20

Religious Programming

Ambassasor Inspirational Radio	GE3, 15	5.96, 6.48
Brother Staire Radio	G5, 6	6.48
KHCB-FM (105.7) Houston, TX	C1, 10	7.28
Salem Radio Network	GE3, 17	5.01
Trinity Broadcasting radio service	G5, 3	5.58/5.78 (DS)
WHME-FM (103.1) South Bend, IN, ID-*Harvest FM*	G6, 15	5.58/5.78
WROL-AM (950) Boston, MA (occasional Spanish)	GE3, 3	6.20
Z-music–Christian rock	G1R, 6	7.38/7.56

Rock Music

SuperAudio–*Classic Hits*-oldies	G5, 21	8.10/8.30 (DS)
SuperAudio–*Prime Demo*-mellow rock	G5, 21	5.22/5.40 (DS)
WOKI-FM (100.3) Oak Ridge-Knoxville, TN., (oldie rock) ID-*The Eagle*	E2,57	6.20

Shortwave Broadcasters via Satellite

C-SPAN Audio 1: Various shortwave broadcasters	C3, 7	5.20
C-SPAN Audio 2: British Broadcasting Corporation (BBC)	C3, 7	5.41
Deutsche Welle	GE1, 22	7.38, 7.56, 7.74, 7.92
Radio Dubai United Arab Emirates (Arabic)	G7, 10	7.48
RAI Satelradio Italy (Italian)	G7, 14	7.38
WEWN–Worldwide Catholic Radio, Vandiver, AL	G1R, 11	5.40 (English), 5.58 (Spanish)
WHRA Africa/Middle East–World Harvest Radio, South Bend, IN	G6, 15	7.82
WHRI Americas–World Harvest Radio, South Bend, IN	G6, 15	7.46
WHRI Europe –World Harvest Radio, South Bend, IN	G6, 15	7.55
KWHR Asia–World Harvest Radio, South Bend, IN	G6, 15	7.64
KWHR South Pacific–World Harvest Radio, South Bend, IN	G6, 15	7.73
World Radio Network: WRN1 North America	G5, 6	6.80
World Radio Network: WRN2 North America	G5, 6	6.20 (Multi-lingual)

Sports

New York Yankees Spanish Language S.A.P. (occ)	C4, 6	6.20

Speciality Formats

Aries In Touch Reading Service	C4,10	7.87
Colorado Talking Book Network	C1,3	5.60
Ozarkana Radio Network	G6, 6	7.96
SuperAudio–Big Bands (Sun 0200-0600 UTC)	G5, 21	5.58/5.76 (DS)
Weather Channel–background music	C3, 13	7.78
Wisdom Radio Network	GE1, 12	7.10
Yesterday USA–nostalgia radio	G5, 7	6.80
	G1R, 24	7.38

Talk Programming

American Freedom radio network	S4, 19	5.80
Amerinet Broadcasting	G1R, 17	5.58
For the People radio network	C1, 6	7.50
Friday Night Live (Friday 9 p.m.ET)	SBS6, 3 Upper (Ku-band)	6.20
Omega Radio Network	GE1, 6	7.56
Orbit 7 Radio Network	C1, 14	7.48
Radio America Network	C1, 2	5.58
Republic Radio International	G7, 14	7.70
Talk America Radio Network #1–talk programs	GE3, 9	6.80
Talk America Radio Network #2–talk programs	GE3, 9	5.41
Truth Radio	S4, 19	7.56
TVRO.NET (featuring Keith Lamonica)	S4, 16	5.80
United Broadcasting Network	C1, 2	7.50
WOKIE Network–tech talk	SBS6, 3 Upper (Ku-band)	6.20 (network active when Megabingo on Monday-Friday 21-22 ET)
WWTN-FM (99.7) Manchester, TN–news and talk	G5, 18	7.38, 7.56

Variety Programming

CBM-AM (940) Montreal, PQ Canada–variety/fine arts	E2, 1	6.12
KBVA-FM (106.5) Bella Vista, AR., ID-*Variety 106.5*	G6, 6	5.58/5.76 (DS)
KSL-AM (1160) Salt Lake City, UT–news/talk/country (*Road Gang*-overnight)/BYU Sports	C1, 6	5.58
WCBS-FM (101.1) New York, NY	S4, 16	5.80 (when TVRO.NET is not on the air)
West Virginia Public Radio	GE1, 12	7.74
WHVN-AM (1240) Charlotte, NC–religious		
WIST-AM (550) Statesville, NC–country		
WNMX-FM (106.1) Waxhaw, NC (The three stations above are on at varous times)	G1R, 17	7.92
WUSF-FM (89.7) Tampa-St. Petersburg, FL (Public Radio), ID-*Concert 90*	C4, 10	8.26 (N)
American Urban Radio Network	GE3, 9	6.30, 6.48 (DS)

Satellite Radio Guide/SCPC Services Guide

FM SQUARED (FM²) AUDIO SERVICES

Another type of satellite audio carrier is known as FM Squared. FM Squared signalsdo not require a video carrier to exist. These signals are similar to audio subcarriers as we know it except that they are normally located below the 5.00 MHz audio subcarrier frequency that a normal satellite receivers can tune to. The new Universal SC-50 can tune these frequencies and was used to update this section.

GE-3 Transponder 13 (C-band)

Ambassador Inspirational Radio	1.410, 4.470 and 4.650 MHz
Blank audio carriers	1.050 and 3.570 MHz
Focus on the Family	1.230 MHz
Information Radio Network	3.390 MHz
International Broadcasting Network (IBN)	4.830 MHz
USA Radio Network	5.010 (ch 1) and 5.200 MHz (ch 2)
Various Religious Programs (no common ministry)	.330 and 3.750 MHz
VCY/America (channel 1)	.510 MHz
VCY/America (channel 2)	.780 MHz

GE-3 Transponder 17 (C-band)

Blank audio carriers	1.770 and 3.570 MHz
Data Transmission	.800 and 1.210 MHz
Focus on the Family	1.050 and 1.400 MHz
In-Touch–religious	4.470 MHz
Salem Satellite Network	4.650, 4.840 and 5.010 MHz
SRN News	.330 MHz

Galaxy 3R Transponder 3 (Ku-band)

Blank Audio Carriers	1.000, 1.050, 2.060, 3.250, 3.620, 4.200, 4.340 and 4.450 MHz
Data transmissions	.060, 2.950, 3.070 and 3.190 MHz
AP Network News	3.530 MHz
In-Store audio network ads (various companies)	.710, .810, .910, 1.150, 1.260, 3.440, 3.700, 3.800, 3.880 and 3.970 MHz
Muzak Services	.150, .270, .390, .510, 1.360, 1.480, 1.600, 1.720, 1.840, 1.960, 2.190, 2.310, 2.440, 2.560, 2.680, 2.800, 3.340 and 4.080 MHz

Galaxy 3R Transponder 16 (Ku-band)

Data transmissions	.645, 1.950, 2.180, 2.400, 2.520, 2.730, 2.820, 2.920, 3.205, 3.245, 3.265, 3.475, 3.735 and 3.970 MHz
In-Store audio networks	.150, .270, .390, .755, .870, .990, 1.110, 1.230, 1.350, 1.470, 1.590, 1.710, 1.835 and 2.070 MHz

SBS 6 Transponder 13 (Ku-band)

Data Transmissions	.060, .180, .255, .300, .350, .470, .510, .575, .650, .710, .740, .765, .845, .890, .930, .960, 1.050, 1.120, 1.225 and 2.080 MHz

Telstar 5 Transponder 6 (Ku-band)

Data Transmissions	.060, .180, .230, .280, .300, .350, .380 .470, .575, .650, .710, .740, .765, .845, .890, .930, .960, 1.050, 1.120, and 1.225 MHz

Anik E1 Transponder 6 (Ku-band)

Nova Network FM Squared Services

FM CUBED (FM³) AUDIO SERVICES

This audio is digital in nature and home dish owners have not been able to receive it by normal decoding methods yet. The only satellite that FM Cubed transmissions have been discovered on so far is SBS6. WEFAX transmissions and Accu-Weather (for subscribing stations) are transmitted on this transponder.

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

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

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

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

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

1178.70 (81.3)	NASA space shuttle audio

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

1207.90 (52.1)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming
1204.45 (55.55)	KJAV-FM (104.9) Alamo, Tex–Spanish language religious programming/ *Nuevo Radio Christiana Network*
1204.25 (55.75)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming
1204.00 (56.0)	SRN (Salem Radio Network) News
1201.50 (58.5)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming
1201.30 (58.7)	Wisconsin Voice of Christian Youth (VCY) America Radio Network–religious programming

Galaxy 6 Transponder 1-Horizontal (C-band)

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

Galaxy 6 Transponder 3-Horizontal (C-band)

1404.80 (55.2)	KOA-AM (850)/KTLK-AM (760) Denver, Colo–news and talk radio/Colorado Rockies MLB radio network
1404.60 (55.4)	WGN-AM (720) Chicago, IL–news and talk radio/Chicago Cubs MLB radio network
1404.40 (55.6)	Illinois News Network–network news feeds/WMVP-AM (1000) Chicago, IL–talk/ Chicago White Sox MLB radio network
1404.20 (55.8)	Tribune Radio Networks/Wisconsin Radio Network
1402.70 (57.3)	WLAC-AM (1510) Nashville, TN–news and talk/*Road Gang* trucker program (overnight)
1402.20 (57.8)	NorthWest Ag News Network–Ag info for the Pacific Northwest
1402.00 (58.0)	Occasional audio
1401.80 (58.2)	Michigan News Network–network news feeds
1401.50 (58.5)	Occasional audio/Agrinet–Agriculture news/USA Radio Network–network feeds
1399.60 (60.4)	Occasional audio
1399.20 (60.8)	Occasional audio

(Continued on Page 38)

Single Channel Per Carrier (SCPC) Services Guide

By Robert Smathers

(Continued from Page 37)

1399.00 (61.0)	Sports Byline USA/Sports Byline Weekend/ *On Computers* radio show
1398.80 (61.2)	United Broadcasting radio network–talk radio
1398.50 (61.5)	Occasional audio
1398.30 (61.7)	WSB-AM (750) Atlanta, GA– news/talk/ Atlanta Braves MLB radio network
1398.00 (62.0)	Occasional audio
1397.80 (62.2)	Occasional audio
1397.50 (62.5)	Minnesota Talking Book Radio Network–reading service for the blind
1397.10 (62.9)	Wisconsin Radio Network
1396.90 (63.1)	KRLD-AM (1080), Dallas, TX–news, talk/ Texas Rangers MLB radio network
1396.70 (63.3)	Radio America Network
1396.40 (63.4)	Georgia News Network (GNN)–network news feeds
1396.00 (64.0)	WHO-AM (1040) Des Moines, IA–talk radio/Iowa News Network–network news feeds
1395.80 (64.2)	WTMJ-AM (620) Milwaukee, WI–talk radio/Milwaukee Brewers MLB radio network
1395.60 (64.4)	WGST-AM/FM (640/105.7) Atlanta, GA ID *Planet Radio*–news and talk radio
1395.40 (64.6)	Michigan News Network–network news feeds
1395.00 (65.0)	Occasional audio
1394.70 (65.3)	WJR-AM (760) Detroit, MI–news and talk radio/Michigan News Network/Detroit Tigers MLB radio network
1394.50 (65.5)	XEPRS-AM (1090) Tijuana, Mexico–Spanish language programming/California Angels MLB Network (Spanish)
1394.30 (65.7)	Michigan News Network
1384.40 (75.6)	KOA-AM (850)/KTLK-AM (760) Denver, CO–news and talk radio/Colorado Rockies MLB radio network
1383.70 (76.3)	Motor Racing Network (occasional audio) NASCAR racing
1383.40 (76.6)	Occasional audio
1383.10 (76.9)	KIRO-AM (710) Seattle, WA–news and talk radio/Seattle Mariners MLB radio network
1382.90 (77.1)	Michigan News Network–network news feeds
1382.60 (77.4)	Soldiers Radio Satellite (SRS) network–U.S. Army information and entertainment radio
1382.00 (78.0)	Tennessee Radio Network–network news feeds
1381.80 (78.2)	Occasional audio
1381.60 (78.4)	KEX-AM (1190) Portland, OR–news and talk radio
1381.40 (78.6)	Occasional audio
1381.20 (78.8)	KJR-AM (950) Seattle, WA– sports talk radio
1377.10 (82.9)	In-Touch–reading service for the blind
1376.00 (84.0)	Kansas Audio Reader Network–reading service for the blind
1375.40 (84.6)	USA Radio Network/Agrinet Agriculture news service

Galaxy 6 Transponder 4-Vertical (C-band)

1376.00 (64.0)	Data Transmissions

Galaxy 6 Transponder 6-Vertical (C-band)

1347.00 (53.0)	WCRP-FM (88.1) Guayama, PR–Spanish language religious programming

Anik E2 Transponder 1-Horizontal (C-band)

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

Anik E2 Transponder 7-Horizontal (C-band)

1326.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (Eastern Arctic) service

Anik E2 Transponder 13-Horizontal (C-band)

1206.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (MacKenzie) service
1205.00 (54.5)	Canadian Broadcasting Corporation (CBS) Radio–Occasional feeds/events

Anik E2 Transponder 17-Horizontal (C-band)

1126.00 (54.0)	Canadian Broadcasting Corporation (CBC) Radio–North (Western Arctic) service
1125.50 (54.5)	Canadian Broadcasting Corporation (CBC) Radio–North (Newfoundland and Labrador) service

Anik E2 Transponder 23-Horizontal (C-band)

1006.00 (54.0)	Societe Radio-Canada (SRC) Radio–AM Network
1005.50 (54.5)	Canadian Broadcasting Corporation (CBC) Radio-North (Yukon) service

Anik E1 Transponder 21-Horizontal (C-band)

1036.70 (63.3)	In-store music
1037.00 (63.0)	In-store music
1037.50 (62.5)	In-store music

SBS5 Transponder 2-Horizontal (Ku-band)

1013.60 (80.4)	Wal-Mart in-store network (English)
1013.20 (80.8)	Wal-Mart in-store network (English)
1012.80 (81.2)	Sam's Wholesale Club in-store network (English)
1004.00 (90.0)	Wal-Mart in-store network (English)
1003.60 (90.4)	Wal-Mart in-store network (English and Spanish ads)
1003.20 (90.8)	Sam's Wholesale Club in-store network (English)
1002.80 (91.2)	Wal-Mart In-Store Network (English)

SBS5 Transponder 12-Vertical (Ku-band)

1095.00 (91.0)	Russian-American Radio Network

RCA C5 Transponder 3-Vertical (C-band)

1404.80 (55.2)	RFD Radio Service
1404.60 (55.4)	Wyoming News Network–network news feeds/Colorado Rockies MLB radio network
1400.60 (59.4)	Learfield Communications
1400.40 (59.6)	Learfield Communications/Missouri Net
1400.20 (59.8)	Occasional audio/Data transmissions
1400.00 (60.0)	Learfield Communications
1396.60 (63.4)	Kansas Information Network/Kansas Agnet–network news feeds
1396.20 (63.8)	Missouri Network/St. Louis Cardinals MLB radio network
1396.10 (63.9)	Occasional audio
1395.90 (64.1)	Occasional audio/Red River Farm Network
1395.70 (64.3)	Missouri Net/Kansas City Royals MLB radio network
1386.40 (73.6)	Learfield Communications
1386.20 (73.8)	Radio Iowa
1386.00 (74.0)	United broadcasting Network–talk radio
1384.60 (75.4)	Capitol Radio Network
1364.00 (76.0)	Occasional audio/ABC Direction Network–network news feeds
1383.80 (76.2)	Occasional audio
1383.40 (76.6)	Capitol Radio Network
1382.90 (77.1)	Missourinet
1382.50 (77.5)	Virginia News Network–network news feeds
1382.10 (77.9)	Learfield Communications/Missourinet

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

EchoStar 3 — 61.5°West

This direct-to-home satellite operates in the 12.2-12.7 GHz BSS band and delivers local television channels and international channels.

SBS 6 (SBS6) — 74° West

1	11717-H	Data transmissions/FamilyNet [digicipher]
2	11749.5-V	CONUS Communications (half transponders)
3	11774-H	CONUS Communications (half transponders)
4	11798.5-V	Occ video
5	11823-H	CONUS Communications (half transponders)
6	11847.5-V	Data transmissions
7	11872-H	Occ video
8	11896.5-V	Occ video
9	11921-H	Occ video
10	11945.5-V	DigitalXpress
11	11963-H	Spacecom FM Cubed
12	11994.5-V	Occ video
13	12019-H	Spacecom FM2/HyperCubed Transmissions
14	12043.5-V	Data transmissions
15	12075-H	Occ video
16	12092.5-V	Occ video
17	12110-H	Data transmissions
18	12141.5-V	Occ video
19	12174-H	Occ video

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

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

1	11725-H	Data transmissions

Satcom K2 (K2) — 81° West

7	11906-H	Data transmissions
15	12142-H	Satcom K2 ID Slate

Spacenet 3R (S3R) 83° West

19	11740-H	Unknown user [digital video]
22	11980-H	NY Network (occ)/SUNY (occ)
23	12060-H	Oregon Educational Network (occ)

GE-2 (GE2) — 85° West

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

GE-3 (GE3) — 87° West

1	11720-H	New Mexico State University Instructional TV [MPEG-CLI]/ Data transmissions
2	11740-V	Data transmissions
3	11760-H	Data transmissions
4	11780-V	Occ video
5	11800-H	Unknown user [digital video]/ Data transmissions
6	11820-V	Unknown user [digital video]/ Data transmissions
7	11840-H	Occ video
8	11860-V	Occ video/CNN Newsource (secondary feeds) (occ)
9	11880-H	CNN Newsource [LEITCH]
10	11900-V	National Technology University (NTU) [Spectrumsaver]
11	11920-H	Data transmissions
12	11940-V	Occ video
13	11960-H	Occ video
14	11980-V	Occ video
15	12000-H	Occ video
16	12020-V	Occ video
17	12040-H	Occ video
18	12060-V	PBS leased analog/digital services
19	12080-H	PBS leased analog services (occ) /PBS *The Business Channel (occ)*
20	12100-V	PBS leassed analog/digital services
21	12120-H	PBS leased digital services/ High Definition TV Testing
22	12140-V	PBS leased digital services/ Indiana Higher Education [Spectrumsaver]
23	12160-H	PBS stations/regionals 1, 2 and 3 [Digicipher 2 SCPC]
24	12180-H	PBS six-channel affiliate feeds [4DTV]

Telstar 4 (T4) — 89°West

1	11730-V	Loral Skynet services [digital]
2	11743-H	Loral Skynet services [digital]
3	11790-V	Loral Skynet services [digital]
4	11803-H	Loral Skynet services [digital]
5	11850-V	Loral Skynet services [digital]
6	11863-H	Georgia Public TV [4DTV]
7	11910-V	Data transmissions/Unknown user [digital video]
8	11923-H	Data transmissions
9	11971-V	Occ video (half-transponders common)
10	11984-H	Occ video (half-transponders common)
11	12033-V	South Carolina Educational TV [4DTV]
12	12046-H	Occ video (half-transponders common)
13	12095-V	Occ video (half-transponders common)
14	12108-H	Louisiana Public TV [Digicipher]/LeHigh University [Spectrumsaver]
15	12157-V	DMX for Business [digital]/ Muslim TV Ahmadiyya (PowerVu)
16	12170-H	Occ video

Galaxy 7 (K7) — 91° West

TCI Headend in the Sky [Digicipher 2] uses transponders 1, 4, 6-7, 9-10, 12-13, 15, 19 and 21-22. Using a 4DTV receiver, an unidentified digital audio service (40 channels: 820-859) has been observed on this satellite.

2	11750-H	Data transmissions/Unknown user [digital video]
3	11750-V	Data transmissions
5	11810-H	Data transmissions
8	11870-H	Data transmissions
11	11930-H	Westcott Communications? [Spectrumsaver]
14	11990-H	Occ video (half transponders common)
16	12020-V	Data transmissions
17	12050-H	Westcott Communications [Spectrumsaver] (lower half transponder)
17	12050-H	National Weather Networks (upper half transponder occasional)/Occ video
18	12050-V	Westcott Communications [Spectrumsaver]
20	12110-H	Data transmissions
23	12170-H	Data transmissions/Unknown user [digital video]
24	12170-V	Data transmissions

Galaxy 3R (G3R) — 95° West

Additional DirecTV United States capacity to be used for international programming and other services that are to be announced. This satellite and SBS 6 carry the bulk of the Ku-band traffic rerouted from the failed Galaxy 4 satellite.

1	11720-V	DirecTV Services [digital]
2	11750-V	Data transmissions
3	11750-H	FM² services/Muzak/Data transmissions
4	11780-V	Data transmissions
5	11810-V	Data transmissions
6	11810-H	Microspace Velocity [digital]
7	11840-H	DirecTV Services [digital]
8	11870-V	Data transmissions
9	11870-H	Data transmissions
10	11900-H	CNN Airport Network [Powervu]/Data transmissions
11	11930-V	MSNBC feeds (half transponders)
12	11930-H	Occ video
13	11960-H	CCTV-4 (China)
14	11990-V	Data transmissions
15	11990-H	DirecTV services
16	12020-H	FM² services
17	12050-V	CBS NewsNet SNG [analog/ digital]
18	12050-H	Hong Kong TVB Jade Channel [Videocrypt]
19	12080-H	DirectPC [digital]
20	12110-V	Data transmissions
21	12110-H	Conus Communications/Occ video
22	12140-H	Data Transmissions
23	12170-V	CBS NewsNet SNG [analog/ digital]
24	12170-H	Conus Communications/Occ video

Telstar 5 (T5) — 97° West

1	11728.0-V	Data transmissions
2	11735.0-H	Data transmissions
3	11789.5-V	Occ video (half transponders common)
4	11796.0-H	Unknown user [digital video]
5	11836.0-V	Telquest DBS [digital]
6	11842.5-H	Spacecom FM2/HyperCubed Services
7	11867.0-V	Unknown user [digital video]
8	11873.5-H	EABC/ESC 1 and 2/Nile TV International/Nile Drama [MPEG-2 Clear]
9	11898.0-V	Occ video
10	11904.5-H	U-Best Satellite Channel [MPEG-2 Clear]
11	11929.0-V	Occ video
12	11935.5-H	Occ video
13	11960.0-V	Occ video
15	11991.0-V	Space TV: Thai TV 5 Global Network [MPEG-2]
17	12022.0-V	Telquest DBS [digital]
18	12028.5-H	Occ video
19	12053.0-V	Occ video
20	12059.5-H	Occ video
21	12084.0-V	Unknown user [digital video]
22	12090.5-H	ABS-CBN International: The Filipino Channel, Sarimanok News Network, Pinoy Blockbuster Channel, CTN Zhong Tian, CTN Dadi plus DZMM/DWRR Radio Stations [MPEG 2 TVCOM]
23	12115.0-V	Unknown user [digital video]
24	12121.5-V	Occ video
25	12148.0-V	Occ video
26	12152.5-H	Telquest DBS [digital]
27	12177.0-V	Satcom Systems: Asian TV Network/Fox Sports/ Bloomberg TV/Health South/fX [MPEG2/DVB]
28	12183-H	Unknown user [digital video]

Spacenet 4 (S4) — 101° West

Transponders 19 (11740-H), 21 (11900-H), and 23 (12060-H) have failed on this satellite.

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

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

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

GE-1 (GE1) — 103° West

1	11720-H	Qualcomm data [digital]
2	11740-V	Data transmissions
3	11760-H	NBC Eastern/Central Time Zone programming
4	11780-V	Data transmissions
6	11820-V	Empire Sports [Wegener]/ Kentucky Educational TV (KET) [Digicipher 2]
7	11840-H	NBC Pacific Time Zone programming
8	11860-V	Qualcomm data [digital]
9	11880-H	NBC Mountain Time Zone programming
10	11900-V	Qualcomm data [digital]
11	11920-H	Data transmissions
12	11940-V	Microspace: Serbian TV/Nat Pharmacy TV/TechNet-Signature TV/Caliber Learning Network/WRAL-TV Raleigh [MPEG Nagravision]
13	11960-H	NSN data transmissions [digital]
14	11980-V	Qualcomm data [digital]
15	12000-H	NBC Contract Channel-Skypath
16	12020-V	DirectPC [digital]
17	12040-H	NBC Contract Channel-Skypath
18	12060-V	Starnet [Digicipher]
19	12080-H	NBC Newschannel [MPEG Wegener]
20	12100-V	Vyvx TV Commmercials distribution [Digicipher]/Occ video
21	12120-H	NBC NewsChannel SNG feeds [Wegner digital]
22	12140-V	Chinese Communications Channel (CCC) [Oak]
23	12160-H	NBC Newschannel SNG/NBC Contract Channel –mixture of Wegener digital SNG and analog feeds
24	12180-H	Fed Ex TV [BMAC]/Occ video

GSTAR-4 (GST4) — 105° West

1	11730-H	Data transmissions
2	11791-H	Data transmissions
3	11852-H	Occ video
4	11913-H	Data transmissions
5	11974-H	Occ video/Court TV Backhauls (occ video)
6	12035-H	CBS NewsNet SNG feeds
7	12096-H	Occ video
8	12157-H	CNN Newsource International/ Occ video
9	11744-V	Data transmissions
10	11805-V	Data transmissions
11	11866-V	ABSAT (ABC) SNG feeds
12	11927-V	Data transmissions
13	11988-V	Occ video
14	12049-V	Data transmissions
15	12110-V	Occ video
16	12171-V	Data transmissions/Unknown users [digital video]

Anik E2 (A1) — 107.3° West

Expressvu DBS service uses transponders 1-3, 6, 11-14, 22-26 and 31-32 with MPEG Nagravision. Stentor's Star Choice DBS service uses transponders 4-5, 7-10, 16, 21 and 27-29 with Digicipher 2. Transponders 1-8/17-20 are nationwide beams, transponders 9-16 are west beams, and transponders 21-32 are east beams

15	12144-V	Telesat Canada stationkeeping (GLACS)
30	12122-H	Telesat Canada stationkeeping (GLACS)

Solidaridad 1 SD1 109.2° West

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

Anik E1 (A2) 111° West

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

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

Solidaridad 2 (SD2) — 112.9° West

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

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

This satellite rarely has any Ku-band video transmissions.

7	11900-V	Occ video

Morelos 2 (M2) — 116.8° West

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

EchoStar 1/2 & Tempo 1 — 119°West

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

SBS 5 (SBS5) — 123° West

1	11725-H	Satellite Cinema PPV [digital video]
2	11760-H	SCPC services/Data transmissions
3	11823-H	Data transmissions
5	11921-H	Data transmissions
6	11970-H	Data transmissions
7	12019-H	Data transmissions
8	12068-H	Data transmissions/Unknown user [digital video]
9	12117-H	Data transmissions/Unknown user [digital video]
10	12166-H	Wal-Mart Business TV [V2]/Occ video
11	11748-V	Data transmissions
12	11898-V	WMNB Russian-American TV [inverted video]
13	11994-V	Data transmissions
14	12141-V	Data transmissions/USC TV [digital]/CSU-Chico [digital]

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	Spacenet 3R (S3R) 83°	GE-2 (GE2) 85°	GE-3 (GE3) 87°	Telstar 4 (T4) 89°	Galaxy 7 (G7) 91°	Galaxy 3R (G3R) 95°	Telstar 5 (T5) 97°	Galaxy 6 (G6) 99°	Spacenet 4 (S4) 101°	GE-1 (GE1) 103°	Anik E2 (A1) 107.3°
1	(none)	o/v	Associated Press TV [MPEG/DVB]	Natl Jewish TV/o/v	Sega Channel Interactive [digital]	TVN Theatre 1 [V2+]	o/v	SCPC services	Data Transmissions	MLB Intl [Leitch]/o/v	CBC-H Eastern (English)
2	(none)	o/v	American Independent Network (AIN) [CLI Spectrumsaver]	WTN [PowerVu]/Data Transmissions	CBS West [Leitch]	TVN Theatre 2 [V2+]	o/v	Telemundo [Powervu]	STARZ! 2 [V2+]	Data Transmissions/AF-RTS [Powervu]	o/v
3	Hollywood Treasures Network-shopping	o/v	WSBK-UPN Boston [V2+]	Rogue TV (adult) [V2+]	BET Action PPV [V2+]	TVN Theatre 3 [V2+]	o/v	SCPC services	Data Transmissions	PBS Alaska/Caribbean 7-channel [4DTV]	Star Choice DBS [Digicipher 2]
4	(none)	La Cadena de Milagro	Nebraska Educational TV (NETV) [4DTV]	Shop at Home	fX East [V2+]	TVN Theatre 4 [V2+]	o/v	Data Transmissions	Encore-Westerns [V2+]	FOX Sports Ohio/FOX Sports Cincinnati [V2+]	(none)
5	(none)	NASA Contract Channel [Leitch]	Univision [V2+]	FOX feeds [LEITCH]	fX East/West/Fox Sports [MPEG 2-Clear]	TVN Theatre 5 [V2+]	o/v	o/v	Data Transmissions	Hero Teleport (GEMS/HTV) [4DTV]	Video Catalog Channel
6	(none)	Kuwait TV	Midwest Sports Channel (MSC) [V2+]	o/v	Game Show Network [V2+]	TVN Theatre 6/TVN Promo [V2+]	o/v	Shepherd's Chapel Network (Rel)	KNBC-NBC Los Angeles (PT24W) [V2+]	WNBC-NBC New York (PT24E) [V2+]	o/v
7	(none)	Data Transmissions	Data Transmissions	Bet Jazz Intl/Adam and Eve/Spice (adult)/Spice Hot [4DTV]	The Golf Channel [V2+]	Guthy-Renker TV 1 (infomercials)/TVN Theatre 7 [V2+]	El Comandante Horse Racing/o/v	o/v	o/v	Unknown user [digital video]	CBC-M feeds o/v
8	(none)	Data Transmissions	(none)	ABC feeds East [LEITCH]	o/v	Pandamerica Home Shopping/TVN Theatre 8 [V2+]	ABC NewsOne Channel	Much Music USA [V2+]	KOMO-ABC Seattle (PT24W) [V2+]	Fox Sports Chicago [V2+]	Cancom OVC US/Canadian TV Stns [PowerVu]
9	(none)	NASA TV	WPIX-Ind New York [V2+]	Horse Racing [digital video]	Outdoor Life/Telenoticias/-CBS Eye on People [PowerVu]	TVN Theatre 9-adulTVision (adult) [V2+]	FOX Feeds [LEITCH]	o/v	Data Transmissions	Fox Sports South [V2+]	CBC-B Atlantic (English)
10	(none)	Data Transmissions	Data Transmissions	FOX News Edge	United Arab Emirates TV Dubai	Horse Racing [digital video]/o/v	FOX Feeds [LEITCH]	o/v	FOXNet (PT24E/W) [V2+]	WKRN-ABC Nashville, TN (PT24E) [V2+]	Cancom OVC US/Canadian TV Stns [PowerVu]
11	(none)	Horse racing [digital video]	CNN/SI	Xxxcite (adult) [V2+]	Encore [V2+]	o/v	Exxxtasy (adult) [V2+]	o/v	STARZ! East [V2+]	Univision [PowerVu]	CBC-A (French) [Powervu]
12	(none)	Data Transmissions	Data Transmissions	Horse Racing [digital video]	Romance Classics [V2+]	Gem Shopping Channel (o/v)/RAI TV	Exotica (adult) [V2+]	o/v	(none)	Wisdom Network	Cancom OVC US/Canadian TV Stns [PowerVu]
13	KMPX DayStar TV (Rel)	Data Transmissions	SCPC/FM2 services	FOX feeds West [LEITCH]	TCI Hits: Ovation/CSN/Kaleidoscope/Bloomberg/Box [4DTV]	Horse Racing [digital video]/o/v	FOX feeds East [LEITCH]	o/v	Data Transmissions	Fox Sports South Alternate (occ)/o/v	CBC-C Pacific (English)
14	(none)	USIA Worldnet TV/VOA radio [PowerVu]	CNN feeds	ABC feeds East [LEITCH]	Independent Film Channel [V2+]	Horse Racing [digital video]/o/v	True Blue (adult) [V2+]	o/v	WWOR-UPN New York [V2+]	Fox Sports New England [V2+]	Cancom OVC US/Canadian TV Stns [PowerVu]
15	(none)	Data Transmissions	KTLA-Ind Los Angeles [V2+]	The X! Channel (adult) [V2+]	Your Choice TV [Digicipher 2]	Infomercials/o/v	Paramount Syndication/o/v	World Harvest TV (Rel)	Data Transmissions	Southern Entertainment TV (SET) [V2+]	o/v
16	(none)	Data Transmissions	CNN International/CNN fN [V2+]	Eurotica (adult) [V2+]	TCI Hits: Access Television/The Recovery Network [Digicipher 2]	HBO 2 East [V2+]	UPN Network/o/v	CBS West [Leitch]	NPS Promo Channel	Fox Sports Bay Area [V2+]	Cancom DVC Global/Prime TV/ASN [PowerVu]
17	(none)	Data Transmissions	FM2 services	FOX feeds [LEITCH]	Toon Disney [PowerVu]	MoreMax 2 East [V2+]	o/v	CBS feeds/o/v	Data Transmissions	o/v	CBC-D feeds o/v
18	(none)	Horse Racing [digital video]/o/v	fXM-Movies from Fox [V2+]	PBS National Schedule	Teleport Minnesota/CBS feeds/o/v	Inforamerica TV (Informercials)	WB Network-Domestic TV/o/v	o/v	STARZ! West [V2+]	Fox Sports New York [V2+]	Cancom OVC Cable Networks (French) [PowerVu]
19	(none)	Data Transmissions	Fox Sports Detroit/Net Base [V2+]	Exxxtasy Promo (adult)	CBS East [Leitch]	HBO 3 [V2+]	America's Collectibles Network	CBS East [Leitch]	Cornerstone TV (Rel)	America's Voice TV	Telsat OVC Cable Networks (French) [PowerVu]
20	(none)	Horse Racing [digital video]	(none)	o/v	(none)	HBO 2 West [V2+]	Buena Vista Syndication	CBS East [Leitch]	(none)	AFRTS [Powervu]	(Inactive)
21	(none)	Horse Racing [digital video]/o/v	University Network Dr. Gene Scott	ABC feeds West [LEITCH]	BET on Jazz	Superstar Programming Promo/o/v	ABC West Hot Backup [LEITCH]	CBS feeds/o/v	Data Transmissions	Univision feeds (occ)	Telesat OVC [PowerVu]
22	(none)	Arab Network of America (ANA)	Fox Sports World [V2+] o/v	ABC feeds East [LEITCH]	CBS Newspath	Horse Racing [digital video]	ABC East Hot Backup [LEITCH]	o/v	(none)	Deutsche Welle TV	Star Choice DBS [Digicipher 2]
23	Home Team Sports (HTS)	Horse Racing [digital video]/o/v	o/v	o/v	(none)	3 Angels Broadcasting	o/v	SCOLA [Wegener]	Data Transmissions	Outlaw Music Channel [V2+]	CBC-E (English) o/v
24	(none)	Horse Racing [digital video]/o/v	America One	Four Media Syndication feeds/o/v	Intl Channel/TV5/CC-TV4/Encore Themed Channels [4DTV]	Horse Racing [digital video]/o/v	o/v	o/v	KPIX-CBS San Francisco (PT24W) [V2+]	WSEE-CBS Erie, PA (PT24E) [V2+]	CTV/NewsWorld/CBLT/Weather Network [PowerVu]

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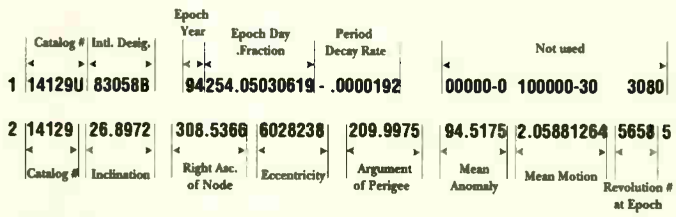
olidaridad 1 SD1) 109.2°	Telesat E1 (A2) 111°	Solidaridad 2 (SD2) 112.9°	Morelos 2 (M2) 116.8°	Galaxy 9 (G9) 123°	Galaxy 5 (G5) 125°	Satcom C3 (F3) 131°	Galaxy 1R (G1) 133°	Satcom C4 (F4) 135°	Satcom C1 (F1) 137°	Satcom C5 (F5) 139°	
Data Transmissions	Data Transmissions	Data Transmissions	Data Transmissions	Gospel Mustic Television	Disney East [V2+]	Family Channel-E/W/ FIT TV [PowerVu]	Comedy Central West [V2+]	American Movie Classics (AMC) [V2+]	SSN Extra 1 (various sports nets) [V2+]	Data Transmissions	1
Data Transmissions	(Inactive)	Data Transmissions	Unknown User [digital video]	Vyvx feeds/o/v	Playboy (adult) [V2+]	The Learning Channel [V2+]	Univision/Galavision [PowerVu]	Pay Per View [Digicipher 1]	KMGH-ABC Denver [V2+]	Data Transmissions	2
SCPC services	Data Transmissions	Data Transmissions	Data Transmissions	NHK TV	Trinity Broadcasting (Rel)	Viewer's Choice PPV [Digicipher 2]	Encore Themed Services [4DTV]	Nickelodeon East [V2+]	KRMA-PBS Denver [V2+]	SCPC Services	3
Data Transmissions	Data Transmissions	Data Transmissions	(none)	(none)	Sci-Fi [V2+]	Lifetime West [V2+]	TV Food/Outdoor Life/BBC World/AHN/CNBC [Digicipher 1]	Lifetime East [V2+]	Fox Sports Alternates (occ)	SCPC Services	4
o/v	Data Transmissions	(none)	Data Transmissions	Showtime/TMC/S-DC(W) [4DTV]/VH-1(W)-[Powervu]	CNN [V2+]	Odyssey (Rel)	Classic Arts Showcase	(none)	KDVR-Fox Denver [V2+]	Data Transmissions	5
Unknown User [digital video]	(Inactive)	Data Transmissions	Unknown User [digital video]	o/v	WTBS-Ind Atlanta [V2+]	Court TV/NW Cable News/MuchMusic [4DTV]	Z-Music	Madison Square Garden [V2+]	KCNC-CBS Denver [V2+]	(none)	6
Unknown User [digital video]	Data Transmissions	Unknown user[digital]/Data Transmissions	Data Transmissions	TVN Digital Theaters 1-8/Prevue [4DTV]	WGN-Ind Chicago [V2+]	C-SPAN 1	Disney West [V2+]	Bravo [V2+]	SSN FOX Sports West [V2+]	Data Transmissions	7
Unknown User [digital video]	(Inactive)	Data Transmissions	XHGC canal 5	(none)	HBO West [V2+]	Q2	Cartoon Network [V2+]	Prevue Channel	NBC-East	(none)	8
MVS Multivision [Digicipher 1]	(Inactive)	(none)	Unknown User [digital video]	TVN Digital Theaters 9-16/DMX 820-834 [4DTV]	ESPN [V2+]	(none)	ESPN2 Blackout [V2+]/SAH	QVC Network	FOX Sports Net Base 1	Data Transmissions	9
Mexican Government Channel	RTPi (Portugal)	Data Transmissions	XEIPN TV Once	TVN Digital Theaters 17-24/DMX 835-849 [4DTV]	MOR Music	America's Store	MSNBC [V2+]	Home Shopping Network (HSN)	SSN FOX Sports SW [V2+]	SCPC Services	10
MVS Multivision [Digicipher 1]	(Inactive)	Digital TV (SAm beam) [Digicipher 1]	Unknown User [digital video]	TVN Digital Theaters 25-32/DMX 850-859 [4DTV]	Family Channel East [V2+]	Fox Sports Net Base [V2+]	Eternal Word TV Network (Rel)	SpeedVision	NHK secondary feeds	Data Transmissions	11
(none)	o/v	(none)	(none)	(none)	Discovery West [V2+]	History Channel [V2+]	Valuevision	Ziff Davis TV (ZDTV)	Data Transmissions	(none)	12
o/v	(Inactive)	(none)	Mexican Cable (Spanish) [Digicipher 1]	GRTV/Panda [4DTV]	CNBC [V2+]	The Weather Channel [V2+]	Encore Themed Services [4DTV]	Travel Channel [V2+]	Fox Sports Rocky Mountains [V2+]	Data Transmissions	13
(none)	(Inactive)	Data Transmissions	XEW canal 2	Sundance Channel [V2+]	ESPN2 [V2+]	New England Sports Network [V2+]	ESPN Alternate [V2+]/SAH	California Channel [PowerVu]/IFE o/v	KUSA-NBC Denver [V2+]	SCPC Services	14
MVS Multivision [Digicipher 1]	(Inactive)	Data Transmissions	Mexican Cable (Spanish) [Digicipher 1]	Showtime West [V2+]	HBO East [V2+]	Viacom Services [4DTV]	CNNSI/CNN fn/CNN Int/TCM/CNN Espanol/Headline [4DTV]	Animal Planet [V2+]	SC Florida [V2+]	Digital Services [DAT]	15
Data Transmission	(Inactive)	Data Transmissions	XEIMT Canal 22	(none)	Cinemax West [V2+]	M2: Music Television	Turner Classic Movies [V2+]	Pay Per View [V2+]	FOX Sports Arizona/Americas [Digicipher]	SCPC Services	16
Data Transmissions	(Inactive)	(none)	Mexican Cable (Spanish) [Digicipher 1]	Nickelodeon West [V2+]	TNT [V2+]	Movie Channel East [V2+]	The New Inspirational Network (Rel)	MTV East [V2+]	SSN FOX Sports (alternates) [V2+]	Data Transmissions	17
o/v	(Inactive)	(none)	o/v	The Movie Channel West [V2+]	TNN [V2+]	TVLand	HBO/Cinemax [4DTV]	Viewer's Choice [Digicipher 2]	FOX Sports Extra 2 [V2+]	Live Net	18
Data Transmissions	TV Northern Canada [PowerVu]/Data Transmissions	Data Transmissions	Mexican Movie Channels [PowerVu]	MTV West [V2+]	USA East [V2+]	Showtime/TMC/S-DC (East) [4DTV]	Cinemax East [V2+]	C-SPAN 2 [analog]/CSPAN Extra [PowerVu]	FOXNet [V2+]	Digital Services [SEDAT]	19
(none)	(Inactive)	(none)	Data Transmissions	(none)	BET [V2+]	Knowledge TV/GAC/PIN [4DTV]	Home and Garden Network [V2+]	Showtime East 2 [V2+]	StepStar Network [Digicipher 1]	(none)	20
(none)	SCPC services/ Data Transmissions	(none)	Mexican Cable (Spanish) [Digicipher 1]	ESPNews [V2+]	Knowledge TV	Comedy Central East [V2+]	USA West [V2+]	Discovery East [V2+]	FOX Sports West 2 [V2+]	Data Transmissions	21
(none)	(Inactive)	(none)	XHIMT TV Azteca 7	o/v	CNN/HN [V2+]	BBC America [Digicipher 2]	Good Life TV Network [V2+]	FLIX [V2+]	SSN FOX Sports NW [V2+] (occ)	(none)	22
Data Transmissions	(Inactive)	Data Transmissions	Mexican Cable (Spanish) [Digicipher 1]	Group W Network Services [digital]	A&E [V2+]	E! Entertainment TV (East) [V2+]/E! (West) [PowerVu]	HBO/Cinemax [4DTV]	VH-1 [V2+]	KWGN-Ind Denver [V2+]	Digital Services [SEDAT]	23
Unknown User [digital video]	(Inactive)	(none)	XHDF TV Azteca 13	General Communications [digital]	Showtime (East) [V2+]	The Military Channel	Outdoor Channel	CMT [V2+]	SSN Sunshine Network [V2+]	Alaskan Rural Comm Svc [PowerVu]	24

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

Amateur and Weather Satellite Two-Line Orbital Element Sets

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

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



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

AMATEUR RADIO SATELLITES
AMSAT OSCAR 10 (Phase 3B, AO-10)
1 14129U 83058B 98194.78638179 -.00000246 00000-0 10000-3 0 5545
2 14129 26.8628 78.5458 5998724 232.3898 56.3008 2.05883960 85452
UoSAT OSCAR 11 (UoSAT-B, UO-B, UoSAT 2, UO-2, UoSAT 11, UO-11)
1 14781U 84021B 98204.93437900 .00000295 00000-0 57250-4 0 837
2 14781 97.8836 176.3264 0012087 154.1890 205.9906 14.69806110770268
Russian *Mir* Space Station
1 16609U 86017A 98205.42710495 .00008474 00000-0 86986-4 0 6496
2 16609 51.6607 217.9388 0006391 262.6810 97.3413 15.65863927709893
Pacsat OSCAR 16 (Microsat-A/Pacsat)
1 20439U 90005D 98205.22088289 .00000013 00000-0 21759-4 0 1630
2 20439 98.5118 286.4134 0011732 102.1208 258.1295 14.30073476443691
DOVE OSCAR 17 (Microsat-B, DO-17)
1 20440U 90005E 98205.16627132 .00000053 00000-0 37200-4 0 1790
2 20440 98.5165 287.5349 0012152 103.1551 257.0991 14.30220332443724
Webersat OSCAR 18 (Microsat-C, WO-18)
1 20441U 90005F 98205.17391043 .00000020 00000-0 24431-4 0 1809
2 20441 98.5152 287.3856 0012666 103.3369 256.9232 14.30182211443720
Lusat OSCAR 19 (Microsat-D, LO-19)
1 20442U 90005G 98205.24787603 .00000045 00000-0 33850-4 0 1665
2 20442 98.5199 288.3788 0013083 102.6201 257.6441 14.30304015443760
Fuji OSCAR 20 (JAS-1B, Fuji-2, FO-20)
1 20480U 90013C 98205.18005413 -.00000030 00000-0 46844-5 0 685
2 20480 99.0674 96.8093 0540844 187.5254 171.7484 12.83243859396266
Radio Sputnik-12/13 (Cosmos 2123, RS-12/13)
1 21089U 91007A 98204.87360809 .00000041 00000-0 27296-4 0 908
2 21089 82.9203 340.7374 0027836 260.0822 99.7194 13.74102670374329
UoSAT OSCAR 22 (UoSAT-F, UoSAT-5, UO-22)
1 21575U 91050B 98205.18789099 .00000050 00000-0 30639-4 0 8720
2 21575 98.2474 255.2558 0008009 120.7002 239.4972 14.37158500368228
KITSAT OSCAR 23 (Uribyol, KITSAT-A, KITSAT-1, KO-23)
1 22077U 92052B 98204.94424306 -.00000037 00000-0 10000-3 0 7703
2 22077 66.0876 24.0455 0012703 301.2599 58.7177 12.86310867279426
AMRAD OSCAR 27 (EYESAT-A, EYESAT-1, AO-27)
1 22825U 93061C 98204.76306760 .00000028 00000-0 28562-4 0 6619
2 22825 98.5000 274.0785 0008931 138.3275 221.8588 14.27786034251370
ITAMSAT OSCAR 26 (IO-26)
1 22826U 93061D 98205.19080450 .00000019 00000-0 24710-4 0 6513
2 22826 98.5026 274.8559 0009444 138.2206 221.9697 14.27899235251458
KITSAT OSCAR 25 (KITSAT-B, KITSAT-2, KO-25)
1 22828U 93061F 98205.12748858 .00000031 00000-0 29712-4 0 6578
2 22828 98.4958 274.8998 0010686 121.9978 238.2244 14.28251724219588
POSAT OSCAR 28 (PO-28) Not in amateur service at presstime
1 22829U 93061G 98205.29245067 .00000042 00000-0 33945-4 0 6497
2 22829 98.4965 275.1933 0010935 124.2233 235.9968 14.28241742251523
Radio Sputnik 15 (RS-15)
1 23439U 94085A 98205.12100510 -.00000039 00000-0 10000-3 0 3206
2 23439 64.8134 222.9104 0147524 54.1408 307.3112 11.27529653147251
Fuji OSCAR 29 (JAS-2, Fuji-3, FO-29)
1 24278U 96046B 98204.94003503 -.00000028 00000-0 87580-5 0 1913
2 24278 98.5182 195.7275 0350890 224.5772 132.6657 13.52643726 95438
Radio Sputnik 16 (RS-16)
1 24744U 97010A 98205.29822165 .00009400 00000-0 26187-3 0 2327
2 24744 97.2478 108.3709 0008637 91.3488 268.8759 15.36965043 77714
TMSAT-1 (1998-043C)
1 25396U 98043C 98205.17702477 -.00000045 00000-0 00000-0 0 225
2 25396 98.7954 275.1710 0000637 195.2863 164.8298 14.22355623 1992
Techsat-1B (1998-043D)
1 25397U 98043D 98205.17607807 -.00000045 00000-0 00000-0 0 485
2 25397 98.7964 275.1736 0001654 276.5699 83.5291 14.22456024 2013

WEATHER/IMAGING SATELLITES
Geostationary Satellites
GOES 2 (Standby spacecraft-US 136.860 MHz on continuously, high power)
1 10061U 77048A 98197.74405204 .00000000 00000-0 10000-3 0 78
2 10061 13.2337 28.7302 0004436 156.9837 203.0775 1.00261680 22133
GOES 3 (Standby spacecraft-US 137.190 MHz on continuously, high power)
1 10953U 78062A 98200.54947457 -.00000143 00000-0 00000-0 0 9321
2 10953 12.2930 31.8783 0001186 232.2481 127.7381 1.00279989 26704
GOES 7 (Standby spacecraft-US)
1 17561U 87022A 98201.39062640 -.00000167 00000-0 10000-3 0 5376
2 17561 4.5130 64.5557 0001168 19.7348 257.4784 1.00266470 24958
GOES 8 (Operational East-US)
1 23051U 94022A 98197.64168875 .00000000 00000-0 10000-3 0 2310
2 23051 0.0526 106.4449 0002834 50.6165 293.4780 1.00263729 22977
GOES 9 (Standby. Placed in storage at 105° west-US)
1 23581U 95025A 98204.20436997 .00000066 00000-0 00000-0 0 244
2 23581 0.3566 279.4585 0000361 281.6426 37.8471 1.00277187 11601
GOES 10 (Operational West-US)
1 24786U 97019A 98201.99915632 -.00000119 00000-0 00000+0 0 2160
2 24786 0.4088 276.9198 0002635 248.4191 29.1118 1.00283381 4558
ELEKTRO (Operational Russian spacecraft)
1 23327U 94069A 98200.99702731 -.00000113 00000-0 10000-3 0 6641
2 23327 1.6037 87.1864 0003554 114.5850 170.2303 1.00272823 13646
Feng Yun 2B (Operational Chinese spacecraft)
1 24834U 97029A 98200.76930556 -.00000344 00000-0 00000-0 0 1565
2 24834 0.4344 237.2065 0000599 57.5191 23.7586 1.00258357 4044
Meteosat 5 (Operational ESA spacecraft at 65 deg East, aka MOP-2)
1 21140U 91015B 98201.60030920 .00000003 00000-0 00000+0 0 4687
2 21140 2.0889 77.9818 0000777 319.9739 179.1327 1.00268819 29263
Meteosat 6 (Operational ESA spacecraft)
1 22912U 93073B 98204.11022640 -.00000096 00000-0 00000-0 0 2187
2 22912 0.2483 31.7155 0001072 353.4584 306.2095 1.00273857 15531
Meteosat 7 (Operational ESA spacecraft)
1 24932U 97049B 98204.22762233 -.00000020 00000-0 00000-0 0 1624
2 24932 1.1782 291.2864 0001930 49.2848 42.8787 1.00275328 3266
GMS 4 (Standby Japanese spacecraft, aka Himawari 4)
1 20217U 89070A 98205.02425926 -.00000388 00000-0 00000+0 0 8202
2 20217 3.2915 71.3799 0001298 186.0316 172.7253 1.00260176 33102
GMS 5 Operational Japanese spacecraft, aka Himawari 5)
1 23522U 95011B 98200.65489005 -.00000300 00000-0 00000-0 0 8045
2 23522 0.3932 13.3484 0001219 30.3554 269.3486 1.00268771 12091

Near Polar/Polar Orbiting Imaging Spacecraft
NOAA 12 (Operational morning US spacecraft 137.500 MHz APT)
1 21263U 91032A 98205.12817794 .00000087 00000-0 57606-4 0 9007
2 21263 98.5285 211.9037 0012022 201.5568 158.5105 14.22840190373515
NOAA 14 (Operational afternoon US spacecraft 137.620 MHz APT)
1 23455U 94089A 98205.09972938 .00000065 00000-0 60829-4 0 5480
2 23455 99.0440 163.5085 0008522 242.9902 117.0399 14.11792227183659
NOAA 15 (Post launch testing. NASA has handed over satellite to NOAA 137.500 MHz APT)
1 25338U 98030A 98205.15675768 .00000135 00000-0 79931-4 0 869
2 25338 98.7128 234.2921 0011475 122.8825 237.3458 14.22774416 10165
Meteor 3-5 (Operational Russia spacecraft 137.850 MHz APT when in sunlight only)
1 21655U 91056A 98204.90783580 .00000051 00000-0 10000-3 0 859
2 21655 82.5512 138.9526 0014782 53.7935 306.4548 13.16863350333580
Resurs O (1-4) (Transmits APT imagery on 137.300 MHz)
1 25394U 98043A 98205.38792348 -.00000045 00000-0 00000+0 0 377
2 25394 98.7983 275.3897 0000421 184.9568 175.1696 14.22373441 2006
DMSP B5D2-7/USA 106 (DoD meteorological polar orbiter: downlink encrypted)
1 23233U 94057A 98205.13151997 .00000080 00000-0 65824-4 0 7421
2 23233 98.7238 259.3469 0012790 156.9908 203.1841 14.12945804201120
DMSP B5D2-8/USA 109 (DoD meteorological polar orbiter: downlink encrypted)
1 23533U 95015A 98205.14292876 .00000062 00000-0 56821-4 0 4965
2 23533 98.8535 209.4077 0008379 44.4091 315.7753 14.12880685171928
DMSP B5D2-9/USA 131 (DoD meteorological polar orbiter: downlink encrypted)
1 24753U 97012A 98205.09104440 .00000093 00000-0 73543-4 0 5361
2 24753 98.8813 252.2625 0009403 359.0926 1.0235 14.13084961 67140

Amateur Satellite Frequency Guide

The Radio Amateur Satellite Corp.

1983-058B/14129 AMSAT OSCAR 10 (Phase 3B, AO-10)
Communications transponder (linear/inverting): Uplink 435.027-435.179 MHz (CW/LSB)/Downlink 145.825-145.977 MHz (CW/USB)/Beacon: 145.810 MHz (Steady unmodulated carrier)

1984-021B/14781 UoSAT OSCAR 11 (UoSAT-B, UO-B, UoSAT-2, UO-2, UoSAT 11, UO-11)
Downlink 145.825 MHz FM (1200 Baud PSK)/Beacon 2401.500 MHz. The operating schedule: ASCII status–210 seconds, ASCII bulletin–60 seconds, BINARY SEU–30 seconds, ASCII TLM–(90 seconds, ASCII WOD–120 seconds, ASCII bulletin–60 seconds, and BINARY ENG–30 seconds.

1986-017A/16609 *Mir* Space Station (*Mir*/SAFEX)
SAFEX II 70-cm repeater: Uplink 435.750 MHz FM with subaudible tone 141.3 Hz/Downlink 437.950 MHz FM
QSO Mode: Uplink 435.725 MHz FM w/subaudible tone 151.4 Hz/Downlink 437.925 MHz FM
PMS: 145.985 MHz FM, 1200 Baud AFSK/Occasional FM voice contacts are made on this frequency.

1990-005D/20439 Pacsat OSCAR 16 (Microsat-A, Pacsat)
Uplinks 145.900, 145.920, 145.940, and 145.960 MHz FM (1200 bps Manchester FSK) /Downlinks 437.0513 (1200 bps RC-BPSK) and 437.026 secondary (1200 baud PSK) MHz SSB/Beacon 2401.1428 MHz (BPSK). Connect Address: Pacsat-1.

1990-005E/20440 DOVE OSCAR 17 (Microsat-B, DO-17)
Downlink 145.825 MHz FM (1200 baud AFSK)/Beacon 2401.220 MHz. DOVE is presently sending 1200 baud AX.25 (standard packet) and ASCII telemetry about every minute on 2-meters. On S-band it transmits PSK flags continuously and also the same data that is sent on 2-meters. At presstime, the 145.825 MHz and 2401.220 MHz downlinks are off the air. Command stations are working on the problem.

1990-005F/20441 Webersat OSCAR 18 (Microsat-C, WO-18)
Downlink 437.104 MHz SSB (1200 baud PSK AX.25). At presstime WO-18 was non-operational. WO-18 is in MBL mode after a software crash. Attempts are being made to find and correct the cause of these suspected seasonal crashes.

1990-005G/20442 Lusat OSCAR 19 (Microsat-D, LO-19)
Uplink 145.840, 145.860, 145.880 and 145.900 (1200 bps Manchester FSK)/Downlinks 437.125 and 437.153 (secondary) MHz SSB (1200 bps RC-BPSK)

1990-13C/20480 Fuji OSCAR 20 (JAS-1B, Fuji-2, FO-20)
JA mode (linear/inverting): Uplink 145.900-146.000 MHz (CW/LSB)/Downlink 435.800-435.900 MHz (CW/USB). FO-20 in mode JA continuously. Callsign: 8J1JBS

1991-007A/21089 Radio Sputnik 12/13 (Cosmos 2123, RS-12/13)
KA mode: Uplink 145.910-145.950 MHz (CW/SSB)/Downlink 29.410-29.450 MHz (CW/SSB). The 15-meter ROBOT is operational. This communication package was carried by Cosmos 2123 as secondary payload.

1991-050B/21575 UoSAT OSCAR 22 (UoSAT-F, UoSAT-5, UO-22)
JD Mode: Uplink 145.900 or 145.975 MHz FM/Downlink 435.120 MHz FM (9600 baud FSK)

1992-052B/22077 KITSAT OSCAR 23 (Uribyol, KITSAT-A, KITSAT-1, KO-23)
JD Mode: Uplink 145.850 and 145.900 MHz FM/Downlink 435.175 MHz FM (9600 baud FSK), Callsigns: HL01-11 (Broadcast) and HL01-12 (BBS)

1993-061C/22828 KITSAT OSCAR 25 (KITSAT-B, KITSAT-2, KO-25)
JD Mode: Uplink 145.870 and 145.980 MHz FM/Downlink 435.175 and 436.5 MHz FM (9600 baud FSK). Callsigns: HL02-11 (Broadcast) and HL02-12 (BBS)

1993-061F/22826 ITAMSAT OSCAR 26 (IO-26)
Uplink 145.875, 145.900, 145.925 and 145.950 MHz FM/Downlink 435.822 MHz SSB (1200 baud PSK). Callsign: ITMSAT

1993-061G/22829 AMRAD OSCAR 27 (Eyesat-A, Eyesat-1, AO-27)
Uplink 145.850 MHz FM/Downlink 436.792 MHz FM

1994-085A/23439 Radio Sputnik 15 (Radio-Rosto, RS-15)
Mode A: Uplink 145.858-145.898 MHz (CW/SSB)/Downlink 29.354-29.394 MHz (CW/SSB)

1996-046B/24278 Fuji OSCAR 29 (JAS-2, Fuji-3, FO-29)
JA Mode (Voice/CW): Uplink 145.900-146.000 MHz (CW/LSB)/Downlink 435.800-435.900 MHz (CW/USB).
JD mode (digital): Uplink 145.850, 145.870, 145.890 and 145.910 MHz FM/Downlink 435.910 MHz FM (9600 baud BPSK)

1997-010A/24744 Radio Sputnik 16 (RS-16)
At press time, the 435 MHz beacon (only) is operational. Recent attempts to command the Mode A transponder on have been unsuccessful. Communications transponder: Uplink 145.915-145.948 MHz/Downlink 29.415-29.448 MHz. Beacons: HF Beacons–29.408 and 29.451 MHz/ UHF Beacon 1–435.504 MHz/UHF Beacon 2–435.548 MHz

1998-043C/25396 TMSAT-1
TMSAT-1 is another Uosat Microbus-class payload built by Surrey Satellite for the Thai Microsatellite Company of Bangkok and carrying a combined Earth observation and data communications payload. The satellite callsign is TMSAT1, and it is transmitting on 436.923 MHz. Presently it may be 3 kHz high in frequency due to the internal spacecraft temperature being quite cold.

Amateur Communications Package
Uplinks: 145.925 and 145.975 MHz
Downlinks: 436.925 (primary), 436.900, 436.950 and 436.975 MHz

1998-043D/25397 TechSAT-1
Gurwin TechSAT-1 is designed as a digital store and forward multi-user system for international amateur radio electronic mail and built by Technion-Israel Institute of Technology. The system is compatible with existing store and forward facilities already in use on AO-16, LO-19 and UO-22.

Main downlink: 435.225 MHz (9600 bit/sec MSK, G3RUH, uplink/downlink)
Redundant downlink: 435.325 MHz
VHF uplink: 145.850, 145.890 and 145.930 MHz
L-band uplink: 1269.700, 1269.800 and 1269.900 MHz

Modulation: Emergency–1200 bit/sec FM uplink/downlink and optional–1200 bit/sec bpsk, downlink only. Protocols: The communication protocol is based on the AX.25 which is the amateur radio derivative of the X.25 The communications package for amateur use will be based on the system developed by Jeff Ward for the UoSAT satellites. Transmission power: 1- and 3-Watts (optional). Antennas: The downlink 70 cm transmitters will be connected to a four-element antenna with circular polarization. Uplink antennas are vertical monopoles with linear polarization.

Geostationary Satellite Locator Guide

By TS Kelso and Larry Van Horn

This guide shows the orbital locations of 246 active geostationary/geosynchronous satellites. Orbital parameters are based on current two-line element sets and satellite names come from the latest Satellite Situation Report.

We are particularly grateful to the following individuals for providing payload information and analysis: Earth News—Philip Chien; Molniya Space Consultancy—Phillip Clark; Baylin Publications—Dr. Frank Baylin; Harvard-Smithsonian Center for Astrophysics—Jonathan McDowell; US Space Command/Public Affairs; Naval Space Command/Public Affairs; NASA NSSDC/WDC-A, Goddard Space Flight Center; and the *Satellite Times* staff.

Orbit Codes

- d satellite is drifting (moving into a new orbital slot or at end of life)
- # satellite has started into an inclined orbit
- i orbital inclination greater than 2 degrees

Radio Frequency Band Key

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

Satellite Service Key

AOR	Atlantic Ocean Region
APR	Asia/Pacific Ocean Region
BSS	Broadcast Satellite Service
DARS	Digital Audio Radio Service
FSS	Fixed Satellite Service
Gov	Government
Intl	International
IOR	Indian Ocean Region
MSS	Mobile Satellite Service
MET	Meteorological Satellite Service
Mil	Military
POR	Pacific Ocean Region

OBJ NO.	INT-DESIG/COMMOM NAME		LONG (DEG)	TYPE SATELLITE
24932	1997-049B	METEOSAT 7 [ESA]	0.6E#	MET (P/L/S) In-orbit spare
23730	1995-067A	TELECOM 2C [FR]	3.0E	FSS-Gov/Mil (S/C/X/Ku)
25049	1997-071A	SIRIUS 2 [SWED]	4.8E	BSS (Ku)
20193	1989-067A	SIRIUS (MARCOPOLO 1) [SWED]	5.2E	BSS (Ku)
22028	1992-041B	EUTELSAT 2-F4 [EUTE]	7.1E	FSS (S/Ku)
21056	1991-003B	EUTELSAT 2-F2 [EUTE]	10.1E	FSS (S/Ku)
19596	1988-095A	RADUGA 22 [CIS]	10.9Ei	FSS-Gov/Mil (X/C)
22269	1992-088A	COSMOS 2224 [CIS]	11.3E#	FSS-Mil Early Warning (X)
22557	1993-013A	RADUGA 29 [CIS]	11.3Ei	FSS-Gov/Mil (X/C)
20777	1990-079B	EUTELSAT 2-F1 [EUTE]	12.9E	FSS (S/Ku)
24665	1996-067A	HOT BIRD 2 [EUTE]	13.0E	BSS (Ku)
23537	1995-016B	HOT BIRD 1 [EUTE]	13.0E	BSS (Ku)
21055	1991-003A	ITALSAT 1 [IT]	13.2E#	FSS/MSS (S/K/Ka)
24931	1997-049A	HOT BIRD 3 [EUTE]	13.4E	BSS (Ku)
25237	1998-013A	HOT BIRD 4 [EUTE]	13.7E	BSS (Ku)
21803	1991-083A	EUTELSAT 2-F3 [EUTE]	16.1E	FSS (S/Ku)
24208	1996-044A	ITALSAT 2 [IT]	16.3E	FSS/MSS (L/S/K/Ka)
21139	1991-015A	ASTRA 1B [LUXE]	19.2E	BSS (Ku)
19688	1988-109B	ASTRA 1A [LUXE]	20.5E	BSS (Ku)
25071	1997-076A	ASTRA 1G [LUXE]	20.5E	BSS (Ku)
23842	1996-021A	ASTRA 1F [LUXE]	20.5E	BSS (Ku)
22653	1993-031A	ASTRA 1C [LUXE]	20.5E	BSS (Ku)
19331	1988-063B	EUTELSAT 1-F5 (ECS 5) [EUTE]	21.6Ei	FSS (VHF/Ku)
22175	1992-066A	DFS 3 [FRG]	23.5E	BSS (S/Ku/K)
23686	1995-055A	ASTRA 1E [LUXE]	23.5E	BSS (Ku)
25153	1998-006B	INMARSAT 3-F5 [IM]	24.6Ei	Intl MSS on-orbit spare (L/C)
18351	1987-078B	EUTELSAT 1-F4 (ECS 4) [EUTE]	25.5Ei	FSS (VHF/Ku)
23948	1996-040A	ARABSAT 2A [AB]	26.0E	BSS/FSS (C/Ku)
20706	1990-063B	DFS 2 [FRG]	28.5E	BSS (S/Ku/K)
23331	1994-070A	ASTRA 1D [LUXE]	28.9E	BSS (Ku)
23200	1994-049B	TURKSAT 1B [TURK]	30.5E	FSS (Ku)
24652	1996-063A	ARABSAT 2B [AB]	30.5E	BSS/FSS (C/Ku)
15629	1985-025A	INTELSAT 510 [ITSO]	33.1Ei	Intl FSS IOR (C/Ku)
21821	1991-087A	RADUGA 28 [CIS]	34.5Ei	FSS-Gov/Mil (X/C)
22963	1994-002A	GALS 1 [CIS]	36.4E#	BSS (Ku)
23717	1995-063A	GALS 2 [CIS]	36.6E#	BSS (Ku)
23775	1996-005A	GORIZONT 31 [CIS]	39.8E#	FSS (C/Ku) Statsionar 12
23949	1996-040B	TURKSAT 1C [TURK]	41.9E	FSS (Ku)
22981	1994-008A	RADUGA 1-3 [CIS]	49.1E#	FSS-Gov/Mil (X/C) Statsionar 24
23880	1996-034A	GORIZONT 32 [CIS]	52.9E	FSS (C/Ku) Statsionar 5
19687	1988-109A	SKYNET 4B [UK]	54.4Ei	FSS-Milcomsat (P/S/X/Ka)

OBJ NO.	INT-DESIG/COMMOM NAME		LONG (DEG)	TYPE SATELLITE
21894	1992-010B	INSAT 2R (ARABSAT 1C) [IND]	54.9E	BSS/FSS (S/C)
23305	1994-064A	INTELSAT 703 [ITSO]	57.1E	Intl FSS IOR (C/Ku)
20659	1990-054A	GORIZONT 20 [CIS]	59.7Eid	FSS (C/Ku)
20667	1990-056A	INTELSAT 604 [ITSO]	59.9E	Intl FSS IOR (C/Ku)
20315	1989-087A	INTELSAT 602 [ITSO]	62.0E	Intl FSS IOR (C/Ku)
18922	1988-014A	STTW-2 [PRC]	63.2Ei	FSS (C)
21140	1991-015B	METEOSAT 5 (MOP 2) [ESA]	63.6Ei	MET (P/L/S)
23839	1996-020A	INMARSAT 3-F1 [IM]	63.9E#	Intl MSS IOR (L/C)
25110	1997-083A	INTELSAT 804 [ITSO]	64.2E	Intl FSS IOR (C/Ku)
21814	1991-084B	INMARSAT 2-F3 [IM]	65.0E#	Intl MSS IOR (L/C)
23461	1995-001A	INTELSAT 704 [ITSO]	66.1E	Intl FSS IOR (C/Ku)
22787	1993-056A	UFO 2 (USA 95) [US]	70.5Ei	FSS-Milcomsat IOR (P/S)
23448	1994-087A	RADUGA 32 [CIS]	70.6E#	FSS-Gov/Mil (X/C) Statsionar 20
23589	1995-027A	UFO 5 (USA 111) [US]	70.9Ei	FSS-Milcomsat IOR (P/S/K)
10669	1978-016A	OPS 6391 (FLTSATCOM 1) [US]	72.1Ei	FSS-Milcomsat IOR (P/S)
13595	1982-097A	INTELSAT 505 [ITSO]	72.1Ei	Intl FSS/MSS APR (L/C/Ku)
22027	1992-041A	INSAT 2A [IND]	74.2E#	FSS/MET (S/C)
23327	1994-069A	ELEKTRO (GOMS) [CIS]	75.5E#	MET (L)
25010	1997-062A	APSTAR 2R [PRC]	76.5E	FSS (C/Ku)
23680	1995-054A	LUCH 1 [CIS]	77.4E#	FSS-SDRN2 (Ku)
23314	1994-065B	THAICOM 2 [THAI]	78.5E	FSS (C/Ku)
24768	1997-016A	THAICOM 3 [THAI]	78.5E	FSS/BSS (C/Ku)
25315	1998-025A	COSMOS 2350 [CIS]	79.1Ei	Unknown Mission
24435	1996-058A	EXPRESS 2 [CIS]	80.0E#	Intl FSS(C/Ku)
23653	1995-045A	COSMOS 2319 [CIS]	80.1E#	FSS-Data Relay (C)
20643	1990-051A	INSAT 1D [IND]	83.0E#	BSS/FSS/MET (S/C)
19548	1988-091B	TDRS 3 [US]	85.4Ei	FSS-Gov (C/S/Ku)
22836	1993-062A	RADUGA 30 [CIS]	85.5Ei	FSS-Gov/Mil (X/C) Statsionar 3
25354	1998-033A	Zhongwei 1 (Chinastar 1) [PRC]	87.5E	FSS (C/Ku)
22880	1993-069A	GORIZONT 28 [CIS]	90.0Ei	FSS (C/Ku) Statsionar 6
23765	1996-002B	MEASAT 1 [MALA]	91.4E	FSS (C/Ku)
22724	1993-048B	INSAT 2B [IND]	93.3E	BSS/FSS/MET (S/C)
23731	1995-067B	INSAT 2C [IND]	93.5E	BSS/FSS/MET (S/C/Ku)
22245	1992-082A	GORIZONT 27 [CIS]	96.8Ei	FSS (C/Ku) Statsionar 14
20473	1990-011A	STTW-4 [PRC]	98.6Ei	FSS (C)
22210	1992-074A	EKRAN 20 [CIS]	99.0Ei	BSS (P) Statsionar-T
23723	1995-064A	ASIASAT 2 [AC]	100.5E	BSS (C/Ku)
21922	1992-017A	GORIZONT 25 [CIS]	103.2Ei	FSS (C/Ku) Statsionar 21
24834	1997-029A	FY-2 [PRC]	104.8E#	MET (L)
20558	1990-030A	ASIASAT 1 [AC]	105.6E	BSS (C)
23176	1994-040B	BS-3N [JPN]	107.2E	BSS (Ku)
25050	1997-071B	INDOSTAR 1 [INDO]	107.3E	BSS/DARS (L/S)
20570	1990-034A	PALAPA B2R [INDO]	108.0E	FSS (C)
21668	1991-060A	BS-3B (YURI 3B) [JPN]	109.6E	BSS (S/Ku)
24769	1997-016B	B-SAT 1A [JPN]	109.8E	BSS (Ku)
25312	1998-024B	B-SAT 1B [JPN]	110.5E	BSS (Ku)
19710	1988-111A	STTW-3 [PRC]	111.4Ei	FSS (C)
23864	1996-030A	PALAPA C2 [INDO]	112.8E	FSS (C/Ku)
25134	1998-002A	SKYNET 4D [UK]	115.1E/i/d	FSS-Milcomsat (P/S/X/Ka)
14985	1984-049A	CHINASAT 5 (SPACENET 1) [PRC]	115.6E#	FSS (C/Ku)
23639	1995-041A	KOREASAT 1 [KOR]	115.9E	BSS/FSS (Ku)
23768	1996-003A	KOREASAT 2 [KOR]	116.0E	BSS/FSS (Ku)
21964	1992-027A	PALAPA B4 [INDO]	117.7E	FSS (C)
22931	1993-078B	THAICOM 1 [THAI]	119.9E	FSS (C/Ku)
20217	1989-070A	HIMAWARI 4 (GMS 4) [JPN]	120.3Ei	MET (P/L/S)
23108	1994-030A	GORIZONT 30 [CIS]	122.1E#	FSS (C/Ku)
24732	1997-007A	JCSAT 4 [JPN]	124.0E	FSS (Ku)
24798	1997-021A	DFH-3 2 [PRC]	125.0E	FSS (C)
23649	1995-043A	JCSAT 3 [JPN]	127.9E	FSS/BSS (C/Ku)
21132	1991-014A	RADUGA 27 [CIS]	128.3Ei	FSS-Gov/Mil (X/C)
23651	1995-044A	NSTAR 1 [JPN]	131.9E	FSS (S/C/Ku/K)
23943	1996-039A	APSTAR 1A [PRC]	134.0E	BSS (C)
23781	1996-007A	NSTAR 2 [JPN]	136.0E	FSS (S/C/Ku/K)
23185	1994-043A	APSTAR 1 [PRC]	138.0E	BSS (C)
20953	1990-102A	GORIZONT 22 [CIS]	139.4Ei	FSS (C/Ku) Statsionar 7
23522	1995-011B	GMS 5 [JPN]	139.7E#	MET (P/L/S)
24880	1997-036A	SUPERBIRD C [JPN]	143.9E	FSS (Ku/K)
20923	1990-094A	GORIZONT 21 [CIS]	144.6Ei	FSS (C/Ku) Statsionar 16
24901	1997-042A	AGILA 2 [PRC]	145.9E	FSS (C/Ku)
24653	1996-063B	MEASAT 2 [MALA]	147.9E	FSS (C/Ku)
25067	1997-075A	JCSAT 5 [JPN]	150.0E	FSS (Ku)

Geostationary Satellite Locator Guide

OBJ NO.	INT-DESIG/COMMOM NAME		LONG (DEG)	TYPE SATELLITE
23779	1996-006A	PALAPA C1 [INDO]	150.4E	FSS (C/Ku)
18350	1987-078A	OPTUS A3 (AUSSAT 3) [AUS]	152.0Ei	FSS (Ku)
20402	1990-001B	JCSAT 2 [JPN]	153.9E	FSS (Ku)
20410	1990-002B	LEASAT 5 [US]	155.6Ei	FSS-Milcomsat (P/S)
23227	1994-055A	OPTUS B3 [AUS]	155.9E	BSS/MSS (L/Ku)
22253	1992-084A	SUPERBIRD A1 [JPN]	158.0E	FSS (Ku/K)
22087	1992-054A	OPTUS B1 (AUSSAT B1) [AUS]	159.9E	BSS/MSS (L/Ku)
22907	1993-072A	GORIZONT 29 [CIS]	161.0Ei	FSS (C/Ku)
21893	1992-010A	SUPERBIRD B1 [JPN]	162.0E	FSS (Ku/K)
22694	1993-039A	GALAXY 4 [US]	162.0Ed	FSS (C/Ku)
16275	1985-109C	OPTUS A2 (AUSSAT 2) [AUS]	164.0Ei	FSS (Ku)
23175	1994-040A	PAS 2 [US]	169.0E	Intl FSS POR (C/Ku)
25258	1998-016A	UFO 8 (USA 138) [US]	171.0Ei	FSS-Milsatcom POR (P/S/K/Ka)
12046	1980-087A	OPS 6394 (FLTSATCOM 4) [US]	172.1Ei	FSS-Milcomsat POR (P/S/X)
24846	1997-031A	INTELSAT 802 [ITSO]	174.0E	Intl FSS POR (C/Ku)
23124	1994-034A	INTELSAT 702 [ITSO]	176.9E	Intl FSS POR (C/Ku)
24674	1996-070A	INMARSAT 3-F3 [IM]	178.0E#	Intl MSS POR (L/C)
20918	1990-093A	INMARSAT 2-F1 [IM]	178.8E#	Intl MSS POR (L/C)
22871	1993-066A	INTELSAT 701 [ITSO]	179.9Wd	Intl FSS POR (C/Ku)
23467	1995-003A	UFO 4 (USA 108) [US]	178.4Wi	FSS-Milcomsat POR (P/S/K)
19121	1988-040A	INTELSAT 513 [ITSO]	176.9Wi	Intl FSS POR (C/Ku)
21639	1991-054B	TDRS 5 [US]	174.3W#	Intl FSS-Gov (C/S/Ku)
23613	1995-035B	TDRS F7 [US]	171.4Wi	FSS-Gov (C/S/Ku)
25126	1997-086A	HGS-1 [US]	153.0W	FSS (C/Ku)
21392	1991-037A	AURORA 2 [US]	139.0W	FSS (C)
20945	1990-100A	SATCOM C1 [US]	136.9W	FSS (C)
22096	1992-057A	SATCOM C4 [US]	135.0W	FSS (C)
23581	1995-025A	GOES 9 [US]	134.5W#	MET (P/L/S)
23016	1994-013A	GALAXY 1R [US]	133.0W	FSS (C)
22117	1992-060B	SATCOM C3 [US]	131.0W	FSS (C)
13637	1982-106B	DSCS III-1 [US]	130.1Wi	FSS-Milcomsat EPAC (P/S/X)
25331	1998-028A	ECHOSTAR 4 [US]	127.0W	BSS (Ku)
21906	1992-013A	GALAXY 5 [US]	125.0W	FSS (C)
23877	1996-033A	GALAXY 9 [US]	123.0W	FSS (C)
19484	1988-081B	SBS 5 [US]	123.0W	FSS (Ku)
15826	1985-048D	TELSTAR 303 [US]	120.0Wi	FSS (C)
23754	1995-073A	ECHOSTAR 1 [US]	119.3W	BSS (Ku)
24748	1997-011A	TEMPO 2 [US]	119.0W	BSS (Ku)
24313	1996-055A	ECHOSTAR II [US]	118.8W	BSS (Ku)
16274	1985-109B	MORELOS 2 [MEX]	116.8W	FSS (C/Ku)
23313	1994-065A	SOLIDARIDAD 2 [MEX]	113.0W	FSSMSS (L/C/Ku)
21726	1991-067A	ANIK E1 [CA]	111.1W	FSS (C/Ku)
22911	1993-073A	SOLIDARIDAD 1 [MEX]	109.2W	FSS/MSS (L/C/Ku)
21222	1991-026A	ANIK E2 [CA]	107.3W	FSS (C/Ku)
23846	1996-022A	MSAT M1 [CA]	106.5W	MSS (L/X)
23696	1995-057A	UFO 6 (USA 114) [US]	106.4Wi	FSS-Milcomsat CONUS (P/S/K)
03029	1967-111A	ATS 3 [US]	105.5Wi	Experimental communications (VHF/C)
15677	1985-035A	GSTAR 1 [US]	105.3W#	FSS (Ku)
19483	1988-081A	GSTAR 3 [US]	105.3Wi	FSS/MSS (L/Ku)
08747	1976-023B	LES 9 [US]	105.0Wi	Experimental Milcomsat (P/Ka)
20946	1990-100B	GSTAR 4 [US]	104.9W	FSS (Ku)
24786	1997-019A	GOES 10 [US]	104.6W#	MET (P/L/S) In-orbit spare
24315	1996-054A	GE 1 [US]	103.0W	FSS (C/Ku)
08746	1976-023A	LES 8 [US]	102.6Wi	Experimental Milcomsat (P/Ka)
22930	1993-078A	DBS 1 [US]	101.3W	BSS (Ku)
21227	1991-028A	SPACENET 4 (ASC 2) [US]	101.0W	FSS (C/Ku)
23553	1995-019A	AMSC 1 [US]	101.0W	MSS (L/X)
23598	1995-029A	DBS 3 [US]	100.9W	BSS (Ku)
23192	1994-047A	DBS 2 [US]	100.8W	BSS (Ku)
17181	1986-096A	FLTSATCOM 7 (USA 20) [US]	100.1Wi	FSS-Milcomsat CONUS (P/S/X/K)
22796	1993-058B	ACTS [US]	100.1W	Experimental communications (S/C/K)
20873	1990-091B	GALAXY 6 [US]	99.0W	FSS (C)
24812	1997-026A	TELSTAR 5 [US]	97.0W	FSS (C/Ku)
17561	1987-022A	GOES 7 [US]	96.5Wi	MET (P/L/S)
23741	1995-069A	GALAXY 3R [US]	95.1W	FSS (C/Ku)

OBJ NO.	INT-DESIG/COMMOM NAME		LONG (DEG)	TYPE SATELLITE
25086	1997-078A	GALAXY 8 [US]	94.9W	BSS (Ku)
16650	1986-026B	BRAZILSAT 2 [BRAZ]	92.0W#	FSS (C)
22205	1992-072A	GALAXY 7 [US]	91.0W	FSS (C/Ku)
23670	1995-049A	TELSTAR 402R [US]	89.0W	FSS (C/Ku)
24936	1997-050A	GE 3 [US]	87.1W	FSS (C/Ku)
24713	1997-002A	GE 2 [US]	85.0W	FSS (C/Ku)
25152	1998-006A	BRAZILSAT B3 [BRAZ]	84.1W	FSS (C/X)
18951	1988-018A	SPACENET 3R [US]	83.1W	FSS (L/C/Ku)
16276	1985-109D	SATCOM K2 [US]	80.9W#	FSS (Ku)
15561	1985-015B	BRAZILSAT 1 [BRAZ]	79.1Wi	FSS (C)
15235	1984-093B	SBS 4 [US]	77.2Wi	FSS (Ku)
12309	1981-018A	COMSTAR 4 [US]	76.1Wi	FSS (C)
23051	1994-022A	GOES 8 [US]	74.6W	MET (P/L/S)
20872	1990-091A	SBS 6 [US]	74.1W	FSS (Ku)
24714	1997-002B	NAHUEL 1A [ARGN]	71.9W	FSS (Ku)
23199	1994-049A	BRAZILSAT B1 [BRAZ]	70.2W	FSS (C/X)
23536	1995-016A	BRAZILSAT B2 [BRAZ]	65.0W	FSS (C/X)
25004	1997-059A	ECHOSTAR 3 [US]	61.6W	BSS (Ku)
24916	1997-046A	PAS 5 [US]	58.2W	BSS (C/Ku)
16101	1985-087A	INTELSAT 512 [ITSO]	55.9Wi	Intl FSS AOR-W (C/Ku)
25371	1998-037A	INTELSAT 805 [ITSO]	55.6W	Intl FSS AOR-W (C/Ku)
21149	1991-018A	INMARSAT 2-F2 [IM]	55.3Wi	Intl MSS AOR-W (L/C)
24819	1997-027A	INMARSAT 3-F4 [IM]	53.9W	Intl MSS AOR-W (L/C)
23571	1995-023A	INTELSAT 706 [ITSO]	53.1W	Intl FSS AOR-W (C/Ku)
23915	1996-035A	INTELSAT 709 [ITSO]	50.1W	Intl FSS AOR-W (C/Ku)
13969	1983-026B	TDRS 1 [US]	48.7Wi	FSS-Gov (S/C/Ku)
22314	1993-003B	TDRS F6 [US]	47.1W	Intl FSS-Gov (S/C/Ku)
19217	1988-051C	PAS 1 [US]	45.1W	FSS AOR (C/Ku)
24891	1997-040A	PAS 6 [US]	43.2W	FSS AOR (C/Ku)
23764	1996-002A	PAS 3R [US]	43.1W	BSS (Ku)
19883	1989-021B	TDRS 4 [US]	40.7W#	FSS-Gov (C/S/Ku)
25239	1998-014A	INTELSAT 806 [ITSO]	40.6W	Intl FSS AOR (C/Ku)
19772	1989-006A	INTELSAT 515 [ITSO]	37.8W#	Intl FSS AOR (C/Ku)
23413	1994-079A	ORION 1 [US]	37.5W	Intl FSS (Ku)
21765	1991-075A	INTELSAT 601 [ITSO]	34.5W	Intl FSS AOR (C/Ku)
20401	1990-001A	SKYNET 4A [UK]	34.0Wi	FSS-Milcomsat (P/S/X/Ka)
24742	1997-009A	INTELSAT 801 [ITSO]	31.5W	Intl FSS IOR (C/Ku)
22723	1993-048A	HISPASAT 1B [SPN]	30.1W	BSS/FSS (S/Ku)
22116	1992-060A	HISPASAT 1A [SPN]	30.0W	BSS/FSS (S/Ku)
14077	1983-047A	INTELSAT 506 [ITSO]	29.7Wi	Intl FSS/MSS AOR (L/C/Ku)
15873	1985-055A	INTELSAT 511 [ITSO]	29.5Wi	Intl FSS (C/Ku)
21653	1991-055A	INTELSAT 605 [ITSO]	27.6W	Intl FSS AOR (C/Ku)
15386	1984-114B	MARECS B2 [ESA]	26.0Wi	MSS AOR (L)
20523	1990-021A	INTELSAT 603 [ITSO]	24.5W	Intl FSS AOR (C/Ku)
23967	1996-042A	UFO 7 (USA 127) [US]	23.5Wi	FSS-Milcomsat AOR (P/S/K)
20253	1989-077A	FLTSATCOM 8 (USA 46) [US]	23.1Wi	FSS-Milcomsat AOR (P/S/X/K)
24957	1997-053A	INTELSAT 803 [ITSO]	21.6W	Intl FSS AOR (C/Ku)
21989	1992-032A	INTELSAT K [ITSO]	21.4W	Intl FSS AOR (Ku)
22921	1993-076A	NATO 4B [NATO]	20.4W#	FSS-Milcomsat (P/S/X)
15391	1984-115A	NATO 3D [NATO]	18.1Wi	FSS-Milcomsat (P/S/X)
23528	1995-013A	INTELSAT 705 [ITSO]	18.0W	Intl FSS AOR (C/Ku)
21047	1991-001A	NATO 4A [NATO]	17.7Wi	FSS-Milcomsat (P/S/X)
21940	1992-021B	INMARSAT 2-F4 [IM]	17.0Wi	Intl MSS AOR-E (L/C)
23426	1994-082A	LUCH [CIS]	16.4W#	FSS-Gov CSDRN (Ku)
24307	1996-053A	INMARSAT 3-F2 [IM]	15.6W#	Intl MSS AOR-E (L/C)
23132	1994-035A	UFO 3 (USA 104) [US]	14.8Wi	FSS-Milcomsat AOR (P/S)
23319	1994-067A	EXPRESS 1 [CIS]	13.9W	Intl FSS(C/Ku) Statsionar 4
23267	1994-060A	COSMOS 2291 [CIS]	13.9W#	FSS-Data Relay (C)
22041	1992-043A	GORIZONT 26 [CIS]	11.0Wi	FSS (C/Ku) Statsionar 11
22912	1993-073B	METEOSAT 6 [ESA]	8.7W#d	MET (P/L/S) Operational Metsat
21813	1991-084A	TELECOM 2A [FR]	8.0W	FSS-Gov/Mil (S/C/X/Ku)
25311	1998-024A	NILESAT [EGYP]	7.0W	FSS (Ku)
21939	1992-021A	TELECOM 2B [FR]	5.0W	FSS-Gov/Mil (S/C/X/Ku)
24209	1996-044B	TELECOM 2D [FR]	5.0W	FSS-Gov/Mil (S/C/X/Ku)
23865	1996-030B	AMOS [ISRA]	3.9W	FSS (Ku)
20776	1990-079A	SKYNET 4C [UK]	1.1W#	FSS-Milcomsat (P/S/X/Ka)
23816	1996-015A	INTELSAT 707 [ITSO]	1.0W	Intl FSS AOR (C/Ku)
	1998-035A	THOR 3 [NOR]	1.0W	BSS (Ku)
20762	1990-074A	THOR 1 (MARCOPOLO 2) [NOR]	0.8W	BSS (Ku)
24808	1997-025A	THOR 2A [NOR]	0.6W	BSS (Ku)
20168	1989-062A	TVSAT 2 [FRG]	0.5W	BSS (Ku)

Satellite Launch Schedules

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Brazil Expendable Launch Schedule

Launch Date	Launch Vehicle	Payload	Launch Site
September 98	VLS	???????	Alcantara

China Expendable Launch Schedule

Launch Date	Launch Vehicle	Payload	Launch Site
October 98	Long March 4A	Fengyun-1C	Taiyuan

European Expendable Launch Vehicles

Launch Date	Launch Vehicle	Payload	Launch Site
September 98	Ariane 44LP	PanAmSat-7 (PAS-7)	Kourou, French Guiana (ELA-2)
October 98	Ariane 44L	Sirius 3	Kourou, French Guiana (ELA-2)
		Afristar	Kourou, French Guiana (ELA-2)
October 98	Ariane 503	ARD/Mockup Commsat	Kourou, French Guiana (ELA-3)
October 98	Ariane 44L	Eutelsat W2	Kourou, French Guiana (ELA-2)
		Skynet 4E	Kourou, French Guiana (ELA-2)

Afristar — Downlink Frequency List
L-band: 1452-1492 MHz

Ariane 4 — Downlink Frequency List
S-band: 2203.0, 2206.0 and 2218.000 MHz

Eutelsat W2 — Downlink Frequency List
Ku-band: 10950-11700 MHz (18 transponders)
12500-12750 MHz (6 transponders)

PAS-7 — Downlink Frequency List
C-band: 3400-3700 MHz (14 transponders)
Ku-band: 10950-11200/11450-11700 MHz (30 transponders)

Sirius 3 — Downlink Frequency List
15 Ku-band transponders

Skynet 4E — Downlink Frequency List
Military X-band 7.2 GHz

India Expendable Launch Schedule

Launch Date	Launch Vehicle	Payload	Launch Site
September 98	PSLV	OceanSat 1 (IRS-P4)	Sriharikota
			Kitsat 3
			Tubsat

Tubsat — Downlink Frequency List
VHF-band: 143.075 MHz

Russian Expendable Launch Schedule

Launch Date	Launch Vehicle	Payload	Launch Site
September 98	Zenit-2	Globalstar (12)	Baikonur
September 98	Proton	Yamal 1 & 2	Baikonur
September 98	Proton	Nimiq 1	Baikonur
September 98	Zenit 2	Okean O-N1	Baikonur
			Tiungsat 1
September 98	Soyuz	Progress M	Baikonur
October 98	Proton	Telstar 6	Baikonur
October 98	Proton	PanAmSat 8	Baikonur

Globalstar — Downlink Frequency Assignments
L-band: 1610.0-1628.5 MHz
C-band: 6875.0-7075.0 MHz

Nimiq-1 — Downlink Frequency Assignments
Ku-band: 12200-12700 MHz

PanAmSat 8 — Downlink Frequency Assignments
C-band: 3700-4200 MHz (24 transponders)
Ku-band: 12250-12750 MHz (24 transponders)

Proton — Downlink Frequency Assignments
VHF-band: 132.400, 136.750 and 192.000 MHz
UHF-band: 232.000 and 240.000 MHz
L-band: 915-930 MHz
S-band: 2800-2810 MHz

Okean — Downlink Frequency Assignments
VHF-band: 137.400 MHz

Progress — Downlink Frequency Assignments
VHF-band: 166.000 MHz

Telstar 6 — Downlink Frequency Assignments
24 C-band and 28 Ku-band transponders

Yamal 1 & 2 — Downlink Frequency Assignments
C-band and 10-12 Ku-band transponders

U.S. Expendable Launch Schedule

Launch Date	Launch Vehicle	Payload	Launch Site
September 98	Delta 2	Iridium Mission 10 (5)	VAFB
September 98	Pegasus XL	Orbcomm (8) Mission 3	WFF
September 98	Taurus	STEX/ATEX	VAFB
October 98	Pegasus XL	WIRE	VAFB
October 98	Atlas 2A	Hot Bird 5	CCAS
October 98	Delta 2	Deep Space 1	CCAS
			SEDSAT
			CCAS
October 98	Delta 2	Iridium Mission 11	VAFB
October 98	Delta 3	Orion F3	CCAS

Atlas — Downlink Frequency List
S-band: 2202.5, 2206.5, 2210.5, 2211.0 and 2215.5 MHz
C-band: 5765.000 MHz

Delta 3 — Downlink Frequency List
S-band: 2241.500, 2252.500 and 2272.500 MHz

Delta 2 — Downlink Frequency List
S-band: 2244.500, 2241.500 and 2252.500 MHz
C-band: 5765.000 MHz

Hot Bird 5 — Downlink Frequency List
Ku-band: 10950-11200 MHz (10 transponders)
11550-11700 MHz (7 transponders)
12500-12600 MHz (5 transponders)

Satellite Launch Schedules

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Iridium	**Downlink Frequency List**
L-band	1616-1626.500 MHz (FDMA/TDMA)
Ka-band	19.4-19.6 GHz (satellite to gateway/earth terminals)
	23.18-23.38 GHz (inter-satellite links)
	29.1-29.3 GHz (gateway/earth terminals to satellite)
L-1011 A/C	**Downlink Frequency List**
L-band	1480.500 and 1727.500 MHz
S-band	2250.500 MHz
C-band	4583.5 and 5765.000 MHz
Navstar GPS	**Downlink Frequency List**
L-band	1227.600, 1381.050 and 1575.420 MHz
S-band	2227.500 MHz
Orbcomm	**Downlink Frequency List**
VHF-band	137-138.000 MHz
UHF-band	400.100 MHz
Orion F3	**Downlink Frequency List**
C-band	3400-3600 MHz (10 transponders)
Ku-band	11450-11700/12250-12750 MHz (33 transponders)
Pegasus XL	**Downlink Frequency List**
S-band TLM	2269.500 and 2288.500 MHz
C-band TRK	5765.000 MHz
Taurus	**Downlink Frequency List**
S-band TLM	2269.500 and 2288.500 MHz
C-band TRK	5765.000 MHz
WIRE	**Downlink Frequency List**
S-band	2215.000 MHz

U.S. Space Transport System (STS-NASA)

Space shuttles are launched from the Kennedy Space Center (KSC), Florida

Mission Number	Launch Date/ Orbiter	Inclination/ Altitude/Pad	Mission Duration	Mission/Cargo Bay/Payloads
STS-95	October 98/ Discovery	28.45/ 300nm/LC39B	9	Spacehab/ Spartan 201/ HOST/IEH package

STS-95 Crew Assignment: Commander Curt Brown, Pilot Steven Lindsey, Mission Specialist 1 Dr. Stephen Robinson, Mission Specialist 2 Dr. Scott Parazynski, Mission Specialist 3 Pedro, Duque, Payload Specialist 1 Dr. Chiaki Mukai, Payload Specialist 2 Sen. John Glenn.

STS	**Downlink Frequency Assignments:**
UHF Voice	243.0 (AM), 259.7 (AM), 279.0 (AM), and 296.8 (AM)
UHF Boosters	240.0 and 242.0 MHz (recovery beacons)
S-band TLM	2217.5, 2250.0 and 2287.5 MHz
C-band TRK	5400-5900.0 MHz

List of Abbreviations and Acronyms

A/C	Aircraft
Afristar	The first of three geostationary digital audio radio satellites to be operated by Worldspace, Inc.
ARD	Atmospheric Reentry Demonstrator
ATEx	Small experimental tether satellite built by the Naval Research Laboratory, Washington, DC.
Badr 2	Small microsatellite for Pakistan.
C-band	3700 to 6500 MHz
CCAS	Cape Canaveral Air Station, FL
Commsat	Communications Satellite
Fengyun-1C	Geostationary Chinese weather satellite
GHz	Gigahertz
Globalstar	Globalstar is a low-Earth-orbiting (LEO) satellite-based digital telecommunications system that will offer wireless telephone and other telecommunications services worldwide beginning in 1999. Owned by Globalstar and satellites built by Space Systems/Loral.
HOST	HOST is to provide Hubble officials the opportunity to test hardware that may be installed on the orbiting telescope during a planned servicing mission in May 2000. The main objective is to verify a new cooling system needed for the NICMOS instrument currently on Hubble.
IEH Package	This package will return to space for a third mission. The payloads are attached to a cross-bay structure in Discovery's bay. For IEH-3, the experiments include the Solar Extreme Ultraviolet Hitchhiker (SEH) that is to obtain EUV and FUV fluxes, the Ultraviolet Spectrograph Telescope for Astronomical Research (UVSTAR) that will measures EUV fluxes from such varied objects as hot stars and the planet Jupiter, STAR-LITE, which will make observations of extended and diffused astrophysical targets, CONCAP-4 designed to grow thin films via physical vapor transport, a Get Away Special (GAS) can, and the Petite Amateur Navy Satellite (Pansat) to be deployed from Discovery to transmit digital communications to specific ground stations.
Iridium	The Iridium system is a planned commercial communications network comprised of 66 low earth orbiting satellites. The system will use L-band to provide global communications services through portable handsets.
K-band	10.90 to 17.15 GHz
L-band	500 to 1549 MHz
Nimiq	Direct Broadcast Satellite (DBS) for Telesat Canada built by Lockheed Martin, a A2100AX model.
Navstar GPS	U.S. Air Force navigation satellite.
Meteor	Advanced Russian weather satellite.
MHz	Megahertz
OceanSat	Indian ocean remote sensing satellite.
Okean	Russian ocean remote sensing satellite.
Orbcomm	Orbcomm will provide low-cost alpha numeric data communications and position determination for emergency assistance, data acquisition and messaging services using pocket portable and mobile subscriber terminals.
PAS-7 and 8	Geostationary communications satellites for U.S. company PanAmSat.
Progress M	An unmanned cargo ship for crew aboard Mir space station.
S-band	2000 to 2300 MHz
Soyuz TM	Manned mission to carry replacement crew to the Russian Mir Space Station.
Spacehab	The module will contain science experiments from NASA, and the European and Japanese space agencies to study life and microgravity sciences and technology applications in space.
Spartan 201	Spartan will fly free of Discovery for two days to collect information on the stream of charged particles from the sun called the solar wind, which can disrupt communications on Earth, and examine the sun's hot outer atmosphere called the corona.
STEX	U.S. Air Force satellite.
Tiungsat	Malaysia's first national microsatellite.
TLM	Telemetry
TRK	Tracking
UHF	Ultra High Frequency (390 to 499 MHz)
VAFB	Vandenberg Air Force Base, Calif.
VHF	Very High Frequency (30 to 300 MHz)
WIRE	Wide-Field Infrared Explorer. The 5th small explorer mission, which will make wide field infrared studies of galaxies.
X-band	8000 and 10,999 MHz
XL	Extra Large
Yamal	Russian geostationary communications satellites.

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 June 1998. The format of the listing is as follows:

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

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

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

The *Satellite Times Satellite Launch Report* is extracted from more detailed monthly listings, *Worldwide Satellite Launches*, compiled by Phillip S. Clark and published by Molniya Space Consultancy, 25 Redfern Avenue, Whitton, Middx TW4 5NA United Kingdom.

Launch Date/Time Ref Epoch	Intl Designator Inclination	Period	Satellite Name Perigee	Mass Apogee
1998 Jun 2/2206	1998-034A		Discovery (STS-91)	117,860 kg
1998 Jun 2.95	51.65 deg	90.18 min	239 km	327 km
1998 Jun 4.75	51.66 deg	92.03 min	370 km	378 km

Ninth and last shuttle-*Mir* mission (SMM-09), carrying six astronauts at launch: C J Precourt (commander), D L P Gorie (pilot), F Chang-Diaz (payload commander, mission specialist MS-1 and EVA astronaut if required, EV-1), W B Lawrence (MS-2), J L Kavandi (MS-3, EV-2) and V V Ryumin (Russian cosmonaut, MS-4). This was the only docking mission of *Discovery* with the *Mir* Complex, although it performed a fly-by of the station February 1995 during the STS-63 mission (1995-004A). Mass quoted is that projected for landing. Payload bay carried Orbiter Docking System plus SPACEHAB module (mass 10,093 kg). Orbiter docked with Docking Module attached to Kristall June 4 at 1700 UTC and A.S.W.Thomas who had been left on *Mir* in January 1998 when *Endeavour*/STS-89 returned to Earth once more became a shuttle crew member (MS 5). Ryumin conducted an inspection of *Mir* during the shuttle visit and NASA equipment was transferred back to the orbiter for return to Earth. *Discovery* undocked from *Mir* Complex with seven crew members June 8 at 1601 and four days later landed at KSC at 1800.

1998 Jun 11/0035	1998-035A		Thor 3	1,300 kg?
1998 Jun 10.07	19.00 deg	684.04 min	1,433 km	37,245 km
1998 Jul 8.21	0.14 deg	1,436.09 min	35,754 km	35,819 km

Thor 3 is a telecommunications satellite launched for Telenor of Oslo, Norway. Mass quoted is estimated at launch: mass on-station at the beginning of operations is 853 kg. Satellite located over 358-359 deg E. Launched from Cape Canaveral using a Delta-2 (7925).

1998 Jun 15/2258	1998-036A		Cosmos 2352	225 kg?
1998 Jun 16.18	82.59 deg	118.03 min	1,310 km	1,875 km
1998 Jun 15/2258	1998-036B		Cosmos 2353	225 kg?
1998 Jun 17.57	82.59 deg	117.87 min	1,300 km	1,870 km
1998 Jun 15/2258	1998-036C		Cosmos 2354	225 kg?
1998 Jun 17.25	82.58 deg	117.96 min	1,307 km	1,872 km
1998 Jun 15/2258	1998-036D		Cosmos 2355	225 kg?

Launch Date/Time Ref Epoch	Intl Designator Inclination	Period	Satellite Name Perigee	Mass Apogee
1998 Jun 16.51	82.59 deg	117.87 min	1,302 km	1,868 km
1998 Jun 15/2258	1998-036E		Cosmos 2356	225 kg?
1998 Jun 16.51	82.58 deg	117.81 min	1,298 km	1,867 km
1998 Jun 15/2258	1998-036F		Cosmos 2357	225 kg?
1998 Jun 16.18	82.59 deg	117.72 min	1,294 km	1,863 km

Cluster of six Strela-3 military store-dump communications satellites. The satellites were launched into the same orbital plane as the previous cluster which has comprised Gonets-D1 4-6 and Cosmos 2337-2339 (1997-006A-F). However the final stage of the three-stage Tsyklon launch vehicle was incorrectly aligned and the satellites entered moderately-eccentric orbits instead of the planned 1,400-1,415 km near-circular orbits, thus permitting the orbital plane of the cluster to gradually drift away from the main constellation of Gonets-D1 and Strela-3 satellites. Russian claims that the satellite maneuvered to their planned operating altitude are incorrect–these satellites have no orbital maneuver capability. Launched from Plesetsk.

1998 Jun 18/2248	1998-037A		Intelsat 805	3,524 kg
1998 Jun 19.06	23.90 deg	628.93 min	176 km	35,700 km
1998 Jun 30.16	0.08 deg	1,436.02 min	35,768 km	35,803 km

Telecommunications satellite launched for Intelsat. Mass quoted is at launch: mass on-station at the beginning of operations is 1,964 kg and the dry mass is 1,503 kg. Satellite is located over 304.5 deg E. Launched from Cape Canaveral using an Atlas-2AS.

1998 Jun 24/1830	1998-038A		Cosmos 2358	6,600 kg?
1998 Jun 24.88	67.13 deg	89.52 min	167 km	334 km
1998 Jul 2.28	67.13 deg	89.95 min	174 km	370 km

Yantar-4K class "Kobalt" fourth generation close-look photo reconnaissance satellite. The more recent satellites of this type (eg Cosmos 2348, 1997-080A) have remained in orbit for up to four months. Launched from Plesetsk using a Soyuz-U.

1998 Jun 25/1400	1996-039A		Cosmos 2359	7,000 kg?
1998 Jun 25.70	64.91 deg	89.12 min	183 km	279 km
1998 Jun 27.43	64.91 deg	89.94 min	240 km	303 km

Yantar family "Neman" fifth generation photo reconnaissance satellite: first launch of this class of satellite since September 1996. Satellite should remain operating in orbit for approximately a year
with data being returned to Earth using a digital satellite-satellite-ground link via Geizer satellites in the Potok system. Launched from Baikonur using a Soyuz-U vehicle.

Updates for Previous Launches

International Designation	Comment
1981-119A	Intelsat 503 was retired from operations on Jan 22. Add the following retirement orbit data: Jan 28.39 7.02 deg 1,447.57 min 35,919 km 36,103 km

1985-055A Intelsat 511 was relocated over 330.5 deg E Jun 21.

1987-029A Palapa-B 2P has been drifting since maneuvering off-station Jan 18 and has probably been retired. Add the following orbital data:
Jan 25.79 1.55 deg 1,441.11 min 35,862 km 35,908 km

1990-077A Yuri 3A has been drifting since Apr 13 and has probably been retired. Add the following orbital data:
Apr 28.68 0.19 deg 1,445.04 min 35,834 km 36,089 km
Jun 9.79 0.49 deg 1,457.31 min 36,155 km 36,247 km

1990-091B According to the two-line orbital elements, Galaxy 6 was relocated from 285 deg E to 261 deg E during the period Jun 4-13, but no elements showing the actual drift were issued.

1991-015B METEOSAT 5 had its longitude re-stabilised over 63 deg E during early June.

1991-074A Gorizont 24 was maneuvered off-station during March, initially to an orbit below geosynchronous altitude. If the two-line data are correct, the orbital period was increased during March-May, while still remaining below the geosynchronous orbit level. No elements were issued for the satellite during May 11-June 22, by which time the satellite was in a retirement orbit. Add the following orbital data:
Mar 20.74 3.49 deg 1,436.15 min 35,774 km 35,801 km
Mar 26.77 3.51 deg 1,428.46 min 35,484 km 35,790 km
Mar 29.29 3.50 deg 1,430.02 min 35,567 km 35,768 km
Apr 23.63 3.60 deg 1,433.19 min 35,617 km 35,842 km
May 11.73 3.59 deg 1,433.23 min 35,672 km 35,788 km
Jun 22.87 3.69 deg 1,462.84 min 36,229 km 36,388 km

1993-073B METEOSAT 6 was maneuvered off-station over 0 deg E during the third week of June.

1997-049B METEOSAT 7 was relocated over 0-1 deg E during the first half of June.

1997-086A Add the following orbital data for HGS 1:
Jun 11.64 10.16 deg 20,271.25 min 34,621 km 445,166 km
Jun 14.74 8.85 deg 2,777.10 min 35,884 km 82,253 km
Jun 17.50 8.74 deg 1,679.79 min 35,868 km 44,994 km
Jun 18.33 8.72 deg 1,434.21 min 35,634 km 35,865 km
Jun 19.52 8.72 deg 1,437.94 min 35,682 km 35,963 km
Jun 25.27 8.70 deg 1,436.36 min 35,684 km 35,899 km

On Jun 14 at 0015 UTC the satellite's main propulsion motor was fired for 46 minutes and at 0150 it fired for two minutes, resulting in the spacecraft entering a near-circular Earth orbit. The main propulsion system ignited again Jun 18 at 0229 and completed a burn which lasted for 12 minutes, placing the spacecraft in a drift orbit: although this was close to geosynchronous altitude, the orbital inclination means that the satellite is not in a true "stationary" orbit. The satellite was then stationed over 207 deg E in dormant mode, awaiting a customer.

1998-006A BRASILSAT B3 was relocated over 276 deg E during the period May 27-Jun 23: no orbital data were issued for the satellite during this interval.

1998-016A UFO 8 was last shown over 188 deg E May 20 and by the end of the month the satellite had relocated to 171 deg E.

1998-024A Real rather than estimated data have now been issued for NILESAT 101 in geosynchronous orbit. Add the following orbital data:
Jun 17.65 0.01 deg 1,436.08 min 35,778 km 35,794 km
The satellite is located over 353 deg E.

1998-026A Add the following orbital data for Iridium 69:
Jun 2.10 86.40 deg 100.40 min 775 km 780 km

1998-033A Add the following orbital data for Zhongwei 1:
Jun 10.45 1.00 deg 2,202.55 min 35,729 km 63,666 km
Jun 17.66 0.14 deg 1,436.14 min 32,308 km 39,267 km
The satellite is located over 87.5 deg E.

Orbital Data for Galileo

The following orbital data for Galileo around Jupiter continues the previous listing. It has been derived from information available on the Galileo WWW site with the Jet Propulsion Laboratory.

1997 Dec 16.50 1.90 deg 56.60 days 568,244 km 7,789,205 km
1998 Jan 13.62 1.89 deg 56.58 days 565,300 km 7,789,217 km
1998 Feb 10.75 1.80 deg 46.34 days 561,579 km 6,734,254 km
1998 Mar 6.15 1.79 deg 46.33 days 560,173 km 6,734,254 km
1998 Mar 29.56 1.94 deg 63.66 days 566,335 km 8,483,048 km
1998 May 31.88 2.09 deg 49.86 days 561,074 km 7,107,294 km
1998 Jun 26.06 2.08 deg 49.86 days 561,219 km 71,07,295 km

ST

THE BEGINNER'S COLUMN

By Ken Reitz, KS4ZR
KS4ZR@compuserve.com

The Poor Man's DBS Revisited

In the June issue of *ST* this column extolled the virtues of the Poor Man's DBS System and this month I'll explore the subject further with a couple of interesting twists. Here's a quick review for those just coming aboard. Small dish DBS satellite systems are popular for the following reasons: they are small, have no moving parts, and are relatively inexpensive. The down side of such systems are that none are compatible with each other and that viewers are charged for minimum programming "packages" which inevitably include many channels few would willingly pay, for while channels some viewers really want aren't offered.

Now for the twists on this idea. First, there's the Ku-band "dedicated" dish in which a non-steerable system is set up for specific use. Second, is the "digital" addition in which an inexpensive "free-to-air" or a General Instrument 4DTV digital receiver is added to enhance channel count. And, finally, the great "parabolic-side-lobe-2-degree-spacing" trick in which we take advantage of parabolic geometry and the satellite receiver's willingness to be tricked.

The Dedicated Dish

Our youngest here at the house is a junior in high school and a big sports fan. He has a TV in his room which gets decent reception on all the local networks over the air, but he wanted to be able to see more sports without having to shell out for a small dish DBS system and the $30 per month charge for programming in which he wasn't interested.

The solution? A small Ku-band dish set to SBS-6, the primary sports satellite used for network back hauls and a cheap receiver capable of receiving Ku-band signals. The dish, feed horn, and LNB were all bought used for about $100.

The receiver, a General Instrument 1000 and nearly 15 years old, was free from a local dealer who knew he would never be able to sell it. It has no remote control, no built-in dish drive, and no option for a descrambler.

Setting up this system is fairly routine. Since there's no actuator motor, installation is cheaper and less complicated. Just lock the dish on SBS-6, run a length of RG/6 to the receiver in the house and a length of three conductor phone or doorbell wire to operate the servo motor to change polarity. Most receivers, this old GI 1000 included, have a jack in the back to attach the LNB cable and the cable from your over-the-air antenna. Switching between the satellite receiver and the other antenna is done on the receiver.

SBS-6 is a powerful Ku-band satellite located at 74 degrees west and formerly co-located with Galaxy 6, the C-band bird which was sent to Galaxy 4's old slot after its failure last May. It's used as a news/sports back haul satellite. During the day it's lit up with satellite news gathering (SNG) teams from all over the U.S. feeding reports back to their respective headquarters.

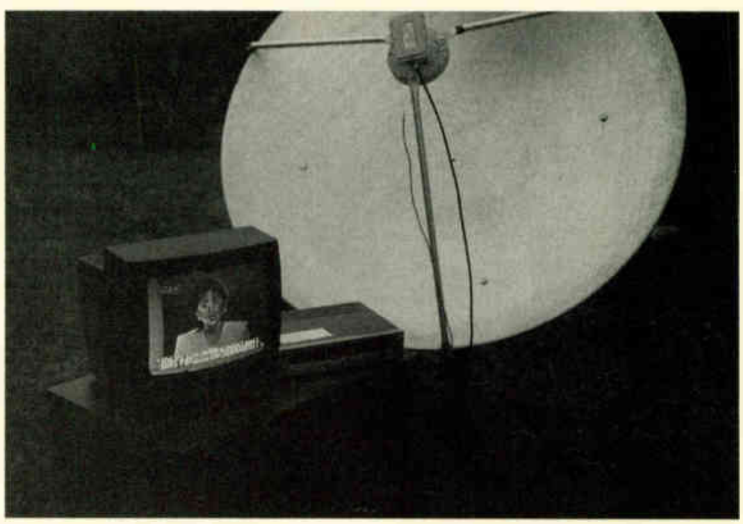
At night it's mostly sports. It's not uncommon, on any given Saturday in the fall, to see as many as a ten simultaneous feeds of different college football games on SBS-6. In winter it's packed with college basketball, NBA and NHL games. In spring you'll see college baseball games here. Additionally, there are golf, tennis and countless motor sports feeds on this bird throughout the year. What you won't see are NFL and Major League Baseball games which are all encrypted.

The Digital Addition

On many satellites in our portion of the Clarke Belt there are different types of digital transmissions containing a combination of video and audio services. Many of these video services are former analog channels which switched to digital, usually for reasons of economy. A good example of this is found on Anik E2 which for years had a combination of CBC and CTV channels in addition to Newsworld International (Canada's "all news" network) and The Weather Network. Only three CBC channels have remained in analog format, the rest are digital and not tunable on analog receivers.

However, the introduction of several brands of "free-to-air" digital receivers have made it possible to receive those digital signals which are unencrypted. The only drawback to these relatively cheap (under $400) receivers is that there's no provision for the addition of a "smart card" or other ways to subscribe to the channels should they decide to encrypt their signals.

Now it's possible to have a DBS style C-band system locked on Anik E2 and receive CBC, CTV, Newsworld International, The Weather Network, and many news and feature feed channels. This is a huge advantage for Canadian viewers without access to cable and whose satellite systems are already locked on Anik E2.



Who says you need a big dish for C-band reception? Here's a complete analog C-band satellite system: 54" dish, 40° LNBF, and receiver all used or surplus for a total cost of about $100.

Adding a Free-To-Air digital receiver, such as the Pansat 100A, gives you access to many MPEGII unencrypted digital channels. Here are a) Canada's Newsworld International on Anik E2 and b) BBC World on Panamsat 5. Both are C-band and receivable on a dish as small as 54".

The main audience for digital free-to-air transmissions has been ethnic groups which have been largely ignored by cable and satellite programmers. A good example of this is found on the Ku-band side of Telstar 5 with several channels of digital video aimed at North America's ethnic Chinese, Indian and Thai populations. In all, some three dozen digital feeds of everything from Fox Sports Americas (Fox Network's Spanish language sports channel) to East and West feeds of the Family Channel are found on Satcom F3, Telstar 401, Telstar 5, Galaxy 7 and Panamsat 5.

Having a General Instrument 4DTV receiver hooked up to a stationary dish could give one access to dozens of channels without having to move the dish. Most, however, would be premium cable channels and there will be some cost in subscribing. Still, this is a particularly useful idea in locations where trees and/or buildings prevent the user from seeing the complete arc or where there's no cable access.

As an example, having a non-steerable dish set up on Galaxy 9 at 123° west would give a viewer access to nine cable channels and 35 channels of first run pay-per-view movies. Setting up on Satcom F3 would yield six analog "in-the-clear" cable channels, eight VCII cable channels, seven 4DTV channels and 30 digital music channels from Music Choice. That's a total of 51 channels including The Weather Channel, Fox Sports, C-SPAN, MTV, TVLand, and the usual premium movie channels all on one bird!

Making Use of Side Lobes

Parabolic antennas are designed so that energy in the 3,7-4.2 GHz range from a satellite at which the dish is aimed will be reflected up into the feed horn and amplified by the low noise amplifier. At that point, the frequencies are converted down to a block of frequencies ranging from 950 to 1450 MHz. This is done so that inexpensive RG/6 coax cable can carry the signal into the house and into your receiver.

The depth of a satellite dish is measured by what's called the f/D ratio which is the ratio of a dish's focal length (how far the feed horn sits from the center of the dish) to the diameter of the dish.

The best parabolic dishes are those which are considered "deep" i.e. a feed horn which sits on a tripod above the center of the dish and is actually at or below the rim of the dish. This makes the "beamwidth," or the area of the sky above "seen" by the dish, very narrow. Side lobe transmissions from adjacent satellites will not interfere with the received signal. Less expensive or "shallow" dishes have the focal point considerably above the rim of the dish, and so are susceptible to side lobe interference. Usually, the smaller the dish, the more effect side lobe transmissions will have on the received signal. The f/D ratio is expressed by a figure given in all antenna specifications as somewhere between .46 (a shallow dish) or .28 (a deep dish). Generally speaking, the higher the number the more shallow the dish.

The FCC, in an effort to make as much room as possible for extra satellites in our region of the Clarke Belt, mandated some time ago that satellites would be spaced two degrees apart. This is why, if you'll look at the *Satellite Services Guide* in the centerfold of this magazine, you'll notice that many satellites are, indeed, separated by only two degrees. That may not seem like much from down here on Earth, but, 23,000 miles up in the Clarke Belt such satellites could be a thousand or more miles apart.

The Shallow Dish/LNBF Trick

One of the clever engineering tricks which has come to satellite TV in recent years was the development of the LNBF (Low Noise Block Down Converter Feed Horn) in which there is no rotating probe to change polarity. Instead two stationary probes, fixed 90 degrees apart are electronically switched to change polarity. This means that an installation has to be very tightly done as the probe won't tolerate being off-axis.

It's possible to engineer a dish installation so that one can receive two satellites on one dish. Here's what you'll need: You must have a small enough dish and a shallow enough dish to allow the adjacent satellite signals to be processed. You have to use an LNBF, the lower the noise temperature the better. I've done this with a 6-foot dish and a 30 degree LNBF and I've tried this with a dish as small as 4.5-foot, but the gain wasn't enough to provide good results. A larger dish, say 10 feet, will be too deep to do this at all.

Initially position the dish precisely on one satellite, say Galaxy 5 at 125 degrees west. Peak the LNBF so that it is precisely positioned to switch polarity. Now reposition the dish precisely between Galaxy 5 and Galaxy 9 next door at 123 degrees west. In other words, position your dish so that the center of its beam width is 124 degrees west.

First tune the receiver to channel 21 and you should still be able to see Knowledge TV on Galaxy 5. Now press the polarity reverse button on your receiver's remote control. You should now be watching ESPNews on Galaxy 9. Tune to channel three on this same polarity and you'll be watching NHK Tokyo feeds on Galaxy 9. Press the polarity reverse button and you'll be watching Trinity Broadcasting on Galaxy 5. Now, that's cool!

This works because the satellites have opposite polarities and your receiver has sharp enough tuning capabilities to center on one carrier while nulling out the other. What this means is that, without using an actuator motor or a polarotor motor, you will be able to tune 24 video channels as well as 24 audio channels on Galaxy 5 in addition to 10 analog channels and 35 digital channels on G9 for a total of 93 channels on a 6-foot dish with no moving parts. Now that's the Poor Man's DBS system!

By Doug Jessop

1998–A Tough Year on Satellite Operators

The person that quoted "variety is the spice of life" must have been a glutton for punishment or a satellite operator. 1998 will not go down as a favorite year for launch insurance folks, they are expected to pay out $165 million for the Galaxy 4 loss. With the failure of Galaxy 4 (see July article) a major chain of events was triggered that is still getting sorted out.

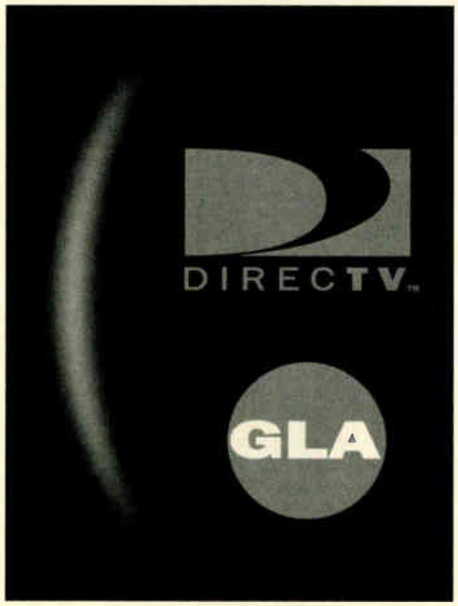
One of the major consequences of the satellite failure was to television programming. As reported earlier, the networks got fairly quick relief, but not without some major bumping of other broadcast clients. With the migration of Galaxy 6 to replace the dead bird another sequence of circumstances was set off like some huge game of dominos.

So you want to move Galaxy 6...fine, but what about all the traffic on Galaxy 6. Imagine that you are a major satellite space broker who has about half a dozen transponders serving the majority of syndication needs of the United States...oh boy.

Of course, let's not forget the law of supply and demand. Imagine for a moment that you absolutely, positively have to get the feed to the bird...any bird. FedEx is not an option. Paying top dollar is. What to do? Launches to the rescue!

At press time Galaxy 10 was scheduled to be launched on August 25 aboard a Delta 3 launch vehicle. Galaxy 10, which has 24 Ku-band and 24 C-band transponders, will be sent to 123° west. The new bird will replace Galaxy 9 which will find a new home at 127° west.

Telstar 6 is scheduled to be launched on October 10, 1998, aboard a Proton launch vehicle. The new satellite will be parked at 93° west and carry 24 C-band and 28 Ku-band transponders.



Somewhere around November 13, 1998, GE-5 will take a ride toward geostationary orbit at 22,300 miles above the earth with a push from an Ariane VII4 launch vehicle. The planned parking space for GE 5 will be 79° west. The satellite will operate with 16 Ku-band transponders.

New DBS satellites will also be launched between now and the end of the year. Tempo 1 is currently scheduled for a November 12 launch on a Proton launch vehicle. It will carry 16 DBS transponders into orbit and will be placed at either 119 or 166 west.

Rounding out the planned US domestic satellite launches for this year in the December 13-14, 1998, time period is MCI1. This new DBS satellite is scheduled to be carried aboard an Atlas AC-156 launch vehicle. MCI 1 new home is to be at 110° west operating with 16-DBS transponders.

And it's not just sat failures, the Leonids are coming.

Failing HS-601 satellites aren't the only problems facing satellite operators in 1998. The Leonids are coming and it could get real interesting in November. But it would appear that at least one operator isn't worried. Here is a press briefing on the Leonids from PanAmSat (the operator of the Galaxy and Pas satellites).

Briefing on Leonid Meteor Storm From PanAmSat

"The discussion below represents PanAmSat's conclusions with respect to the effects on its satellites of the natural phenomena described, and is based on the prior experience of PanAmSat and other operators in the industry and on information available to PanAmSat from various sources. However, notwithstanding prior experience and the information available to PanAmSat, no assurance can be given by PanAmSat that its satellites will be free of any adverse effect or damage from the meteor storm.

> "The Leonid meteor storm in November 1998 is generating considerable interest about the potential implications for satellite communications. PanAmSat, the world's largest commercial provider of satellite services, operates 16 satellites located approximately 22,300 miles above earth in geostationary orbit. PanAmSat's satellites cumulatively have logged hundreds of service years without any problems related to collision with space debris. The probability of a collision during the Leonid storm is very low due to the relative small size of a satellite in space and the extremely small size of meteor particles.
>
> "While predictions vary widely based on the debris models and researchers, the probability of an adverse collision ranges to 1/10th of 1 percent or less for

the duration of the storm. In addition, PanAmSat's satellites have on-board shielding and redundancy to protect critical spacecraft components.

"During the last year, PanAmSat has participated in conferences and evaluated studies by government agencies and the scientific community that have addressed the potential effect of the upcoming storm on man-made satellites. Based on the analysis to date, PanAmSat does not believe the Leonid meteor storm poses a significant risk to PanAmSat satellites. This conclusion is supported by the following reasons:

"The Leonid storm will create more particles than during non-shower periods, but these particles will be very small in density. In addition, the duration of the storm period will be relatively short–less than two hours. The probability of a collision is extremely low, and PanAmSat's satellites are designed with shielding to tolerate collisions with very small particles, reducing the probability that a meteor strike would cause immediate problems or impair performance.

"The timing of the upcoming storm presents a favorable geometry relative to the largest surfaces on the satellites, which are the solar panels. This reduces the probability of an impact that would affect electrical power generation or cause loss of pointing."

Chinese launch vehicles off limits for U.S. satellites?

On the same day that the Galaxy IV kicked the bucket, news came out that the United States Congress was going to suspend the use of Chinese launch vehicles for U.S. satellites. In a business of heavy duty competition and high risks, the use of the Chinese Long March launch program afforded satellite companies another option.

Apparently a Senate investigation into satellite exports has determined that China received military benefits and sensitive technology from the transfers. Announcing the preliminary results of a Senate inquiry, Senate Majority Leader Trent Lott said new information had come to light that "should remove all resistance to naming an independent counsel" to look into China's efforts to influence the American political process.

"In violation of stated U.S. policy, sensitive technology related to satellite exports has been transferred to China," said Lott, R-Miss. He said China had received military benefit from these exports and that the Clinton administration "has ignored overwhelming information regarding Chinese (nuclear) proliferation."

"The Clinton administration's export controls for satellites are wholly inadequate," Lott asserted. "They have not protected sensitive U.S. technology. National security concerns are regularly downplayed and even ignored."

Chinese officials have denied that the country used its commercial satellite-launching program to gain sensitive U.S. technology that could have helped China's ballistic missile capabilities. At issue are the President's decision to waive export controls on U.S. technology transfers to China and the role, if any, that campaign contributions may have played in the decision. Both the Senate and House are investigating Clinton's decision to grant a waiver earlier this year to allow Loral Space and Communications to launch a commercial satellite aboard a Chinese rocket.

The waiver was granted despite a Justice Department investigation into whether Loral gave the Chinese sensitive information in a report on a failed 1996 satellite launch. Congressional investigators also want to know if there is a link between the satellite waivers and Democratic campaign contributions from Loral Chairman Bernard Schwartz and reported donations to the party from a Chinese military official.

Greater appreciation for your satellite dish.

Imagine the army coming to your house and ripping your satellite dish off its mounting and hauling off with it. They then go through your house and trash your television set and even your VCR. To top it off they grab all the cassettes in your car and litter the streets with streamers from your gutted tapes. Impossible? Not if you live in Kabul, Afghanistan.

The religious army has stepped up its campaign to rid Afghanistan of influences it considers contrary to Islam, adding television sets, videocassette recorders and satellite dishes to the cassettes already outlawed.

Afghans were given 15 days to get rid of some of the last bits of entertainment left to them since the Taliban army took over Kabul in 1996 and consolidated its authority over the majority of the country. The Taliban says its latest ban will give people more time to pray. "They should spend their time going to the mosque and learning about prayer," said Haji Mullah Qalamuddin, a Taliban government official. "We want to reform society and make it 100 percent Islamic," he said.

There was no television just before the Taliban takeover, but that was because there was no electricity–a four-year civil war between the government and opposing Islamic groups had destroyed power lines and hydroelectric stations.

"Televisions and these dishes are corrupting the morals of the young people in Kabul," Qala-muddin said. Most people say they won't destroy their television sets. They will hide them and dismantle their satellite dishes.

One resident, Abdullah Jan, bought a dish just to watch the World Cup soccer competition in France. "When it's finished I will pack everything away and just keep it hidden," he said. "Maybe things will change again, and we will be able to use it. Who knows?"

Convergence is the word

In the broadcasting world the buzzword is "convergence." This refers to the blurring line between the message and the delivery system. Most consumers don't care how the program is delivered, be it via over the air TV, satellite, cable or even their computer. I remember dealing with a syndication customer that said he didn't care if we had a hamster running our generator...all he wanted was a clear picture on the other end.

Table one shows that a lot of consumers agree with this observation. With the proliferation of program sources the networks shares have eroded. In this writer's opinion, it does not necessarily reflect less total viewers, but that the pie is just getting cut into smaller pieces. A perfect example of this is the recently announced planned merger of AT&T and cable giant TCI.

TABLE ONE

June 1998	June 1978
NBC 6.8 rating/16 share	12.9 rating/24 share
CBS 6.7 rating/16 share	15.3 rating/28 share
ABC 6.5 rating/15 share	13.1 rating/24 share

"Importantly, this merger will enable consumers to make phone calls over cable, thereby promising an alternative to the Bell monopolies in areas TCI reaches," AT&T Corp. Chairman C. Michael Armstrong said.

After upgrading TCI's owned and affiliated cable TV systems, which reach about one-third of the country's homes, AT&T plans to offer residential customers one-stop shopping for local, long-distance, cable TV, Internet and data services.

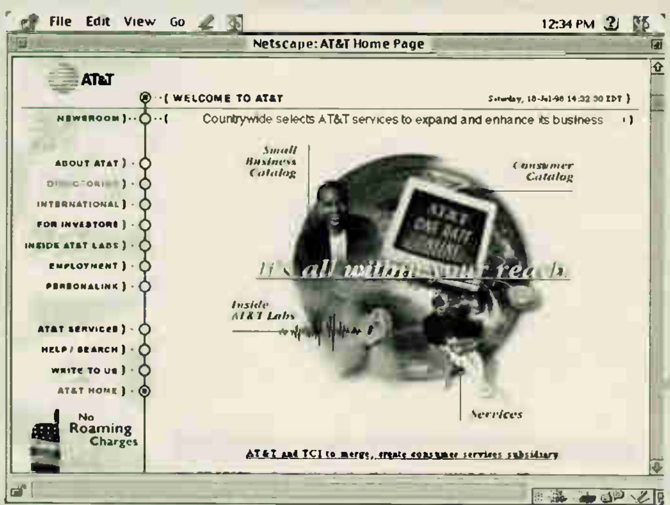
TCI is spending $1.8 billion to upgrade its equipment for two-way transmission by 2000. "It is to this upgraded cable base that we will add the capability for telephone services at an estimated cost per household of $300-$500," Armstrong said.

Gene Kimmelman, co-director of the Consumers Union's Washington office, worries that AT&T may jack up cable TV rates–already outpacing inflation–to pay for this investment. The deal requires approval by the FCC and either the Justice Department or the Federal Trade Commission.

Digital is nearly here

In July, KRON-TV, Channel 4 (San Francisco) presented a digital television (DTV) demonstration for the public enabling thousands of people in locations throughout the Bay Area to watch digital television for the first time on high-definition (HDTV) television sets, in the 1080-interlace format. KRON worked with HD Vision, a DTV mobile production company based in Irving, Texas, to produce the event on-site. The live closed-circuit satellite feed was provided by Global Broadcasting Company.

If you would like to get more information about digital television stop by their website at **http://www.kron.com/nc4/**



Recently Announced -- planned merger of AT&T and cable giant TCI

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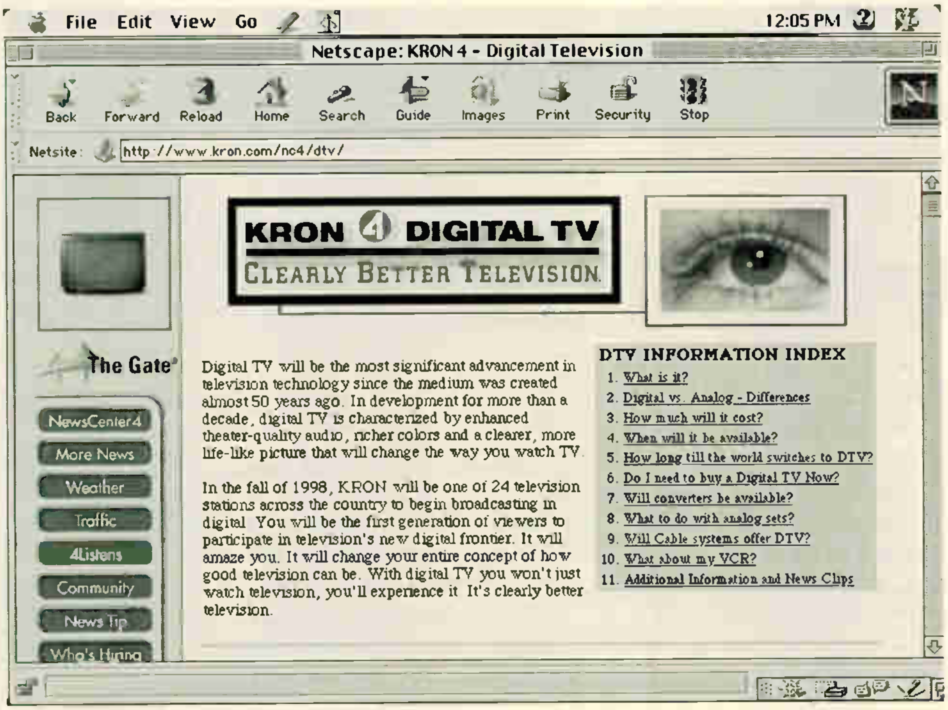


dtv/. For those without Internet access that would like to receive a free brochure with information on digital television, send a self-addressed stamped envelope to: "KRON's Digital Television Q&A," P.O. Box 3412, San Francisco, CA 94119. KRON is one of 24 television stations in the country to begin broadcasting digital television in the fall of 1998.

Programming Notes

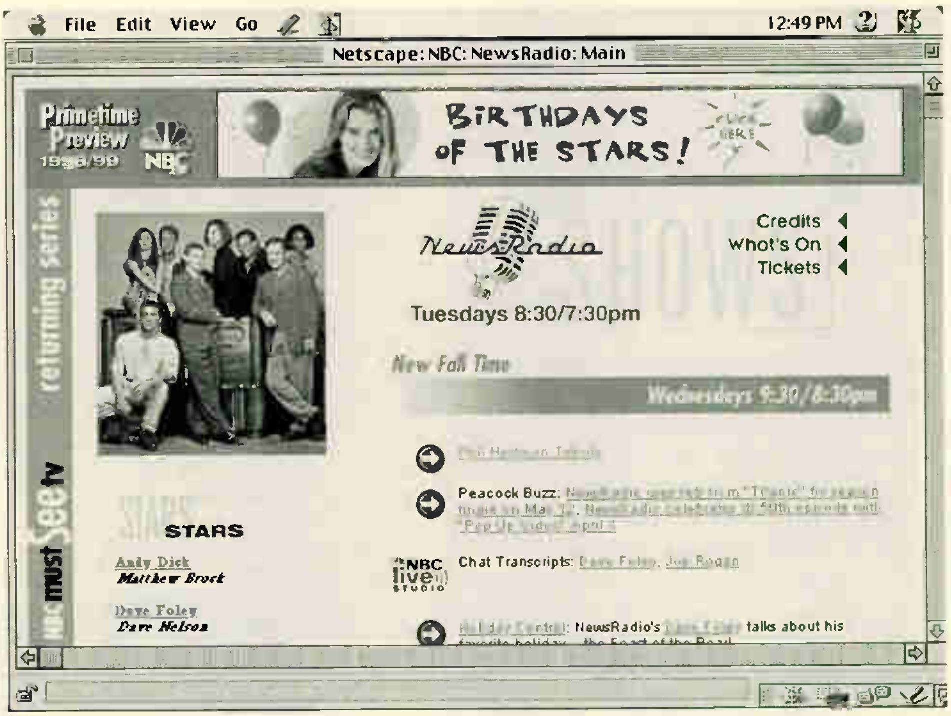
Former *Saturday Night Live* cast member and close friend of Phil Hartman, Jon Lovitz has been asked to join the cast of *NewsRadio*. Lovitz will fill the void left by Hartman's death. *NewsRadio* producers have not determined how Hartman's character will be written out of the show. In light of Hartman's death, *NewsRadio* syndicator Columbia has decided to put the show into syndication starting this fall. Be watching for this show to be on the bird five days a week. As of press time there was no news on which satellite and transponder.

Former child star Ricky Schroeder, known for his roles in *The Champ* and television's *Silver Spoons*, will soon be known as the newest detective on the scene at ABC's *NYPD Blue*. A spokeswoman for the Stephen Bochco-produced series confirmed Friday that Schroeder will be filling the void left by Jimmy Smits, who will leave the show in the first few episodes of the new fall season.

A 78-page script for the infamous Seinfeld episode, *The Contest*, signed by all four cast members, fetched $23,000 at a New York auction of entertainment memorabilia. Christie's pre-sale estimate had been $1,500 to $2000. At the same auction, a 22-foot-long working ship model from a 1953 *Titanic* film expected to bring $12,000 to $15,000, was sold for $6,000.

Sources for this story include friends and neighbors in the business as well as Associated Press, *Los Angeles Times* and the *New York Daily News*.

Doug Jessop has been in the broadcasting industry since 1979 and was the original creator of the North American Satellite Guide. Comments are always welcome at http://www.searcher.com/STcomments.html



By George Wood
wood@rs.sr.se

The Mediamaster

Here in Europe, digital satellite television has finally come of age. For anyone buying a new TVRO set-up today, it would make sense to just buy a digital receiver and forget analog. The prices are comparable, interfacing the two systems can be very tricky, and there's virtually nothing available on analog that isn't on digital as well.

Actually, I can't think of any European satellite television in analog that isn't also in digital, with the exception of some news feeds. But even they are switching. The big difference is radio, as there is still a wider variety available in analog, even if digital does offer the alternative of 30 or more themed Music Choice Europe music channels. If you want to listen to BBC Radio 5, the 24 hour news and sports channel, outside of AM broadcast band distance from Britain, the analog UK Gold transponder on Astra is the only way to do it. (Well, you can listen over the Internet too, but that's another subject.)

This wasn't true just a few months ago when, tuning into digital wasn't really a viable proposition. But the last year has seen the launch of new satellites for Astra, Eutelsat, Sirius, and Thor, all intended for digital operation. Program providers from Spain to Scandinavia, and Britain to Poland, have started digital packages. And there is now a plentiful supply of receivers available for viewing.

I've written before about the appearance of the first digital satellite receivers at London's Cable and Satellite Show in 1996. At the time there were only a few channels available for viewing, and the receivers were definitely first generation. Either they could only pick up free-to-air channels with no provision for subscription smartcards or they were dedicated receivers for a single subscription service, and useless if you took them to a different country or just wanted to switch service providers where you were.

Things are different now. The second generation of European digital satellite receivers not only can receive all the free-to-air channels, they also have a slot for what is called a Conditional Access Module. This is about the size of a computer PCMCIA card, with a slot in the module for a subscription smart card.

The biggest problem with digital satellite TVRO in Europe is the plethora of encryption systems being used. Somewhere I've read that broadcasters once agreed upon a system called Viaccess as the pan-European standard. This is the MPEG-2 version of the Eurocrypt-M standard used for D2-MAC transmissions. D2-MAC has only been used to any great extent by Sweden and Norway, and for reasons which escape me, Norway's Telenor went on to develop its own variation of the encryption system called Eurocrypt-S. This in turn, has been brought into the digital world as Telenor's Conax.

At this year's Cable and Satellite Show I asked the Managing Director of Telenor Conax, Oystein Larsen, why they had gone their own way and thwarted the would-be standard. His reasoning was "Viaccess is France Telecom's system, Conax is ours. We want to make money too."

That doesn't really seem to be a good basis for not keeping standards, but Telenor has not been alone. Before Nethold was bought out by Canal Plus it had its own system called Irdeto, which is still being used in some countries by various Canal Plus systems. Some German broadcasters use Cryptoworks, while those in a number of other countries use Mediaguard or Seca.

The worst problem has been in countries where there have been rival digital broadcasters, the best examples being France and Spain. In both cases the competitors used different CA systems, and it has taken both national and European Union regulation to force the parties into a kind of simulcasting called simulcrypt, which means broadcasting in both encryption system, so subscribers would only have to buy one CA-module, and would be able to switch between them or subscribe to both at will.

While there were a number of manufacturers displaying their new digital receivers at the Cable and Satellite Show, the most prominent was the Finnish company Nokia. This wasn't surprising, since Nokia was one of early pioneers with digital receivers. Their second generation for the European market is the Mediamaster 9600 series.

Nokia very kindly lent me a 9602 S model to test. I soon discovered that you tire rather quickly of the meager free-to-air offerings (unless you speak German), so Canal Plus, which is just starting to market its Canal Digital package to Scandinavia, very kindly loaned me a Conax CA-module and Canal Digital smartcard for the duration of the test.

Satellite is just one way of transmitting digital signals, of course. There are already tests of Digital Terrestrial Television in Britain and Sweden, but regular broadcasts and set-top boxes won't be available until the new year. Digital cable is virtually unknown in much of Europe, but Sweden's largest cable operator, Telia, has been marketing its digital system since January. I already have a Telia digital decoder (from Macab) and I will be comparing the satellite system with its cable counterpart.

Obviously this comparison will also have a Scandinavian bias, as these are the systems I am comparing. In cable the region is far ahead of the rest of Europe, while in satellite it is a little behind. Otherwise, I think my experience is pretty typical of what is happening with digital television in Europe right now.

Satellite vs Cable

The digital satellite and cable boxes are very similar in appearance and size, just a bit smaller than a modern European analog satellite receiver, perhaps half as large as a VCR. There aren't a lot of controls on the front of either, in both cases just a display, an on-off button, and channel up-down buttons.

Serious usage requires the remote, and once again those for the two boxes are extremely similar. Besides the obvious buttons for on-off, volume, channel up-down, and numbers 1 to 0, both have buttons for menus, program guides, and in the middle virtually identical circles broken into four parts for up down left and right, each with a big OK button in the center. Both also have "info" buttons for information about the channel tuned in, and "radio" buttons for switching to audio channels.

The Nokia remote has a "text" button for toggling between subtitles and teletext, the European system of screen "pages" of text information transmitted over the air in the lines in the intervals at the top and bottom of TV screens, which is sort of like proto-Web surfing. The Telia/Macab unit lacks this feature, but it does have four buttons labeled A to D on the bottom for expansion purposes, and since teletext is promised for the service this fall, one of those buttons may be the text button after all. (Most TV sets in Europe are now teletext-equipped, so you always use the set remote to access teletext anyway.)

All these features are extremely important because surfing your way through hundreds of digital channels is a lot harder than accessing even a couple of dozen regular cable or satellite channels. There are really far too many to keep track of, even if you're just looking at one service on one satellite.

But first things first. Before you can go channel surfing, you have to take the box out of the carton and plug it in. Since these devices are mostly computers and the basic rule of the computer world is "nothing ever works the first time," how hard is it to get connected?

The answer is not too bad, but the cable box was a lot easier. All I had to do was plug it into the electric outlet, plug the existing cable cord in, turn it on, and glance at a few menus that came up. The store had indicated a few parameters I would have to choose, but in virtually every case they were already the default. The box then asked me, via the TV screen, if I wanted to upgrade to the latest software, I hit the OK button, and it spent a few minutes downloading, presumably finding the latest channel additions since the box left the factory. After that it was set to go.

(There was a new upgrade when Europe switched to Daylight Savings Time in March. One interesting side-effect then that for about a day afterwards all the encoded channels were in the clear.)

The Nokia receiver would have been almost as easy, if it hadn't been virtually impossible to download any channels, at least in the beginning. The difficulty seems to be interfacing analog and digital systems. This problem can be considerable. More than a year ago, when digital receivers were first appearing on the market, the satellite hardware expert at the Swedish consumer electronics magazine *Elektronikvaerlden*, Lars-Ingemar Lundstrom, wrote a fascinating article describing a method to hook analog and digital receivers together, especially for multi-satellite motorized systems.

All European TVs, VCRs, satellite receivers, and cable decoders use the same SCART cables to interconnect. Lars-Ingemar suggested that the digital receiver be plugged into a spare decoder SCART outlet on the analog receiver. At each satellite position, one channel would be set aside for the digital receiver, with the set-up menu programmed to force it to use the decoder input. So all you'd have to do was switch to that channel, and browse through the channels on the digital receiver.

You might have to use some kind of splitter for the signal from the dish, but basically it was a great approach. But when receivers actually started being sold they didn't quite interface that way. The bottom line–it doesn't work.

The proper way to hook up an analog and a digital receiver, as described in the Nokia Owner's Manual, is to go through something called a Smart priority switch, which acts as a splitter in the cable from the dish, and connects to both receiver LNB inputs. According to Nokia, this gives the analog receiver priority over the Mediamaster, which is only activated if the analog receiver is in standby or unplugged. Unfortunately, Smart priority switches are not yet found on every consumer electronics store shelf, and Nokia neglected to include one.

I did try to add an ordinary splitter, but that was less than successful. The signal loss in the splitter meant that some channels dropped below the threshold for reception. More seriously was the utter confusion in controlling the antenna's horizontal and vertical polarization. After checking out the digital channels, the polarization was stuck when switching back to the analog. (So the Smart switch sounds like a pretty useful device.)

What I've had to do was trick the Mediamaster into thinking I have a whole series of fixed antennas, one for each satellite. For the purposes of this test, I choose an analog channel on each of the satellites with digital signals. Turning the analog receiver off, I plugged the antenna cable into the Mediamaster (which meant a lot of switching back and forth in the long run). Then it was time to wade through the menus and download the channels on that particular satellite.

One thing that drives me crazy about the Mediamaster is that the menus are so very slow in responding. Slowness is the biggest drawback in the Telia system. It seems to take forever to switch between the various services. Generally the Mediamaster is faster, except when going through the menus.

A Loaded Question

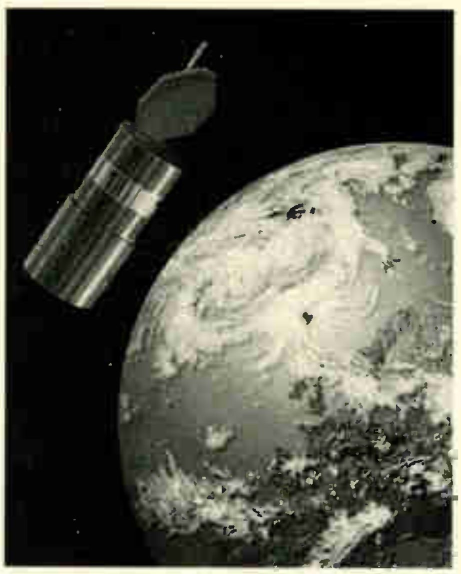
The biggest difference between the two systems is that the cable box came programmed for all its channels, and is easily updated over the cable (all you do is push the "OK" button and it happens). The satellite receiver memory was empty, you have to download all the channels into it from the different satellites.

First you have to choose the antenna installation menu. Then you choose your satellite. Every time I tried to tell it I had a multi-satellite system the attempt failed, so each time I had to claim I was looking at the one and only satellite for me ... Thor, Sirius, Eutelsat's Hot Bird, and Astra are all listed in the menu, along with "Other 1" and "Other 2". I'm not sure that the preprogramming actually made any different in finding the channels, however. I had to try to download repeatedly for each satellite.

Sometimes, as in the case of Thor, all the channels downloaded right away, once I worked out the system. In other cases I had to look up an active digital transponder in a transponder table, and key in the SR rate and FEC parameters before the download would work. In the case of Hot Bird, some transponders that I know carry digital signals never downloaded. Another transponder just downloaded itself but nothing else. Then when I tried to download a third transponder, the box proceeded to download its channels, plus those on four other transponders.

Thor, Sirius, Hot Bird, and Astra at 19 degrees East are certainly the most important TV satellite systems in Europe. But Astra has started a second position at 28 degrees East for digital services to Britain; Rupert Murdoch's British Sky Broadcasting, TCI's British subsidiary Flextech, and the BBC have all been testing there, in preparation for the big launch of Sky Digital this fall. Fortunately Sky maintains a test pattern on an analog PAL transponder on Astra 1D satellite there, so it's easy to find the location. The first time I tried to download channels, both Sky and BBC channels appeared, but except for a few Sky test signals, all were encoded. The second time I tried a download, the BBC channels were missing.

This underlines a major difference between the Mediamaster and ordinary analog satellite receivers. This is no DX machine for transponder hunters, and once channels are programmed, you can't work out the transponder frequency or anything else about them. They are there, and either you can watch then (if they are in the clear or you have the right smartcard and CA-module) or you can't. But you can't work out where they are. This must be possible on some digital receivers, because I see contributors to the *SATCO DX Guide*, for example, listing very precise information for the channels they have uncovered. It might be possible with the Mediamaster, but I haven't worked out how.



For the ordinary user, however, this simplicity is probably a plus. The Mediamaster also scores over the Telia cable approach in that you can edit the channel lists, deleting channels you don't want (or can't watch) and moving them around to whatever order you want.

The only problem I've encountered in this regard is when you have channels from different satellites. Some satellites may have a couple of hundred services or more, but there's no obvious way to see where the channels from one end and where those on the next begin, especially when the same channels are on many satellites as part of different packages. Since you can edit the names of the channels in the menu, I suppose one approach would be to work out the first channel from each satellite, and rename it accordingly.

The Telia box is both easier and more frustrating. Obviously there are no satellites to choose between; everything is there. But all the channels are in alphabetic order, and there is no way to change the order, or even remove or skip the ones you don't subscribe to.

Other Features

Both boxes allow you to choose the languages for menus and such. But the satellite system also lets you choose between the languages used by channels, when there is a choice. For example, on the Telia box the Nordic Cartoon Network is in Swedish no matter what you want, and there's no way to change it. The Mediamaster lets you choose the English soundtrack of that same channel if you want.

A strange incongruity is the digital clock that displays when either unit is turned off (like VCRs), and which is often displayed in the screen with the Mediamaster as well. The Telia box, which takes its signal from the cable, is usually every accurate. Sometimes it will be way off for a day or more, usually after an upgrade, and there's no way to change it.

On the other hand, the Mediamaster clock is programmable to the closest half hour, but it insists on setting its own minutes, and these are invariably a couple of minutes off from the cable box (it doesn't take that long to get a signal up to the Clarke Belt and back).

The outstanding feature of both, and a major requirement of any system with hundreds of channels, is the Electronic Program Guide. In both cases, you get a table with all the programs at the moment and for the next few hours. The Telia guide gives you the opportunity to filter out the channels you don't subscribe to, but this installation disappears every time you turn the box off, and you have to go through the tedious reprogramming process again every time or just never turn the thing off. Telia's guide also allows you to click on a particular channel to see its schedule, or to click on a particular show to get a guide with just programs with that format. You can also go backwards or forwards several days.

The Mediamaster guide has much faster access than Telia's. In both cases, clicking on a program will tune to it immediately. But the Mediamaster guide doesn't extend backwards, although it does go several days forward. The biggest problem I've encountered with the Mediamaster guide is that it only includes the programs in Canal Digital's package. This may be because I plugged in their CA-module, but it certainly restricts the use of what otherwise is an extremely helpful feature. Of course, the guide is only as good as the information downloaded from the satellite channels. For example, when NBC Europe turned into the National Geographic Channel, a transponder labelled NBC continued for some time afterwards, carrying NBC programming. First the guide information was wrong then a few days later the information disappeared completely.

What's to See?

So what's available for viewing on Europe's digital services? Many of the channels are often the same, with local variations for each country. Despite the European Union's Maastrict Agreement guaranteeing access to services anywhere within the EU, there are as yet no pan-European satellite programming providers, except for the free-to-air channels. Generally these are public service broadcasters, such as the German ARD and ZDF, Austria's ORF, and Norway's NRK. Almost everything else is coded, with the notable exception of the Turner Broadcasting channels, which have been in the clear in analog from the beginning and are now uncoded as well in the digital realm. CNN International, TNT, and Cartoon Network are available on a number of satellites, such as Astra and Thor.

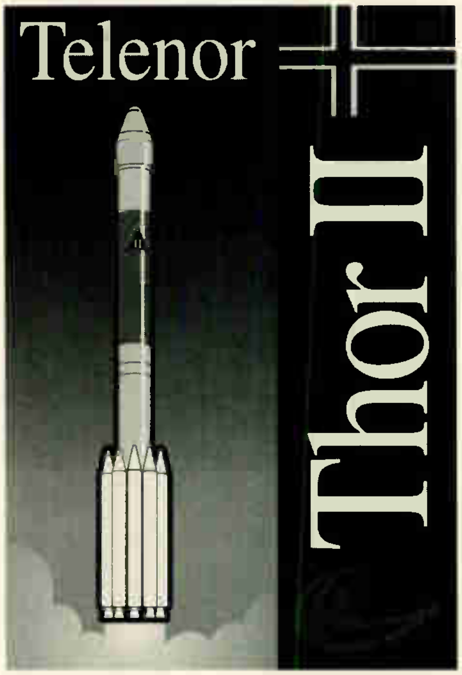
Generally each region has a primary digital satellite operator. In some cases there is competition, usually from a public service broadcaster fighting back against a much more powerful commercial rival. Canal Plus is everywhere, especially after taking over Nethold's networks. In its home base in France, its Canal Satellite is the leader, with its transponders on Astra. But at home Canal Plus faces not just one, but two rivals, TPS (backed by public broadcaster TF1) and the much smaller AB Sat. Both have chosen instead Eutelsat's Hot Bird.

In Spain, Canal Plus is behind Canal Satelit, and for some reason has split its transponders between Astra (with Mediaguard encryption) and Spain's direct broadcast satellites Hispasat at 30 degrees West (using Seca). It faces powerful competition from Via Digital, which is supported by Spain's public service broadcaster, with at least 47 channels on 10 Hispasat transponders.

Canal Plus has maintained its monopoly in the Netherlands, with 16 channels on three transponders (all using Irdeto encryption inherited from the Nethold days).

The situation in Germany is more confusing. Maverick media mogul Leo Kirch spent a fortune acquiring film rights for his DF-1 digital package on Astra (which also used Irdeto). But when the European Commission vetoed DF-1's merger with rival Bertelsmann's Premiere (in which Kirch and Canal Plus both also hold interests), Kirch pulled the plug on DF-1, which has gone off the air and is being replaced by Premiere, which until recently only broadcast in analog mode.

In Italy, Canal Plus took over Telepiu from Nethold and Kirch and has enjoyed a virtual monopoly for the service, renamed Tele Plus. It has at least 30 channels on eight Hot Bird transponders, all still using Irdeto, but with the most important simulcrypting in Seca. Public broadcaster RAI has 9 channels which have been broadcasting in the clear on a single Hot Bird transponder. However, RAI is joining up with Canal Plus' French rival TF1 to expand the service, which is encrypting.



Canal Plus also inherited Nethold's service to Greece, Multichoice Hellas, which has a single transponder on Astra, also using Irdeto. There is a second Greek package in Irdeto on Hot Bird, including channels from public broadcaster ERT.

After a failed attempt at a merger, there are two Polish digital platforms. Canal Plus Polska is launching its digital service in September. It will be relying on its strong analog base to take on direct-to-

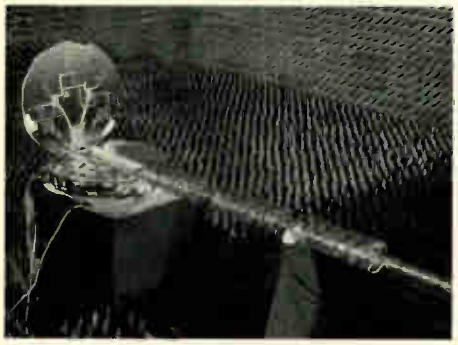
Continued on page 73

By Dan Veeneman

Non-Voice, Non Geo Satellite Services

Personal communications satellites come in a variety of sizes and capabilities. Low earth orbiting constellations that offer voice services are termed Big LEOs and include such heavyweights as Iridium and Globalstar. These large, relatively complex and expensive satellites are designed to provide continuous audio connections for mobile and fixed site callers on a global basis. However, many communications applications don't require voice service. Remote monitoring, tracking, and even some two-way communication can be done more efficiently and less expensively using the so-called Little LEOs.

Officially termed non-voice, non-geosynchronous mobile satellite services (NVNG MSS) by the Federal Communications Commission (FCC), these systems are designed to provide a low-cost alternative when sending small amounts of data will do just as well as placing a phone call.



Licensing

A company called Orbcomm got the ball rolling in 1990 when they filed an application with the FCC to provide a data messaging service via low earth orbiting satellites. Two other organizations filed applications afterward, one by Starsys Global Positioning and another by Volunteers in Technical Assistance (VITA). With the FCC's blessing these three applicants got together and agreed on a plan to share the radio spectrum set aside for these types of systems, which subsequently became the basis for the FCC's rules on little LEO operation. The FCC refers to this early process as the "first processing round."

Orbcomm was issued the first little LEO license in October of 1994 for a constellation of 36 satellites operating in four inclined and two polar orbital planes. Starsys received a license in July, 1995, and VITA in November of 1995.

A second processing round began when the FCC received another application, this one from Leo One USA Corporation, and put it out for public comment. This elicited even more applications, including modification requests from existing license holders. In all, eight applications were part of the second processing round–Orbcomm, VITA, Leo One, Final Analysis, E-Sat, CTA, GE Americom, and Starsys.

This created a real problem for the FCC, since there now wasn't enough spectrum to satisfy everyone. At the time, three blocks of VHF and UHF spectrum were allocated for NVNG. The 137 to 138 MHz and the 400.15 to 401 MHz slots were designated space-to-earth (downlink), to be used by satellite transmitters to communicate with ground stations and subscribers. The 148 MHz to 150.05 MHz band was designated earth-to-space (uplink), set aside for transmissions from subscribers and ground stations up to the satellites. In addition, existing and planned satellites from the National Oceanic and Atmospheric Administration (NOAA), the Department of Defense, and other countries including France and Russia were also making use of those frequencies.

While the FCC was figuring out how to share the radio bands, the pile of applicants got smaller. Orbital Sciences Corporation, part owner of Orbcomm, bought the satellite operations of CTA and withdrew their application. GE Americom and Starsys gave up and also withdrew their applications. In September 1997, the five remaining companies got together and submitted a mutually acceptable spectrum sharing plan to the FCC. Licenses followed in early 1998.

Presently, five little LEO systems are licensed in the United States: Orbcomm, VITA, E-Sat, Final Analysis, and LEO One USA. Orbcomm is currently the only system offering commercial service.

Orbcomm

Orbcomm is jointly owned by Orbital Sciences Corporation (OSC) and Teleglobe, Inc. (based in Canada). They plan to have a "basic" constellation of 28 satellites operating by mid-1998 and a 36-satellite "enhanced" constellation in orbit by the latter part of 1999. In March of this year they received FCC authorization for an additional 12 satellites, bringing their full constellation total to 48. The four dozen satellites will be placed in six orbital planes, each containing eight satellites. Four of these planes will operate at an altitude of 825 kilometers, and the other two at about 775 kilometers. So far, two planes of two each and one plane of eight have been launched.

The complete system is expected to cost more than $332 million, of which $242 million has been spent as of December 1997. Each satellite has an estimated cost of $3 million.

Launches

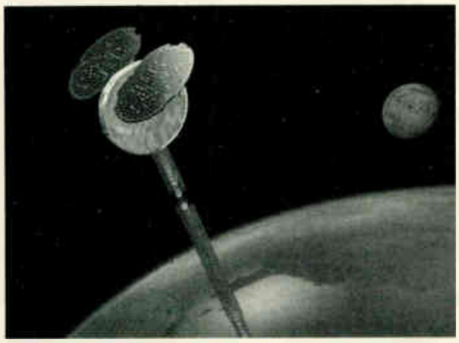
Orbcomm makes use of a somewhat unique launch vehicle built and operated by OSC. Satellites are bundled together on the front of a Pegasus XL rocket and strapped to the underside of a Lockheed L-1011 aircraft. Orbital has conducted about 20 such missions, with about a 90 percent success rate.

A demonstration and test satellite was launched in 1991. On April 3, 1995, Orbcomm Flight Models 1 and 2 were air launched from an OSC Pegasus rocket. Each weighed 104 pounds and were placed in 740 kilometer orbits, circling the earth every 100 minutes. Despite various problems and outages, Orbcomm began limited commercial service on February 1, 1996. Coverage was intermittent with these two satellites, as there was only a 10 to 15 minute "window" of visibility half a dozen times a day when a satellite was overhead.

After a long hiatus and some design changes, eight more satellites were launched on December 23, 1997. Taking off from NASA's Wallops Island Flight Facility in Virginia, the L-1011 climbed to 39,000 feet and about 60 miles off the coast launched the Pegasus XL rocket. The eight satellites were boosted to an altitude of about 820 kilometers, where they orbit the earth in just over 101 minutes.

On February 10, 1998, two more satellites hitched a ride aboard a Taurus rocket launched from Vandenberg Air Force Base, California. These two went into a slightly elliptical orbit, 876 km by 762 km, with an orbital period of 108 minutes.

Although these launches were successful,



the satellites themselves have been experiencing technical difficulties. Some satellites are generating lower than expected electrical power due to a pointing problem with the solar panels. Two satellites suffered an "anomaly" in their subscriber transmitters that effectively prevents them from sending data to subscribers. Orbcomm believes they have identified the sources of these problems and hopes to correct them on future satellites.

By the time you read this, eight more Orbcomm satellites may be in orbit, having been launched in mid-July aboard a Pegasus rocket from Wallops Island.

Satellites

Orbcomm satellites are based on the Orbital Sciences MicroStar platform, a ninety pound disc that looks like a big movie film canister. After launch two solar panels deploy from each side of the 2.3 meter disc, generating up to 160 watts of electrical power. A 2.6 meter long telescopic boom wrapped with helical antenna elements extends toward earth, providing support for the uplink, downlink, and beacon telemetry.

Each satellite contains at least three transmitters–a VHF subscriber link unit sending messages down to customers, a VHF feederlink unit sending messages to Orbcomm ground stations, and a UHF beacon transmitter sending information for ranging. Subscriber downlinking occurs at 4800 bits per second (bps) in the 137 to 138 MHz band. The feederlink operates at 57,600 bps and is on the same frequency for all satellites. The Orbcomm TDMA protocol will allow more than one gateway to communicate with a satellite at the same time.

Table 1: Orbcomm licensed downlink frequency blocks.

Lower Limit (MHz)	Upper Limit (MHz)	Type
137.1750	137.3275	Subscriber
137.4225	137.4725	Subscriber
137.5350	137.5850	Feederlink
137.6500	137.7500	Subscriber
137.7875	137.8125	Subscriber

The 50 kHz-wide beacon operates on a center frequency of 400.1 MHz and is used by the subscriber equipment for Doppler-based position location and tracking.

Six subscriber receivers on board the satellite listen for messages from customers, which are uplinked at 2400 bps between 148 MHz and 149.9 MHz. Another receiver is assigned to an Orbcomm-developed Dynamic Channel Activity Assignment System (DCAAS), which scans the uplink frequencies every five seconds and assigns channels to minimize the possibility of interference with terrestrial VHF systems.

Two additional VHF receivers listen for feederlink information from ground stations.

Table 2: Orbcomm licensed uplink frequency blocks.

Lower Limit (MHz)	Upper Limit (MHz)	Type
148.000	148.250	Subscriber
148.750	148.885	Subscriber
148.905	149.585	Subscriber
149.585	149.635	Feederlink
149.635	149.90	Subscriber

Each satellite uses an on-board GPS receiver to ascertain its exact orbital position. Location and timing information is also downlinked to subscriber units. Thrusters using pressurized nitrogen gas allow the satellites to maneuver in orbit.

Ground segment

The Orbcomm ground segment consists of a network control center in Dulles, Virginia, connected to a number of gateway earth stations in the United States and abroad. Continental U.S. coverage is provided through four gateway earth stations operate in Arizona, New York, Washington State, and Georgia. Additional gateways in operation or under construction are located in Italy, South Korea, and Japan.

Message processing

Orbcomm satellites are basically orbiting packet routers and are designed to handle up to 50,000 messages per hour. Text messages are passed between subscriber units and gateway earth stations using the satellite's onboard receivers, transmitters, and data storage devices.

The user composes a short text message and transmits it from the subscriber unit to the satellite. If an Orbcomm satellite is in view of both the subscriber unit and a gateway earth station, a message of up to 2,000 characters can be immediately delivered. If the satellite can only "see" the subscriber, a message of up to 229 characters will be stored on board the satellite and downlinked when it moves within range of a gateway earth station. After downlinking, the message is forwarded to a gateway control center where it is processed as an electronic mail message and sent out via the Internet or other means to its destination.

Messages waiting for a subscriber are stored on the ground until the customer sends a "message check" transmission, at which point a gateway earth station uplinks them to a satellite for delivery.

Subscriber equipment

Low earth orbit systems make use of small, low power subscriber "communicators." Typically operating between 2 and 6 watts, FCC regulations limit these units to a very low duty cycle and prohibit transmissions longer than 450 milliseconds. Manufacturers building subscriber equipment for Orbcomm include Magellan (owned by OSC), Scientific Atlanta, Panasonic, and Torrey Sciences.

Self-contained transceivers for remote monitoring and unattended operation were first to arrive on the scene, although a consumer-level unit should be available soon.

The Magellan GSC 100, a handheld two-way subscriber unit, sends and receives "GlobalGrams"–short text messages that use the X.400 addressing standard. About the size of a large paperback book, it has an alphanumeric keypad and a liquid crystal display in a two pound package. A telescoping whip antenna provides the VHF and UHF link for the data transceiver. The unit also contains a GPS receiver, allowing the user to know and to transmit, his location to an accuracy of better than 100 meters. Retail price is around $1,000, with an average usage cost advertised as about a penny per character.

Marketing

Orbcomm is pursing three broad market areas primarily through the use of value added resellers (VARs). The first market is fixed asset monitoring services for such things as electric meters, oil and gas storage tanks, wells and pipelines, and environmental projects. Mobile asset tracking is the second area, which includes commercial vehicles, trailers, containers, rail cars, and other movable things of value. For instance, heavy equipment manufacturer Caterpillar has been involved in testing Orbcomm terminals on their vehicles. Messaging services for consumers and commercial and government organizations round out the targeted markets. Orbcomm believes their head start in providing commercial service will allow them to set standards and lead the migration of data services to low earth orbiting satellites.

That's all for this month. As always, more information is available on my website at **http://www.decode.com**, and I welcome electronic mail at **dan@decode.com**. Until next month, clear skies!

By Ken Reitz, KS4ZR

Digital Video Broadcasting with the PANSAT 100A

The Pansat 100A Signal Guide screen gives you all the data you need to adjust your dish for optimum signal strength.

Satellite broadcasting has changed dramatically in the last four years with the introduction of digital compression technology. This move has allowed more efficient use of transponder space which translates directly into cheaper program transmission costs and a bigger profit margin for the programmer. The problem for many satellite TV enthusiasts is that some of our favorite channels seem to have disappeared. It's not that they don't exist anymore, it's just that we can't find them.

Many years ago, when Ku-band technology was just coming into use, feeds we used to take for granted vanished. In reality they just hopped bands and were now being transmitted on the Ku-band which couldn't be seen with only a C-band feed. Luckily, it was easy enough to install a C/Ku feed and hunt down the missing signals. In just the past several years other channels to which we had become accustomed "went digital." And, just when we thought we'd never see them again, General Instrument (G.I.) introduced their 4DTV receiver and many "missing" digital channels were found.

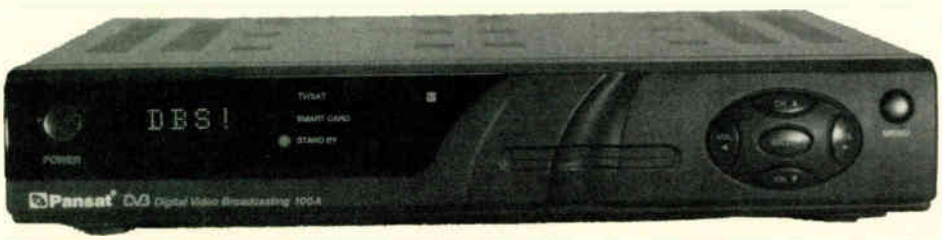
It turns out that G.I.'s DigiCipher format is not the only digital scheme around. Another, which has gained considerable popularity in the industry over the last two years, is known as Digital Video Broadcasting (DVB). Like its G.I. counterpart, DVB is based on the MPEGII video and audio standard and delivers a terrific picture and sound. Unfortunately, that's their only shared similarity. DigiCipher and DVB are incompatible digital systems. Tuning DVB programming requires use of a DVB receiver.

Designing a Receiver

The DVB standard is one widely used in Europe and South America and, as a result, there are quite a few manufacturers of the basic DVB receiver in the world with substantial production runs. However, in order for them to be useful to those of us in the U.S., DVB receivers had to be reconfigured for our market. Voltage input had to be changed from 220 to 110 volts, modulator output had to be changed from the PAL to NTSC standard, and tuning schemes had to match the outputs of our LNBs.

Since European DBS satellites are clustered at virtually one spot in the sky, DVB receivers don't need actuator motor connections, and since most use LNBFs (powered through the coax), polarity switching capability is not needed either. Basically, DVB receivers are stripped down to the essentials of channel tuning. To use them in an American satellite TV environment, they have to be used as a "slave" receiver. This is where the output of the LNB at the dish is split into two feeds and both receivers pick up the signal. An analog receiver is used to send the dish around to where the DVB feeds are found and the DVB receiver is forced to tune whatever satellite the analog receiver has been turned to.

DVB receivers lack the luxuries most American satellite hobbyists have come to expect. They typically feature an infrared remote control, limited front panel controls, bare essential outputs on the rear, and no provision for a future decoder module or "smart card" slot. This may prove crucial in the event that favorite channels decide to encrypt their digital signals. There will simply be no way to subscribe.



The Pansat 100A "Free-To-Air" DVB satellite receiver. One of a new breed of digital receivers available to the TVRO enthusiast. (Courtesy: Panarex Electronics)

Where are the DVB Signals?

Unlike the G.I. DigiCipher format, DVB is rarely used in transmitting cable-TV fare. It is more often found in "niche" programming where programmers of ethnic channels market programming packages to target ethnic groups. A good example of this is with the Chinese programming found on the Ku-band side of Telstar 5. Here more than a dozen video and audio channels are transmitted which are geared to the Chinese population in North America. Most of the video channels are encrypted, but the audio services, which include music, news and chat shows in Chinese, are not. On the same satellite are found channels from Egypt, India, Greece, and Dubai. Some encrypted, some not. There are also a couple of Fox backhaul channels, Bloomberg Business News, and some wild feeds, all in the DVB format.

One of the more interesting channels is World Net, a service of the U.S. Informa-

NHK World Service is found full-time in DVB on Panamsat 5. The earlier analog transmission has been discontinued.

tion Agency. For this particular service USIA produces and retransmits video programming aimed at a predominantly Hispanic audience. The Voice of America (VOA) Express is sent as an audio subcarrier. The USIA is charged with disseminating information about the U.S. throughout the world and one place they transmit is on GE-2 (85° W), the foot print of which covers all of North and Central America as well as the Caribbean. This means that with even the most minimal satellite system, this channel is easily received. Among the programs offered on World Net are *Nightly Business Report, The NewsHour with Jim Lehrer*, a host of PBS and C-SPAN programs as well as USIA produced programming in Spanish.

Canadian programming which went digital last year can be found on Anik E2 (107.3° W) including Newsworld International, The Weather Network, The Outdoor Life Network and several stations in the CTV network. The only programming considered to be typical cable fare is found on Satcom C3 (131° W). Here you'll find east and west feeds of The Family Channel and Fit TV.

The Weather Channel Latin America is found on Panamsat 5 and features Spanish and Portuguese audio channels.

The real fun with DVB is found on Panamsat 5 (58°W) which has more than a dozen full time channels including the Latin American Weather Channel (with audio in Spanish and Portuguese); several feeds from BBC including BBC World (with an audio subcarrier in Japanese); China's CCTV 4 (China's World Service), CCTV 3 and CCTV 9 (both entertainment and variety channels); NHK World Service from Japan (with occasional audio subcarriers in English); and several open feeds for various news and sports backhauls.

If you can crank your dish even further to the east, you'll find other DVB transmissions on Intelsat 806 (40.5°W) and Hispasat at (30° W). Programming on these two satellites is predominately Spanish language and aimed at the South American audience. Hispasat transmits four video channels from Spain and four live radio feeds. Word has it that the video services might become encrypted shortly.

The number of DVB transmissions has increased dramatically in the last year and that increase is expect to continue as broadcasters see DVB as a competitive option to G.I.'s DigiCipher format. The only real unanswered question, and the one most asked, is which channels will continue unencrypted and which will not.

The Pansat 100A

There are at least a half dozen DVB receivers being sold today in the U.S. market. Most have similar if not actually identical features. One reason for this is that they may be manufactured by the same company. Hyundai makes their 100C which is sold by a number of dealers. They also make the Pansat 100A which is sold by Panarex Electronics of Sun Valley, California.

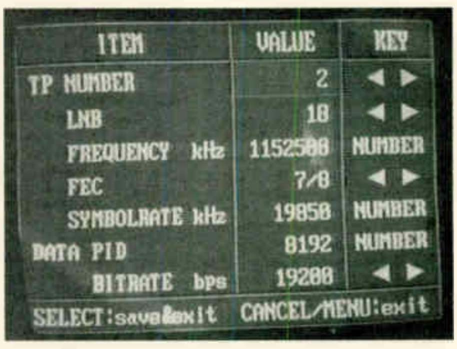
The Pansat 100A is about as straightforward as a satellite receiver can get. It is at once both sophisticated and simple. The simple part is in its outward appearance. Here is a receiver that looks exactly like the little black DBS receivers which have become so popular with the small dish crowd. There are seven buttons on the front panel in that all-too-familiar DBS-style arrangement and a nice little LED screen which has room for four characters which display the transponder number and channel being received. When the set is turned off the display reads: "DBS!"

The infrared remote control, with its 24 rubber buttons, is small, lightweight, well balanced and thoughtfully laid-out. The four main buttons for channel up/down and volume up/down glow in the dark. My only complaint with the remote control is that it lacks a lot of power (I can't bounce the IR signal off the walls or ceiling) and requires a very narrow angle of sight to the infrared receiver.

The sophisticated part of this receiver is in what it will do. Using the remote control you may access a channel directly or you may go up and down as you might a VCR. A detailed description of how MPEGII compressed digital video transmissions are sent will have to be done by someone far more competent than I. To operate a DVB receiver you only need to know a few basics about digital transmissions. Without your needing to know what they are or why you need them, the receiver wants to extract certain information from the data stream pouring into its circuits. It's what determines which channel you're watching and this data is different for each channel.

Once you've entered the proper intermediate frequency (IF), forward error correction (FEC), and symbol rate (SR) into the receiver you may begin watching the channel. This little stumbling block is one of the drawbacks to using some DVB receivers. On some units this information must be painstakingly entered by the consumer for every channel which is available. The Pansat 100A, however, has the data stored on-board in the receiver's memory and may be recalled on-screen by pressing the menu button. Once the data is displayed it

Pressing the "menu" button brings up the reception parameters for any given DVB channel. On the Pansat 100A these are pre-programmed into the receiver. Other receivers may require consumers to enter the numbers themselves.



China's CCTV-9 is just one of four DVB transmissions of these Peking TV stations. Some programs feature English subtitles or have English audio.

may also be changed if necessary. One problem which might come to mind is "Where do I find such information?" Luckily, in the case of the Pansat 100A, Panarex provides an updated sheet with the very latest data all neatly set out. Those without such a convenience are forced to dredge the Internet for the data. One place to look is the SATCO DX website at: **http://www.satcodx.com.**

One very convenient feature on the Pansat 100A is the sophisticated signal strength screen which may be called up at any time when viewing a DVB channel. This screen shows the transponder number; signal sensitivity (in dB); frequency, symbol rate and FEC. It also has a sliding bar graph which registers green when the signal is optimum and red when it's poor. By pressing the actuator left or right controls on your analog receiver you may be able to improve the signal considerably. Of course, unlike analog receivers, the digital receiver is either great or it's gone! You won't see "sparklies" in any of these screens. However, a weak signal will be indicated by the picture dropping out or "freeze framing" or "tiling," things we've all seen before on small dish DBS receivers.

As with analog receivers, you may tune different audio services when they're available. Unlike analog receivers, there are very few choices. There are six selections: the left or right channel of audio one; the left or right channel of audio two; or the stereo signal of audio one or the stereo signal of audio two for a total of six. Few non-related audio services are found on our DVB channels. When digital stereo processed channels are tuned, they usually take up the whole digital channel. In the case of the Chinese radio stations on T5, each station has its own channel.

Some of the other features of the Pansat 100A are a "Play/Pause" button to freeze the screen at any time; the aspect ratio of the output of the receiver can be toggled between 4:3 (standard) and 16:9 (HDTV 35mm film size); and the last channel viewed is stored in the memory of the front panel LED display panel when the set has been turned off and turned back on.

Real Life Operations

As with any new technology there are some things about the Pansat 100A which take some getting used to. One is that it isn't particularly fast. I remember that being a problem with the earlier version of G.I.'s 4DTV as well. It's not that it's painfully slow, it's just that it doesn't respond as quickly as we're used to with analog receivers. My advice? Relax. Wait.

The one thing that occasionally happened to test the limits of my advice was that the unit would lock up on a channel, rendering all buttons useless. To correct this condition the unit had to be shut down and rebooted, a process which itself takes about half a minute.

One interesting aspect about using an MPEGII receiver is that, depending on the satellite, a dish as small as 4.5-feet can be used. This is extraordinary because the

Panamsat's DVB billboard on Panamsat 5, a very active bird with DigiCipherII and DVB transmissions in abundance.

Colorbars for Panamsat 5. There are a number of special event channels which are constantly changing; you never know what will turn up!

bulk of the transmissions are in the C-band. For channels being transmitted in the Ku-band a three foot dish is all that's necessary. Of course, if your location is near the outside of the satellite foot print, a bigger dish will be required. This means that a very simple system comprised of a DVB receiver, a 4.5-foot dish, a 30° LNBF or better and a run of RG/6 coax is all you'd need to set up for viewing the great line-up of channels found on Panamsat 5.

The fun of experimenting with satellite communications is finding the wide range of video and audio programming, the news and sports backhauls, the wild feeds and the dozens of languages and cultures to be seen through this electronic window. It's fascinating, and you don't have to be able to understand the language, to enjoy the similarities Chinese, Indian, Thai, Arabic, Hispanic and European programming have in common. Our news show, games show, our soap operas, even our sitcoms are all alike. It really says something about the human condition.

For more information on the Pansat 100A contact Panarex Electronics at 11672 Tuxford Street, Sun Valley, CA 91352 Telephone 818-768-5161 or FAX 818-768-5191.

The BBC has several feeds in DVB on Panamsat 5 including BBC World, a PAL feed and NTSC feeds for sports and news.

ST FINAL FRONTIER

By Philip Chien

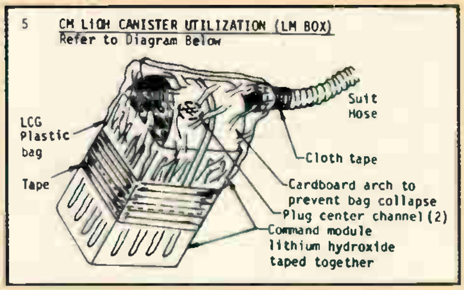
Fixing Things in Space

In a quiet building six engineers share an office. They're creative people who like to tinker with their cars, often mechanics by training. They're the Inflight Maintenance team–IFM in "NASAese."

When things go wrong on the shuttle the IFM team tries to come up with some solution–using equipment aboard the shuttle. The rules are simple–don't do anything which could harm the shuttle or the crew. Sometimes the IFM team will try to correct a problem but it turns out that the fault is in an area which is inaccessible from within the shuttle's crew cabin. In other cases the team will be asked to do a "what-if" exercise in case additional problems occur. But more often than not the IFM team comes up with clever solutions which help contribute to a mission's success. An IFM may be a high priority repair which is needed for the mission to continue safely, it may be a repair which makes the difference between success and failure for a particular payload, or a low priority fix for a minor payload if the crew has enough time.

On each shuttle flight two of the crewmembers are trained in general fix-it skills. They're introduced to the various tools and items in the IFM kit, and typical procedures. The shuttle carries a book of preplanned procedures for possible problems and a standard tool kit on each mission. Practically anything onboard can be used to make repairs. On STS-85 a transparent overlay was used as a makeshift ultraviolet filter. Most of the IFM tools are basically off-the-shelf standard tools with pieces of velcro added to make it easy to place the tools in a convenient place in microgravity. The deadblow hammer has a hollow head filled with lead shot to prevent a recoil in microgravity. With a conventional hammer

STS-75 photo of Scott Horowitz admiring the IFM kit



Apollo 17 contingency procedures flight plan page showing how to build a scrubber. Missions after Apollo 13 included this diagram showing how to construct the scrubber which the astronauts had to assemble on Apollo 13–just in case it was needed again.

an astronaut would fly backwards as the hammer hits a surface. A long handled medical forceps is carried to pull out jams from the shuttle's fax machine. Standard supplies include a roll of duct tape, a roll of aluminum tape, and jumper wires.

An off-the-shelf Fluke 87 multimeter is used for most electrical repairs. The multimeter has transducer accessories which measure pressure and temperature. An electrical breakout box can substitute for a switch panel for diagnostics.

One very obvious item isn't in the shuttle's tool kit–a soldering iron. NASA's strict safety regulations and the closed atmosphere on the shuttle make soldering an unnecessary risk. The only soldering in the shuttle's crew cabin was part of a carefully controlled experiment within an enclosed glovebox. The IFM philosophy is based on using jumpers and bypasses rather than actual repairs. However, cosmonauts on Russian space stations have been using soldering irons for repairs for the past two decades and soldering is planned for the International Space Station.

On the Fly Repairs

I had the opportunity to put together a make-shift wet-vac to dump excess water overboard. I needed a hose, a filter, a nozzle and a set of step-by-step instructions. It was a fairly simple procedure, as long as I followed the instructions. The isolation valves must be switched in the correct order–otherwise waste fluid from the shuttle's toilet could enter the crew cabin, making the rest of my crew incredibly unhappy with me!

The first step is to close the waster water dump isolation valve and turn on a heater to avoid clogs in the lines. I connected the nozzle to the hose, the other end of the hose to a filter, and the filter to the contingency waste water cross tie. Opening up the waste water dump valve connected my contraption to the vacuum outside of the shuttle.

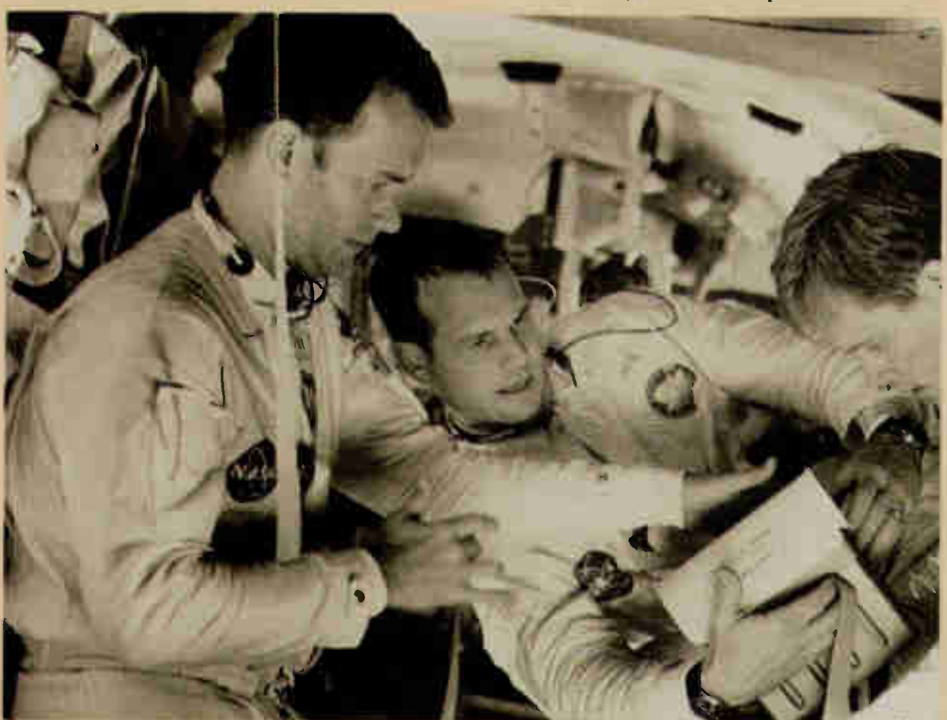
Procedures developed during missions are added to the growing database of IFM tricks, just in case they become useful on future missions.

The most famous IFM was Apollo 13. After the Oxygen tanks failed on the Service Module the Lunar Module had to be used as a lifeboat to keep the three astronauts alive until their return to Earth. The Lunar Module was designed to support two astronauts for four days in space. Engineers on the ground realized that they'd have to come up with an additional system for removing Carbon Dioxide, and the only choice was the lithium hydroxide (LIHO) canisters in the command module.

This Electronic Still Camera (ESC) image shows astronaut Richard A. Searfoss, commander, performing in-flight maintenance (IFM). The Regenerative Carbon Dioxide Removal System (RCRS) shutdown April 24, 1998, setting off an alarm and delaying the crew's sleep period several hours. Searfoss removed a hose clamp and used tape to bypass a check valve that had threatened to cut the flight short. The valve, part of the air-scrubbing systems plumbing that recirculates nitrogen back into the cabin atmosphere, was allowing cabin pressure to leak into the system throwing off its electronics control unit. This ESC view was taken on April 25, 1998 at 17:26:49GMT.

Air is forced through the canisters and the LIHO absorbs CO2. When the canister is saturated it's replaced with a fresh LIHO canister. The problem was how to make a square command module cartridge substitute for the cylindrical shaped Lunar Module cartridges - literally a case of fitting a square peg in a round hole! The two spacecraft were designed independently by different contractors and nobody could have foreseen a situation where the canisters from one spacecraft would be required in the other one.

In the excellent movie *Apollo 13* a group of engineers is shown with table filled with the various items on the two spacecraft but that never happened in real-life. Engineer Ed Smylie was already thinking about how to make an adapter which would tape on to a command module canister and attach to a lunar module hose. The situation is described in detail in the non-fiction book *Lost Moon* by Jim Lovell and Jeff Kluger. The remaining Apollo lunar missions carried the instructions for building the makeshift carbon dioxide scrubber in their procedures, just in case something like it would be needed again.

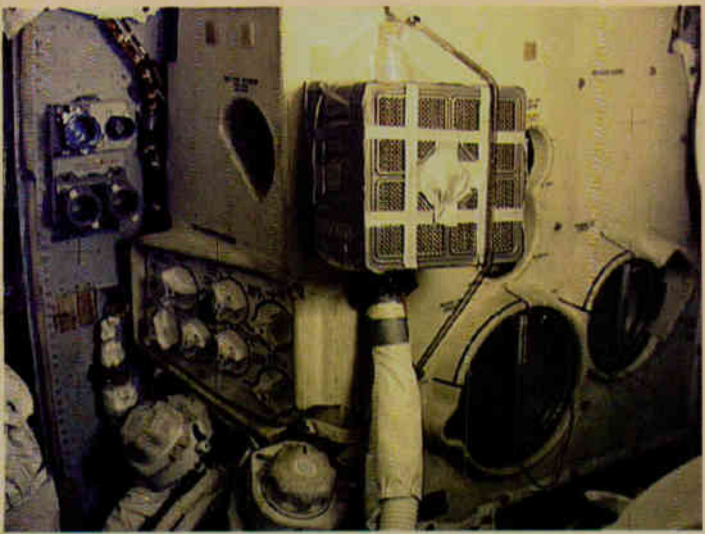
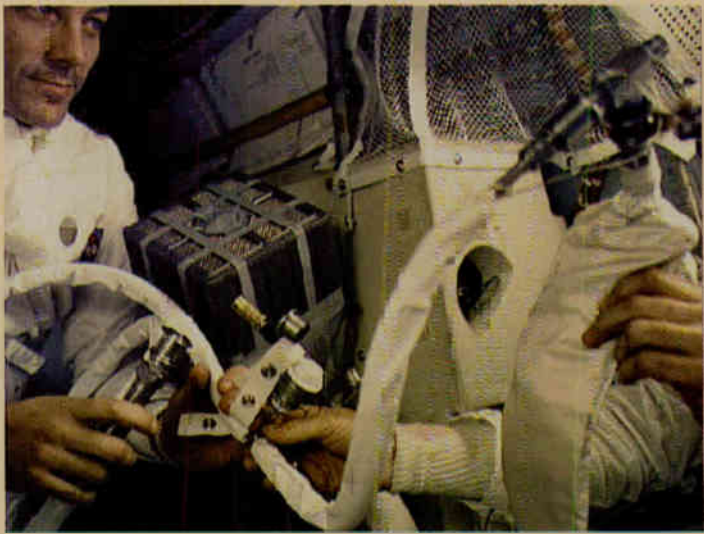


Actors Tom Hanks (Lovell), Bill Paxton (Haise) and Kevin Bacon (Swigert) during the movie Apollo 13. Haise is holding one of the command module carbon dioxide scrubbers which the crew is adapting to work with the lunar module.

The scene where the actor-nauts build their scrubber in space does have a subtle editing error. The ground controllers ask Lovell (Tom Hanks) to get something to stuff in a hole in the LIHO canister and Lovell removes his sock. But in the previous shot you can already see a sock stuffed in the canister. A less subtle mistake shows one of the astronauts floating back to the Command Module to get a second plastic bag when the first bag is ripped. The bags were used to protect the lunar spacewalk cooling garments and were stored in the Lunar Module, so it wouldn't have been necessary to send someone to the Command Module. But it was more dramatic.

The simplest shuttle IFM was the one with the biggest impact and it also involved carbon dioxide removal. During the STS-90 Neurolab mission there was a problem with the Regenerative Carbon Dioxide Removal System (RCRS). The RCRS has two chambers which are alternately connected to the crew cabin's air circulation system and the vacuum of space. When the coated surface is exposed to air it absorbs carbon dioxide. When the system is exposed to vacuum and heated the CO2 is dumped overboard.

The RCRS system has flown on all of the

Command Module (square) and Lunar Module (cylindrical) LIHO canisters (props from the movie Apollo 13). One of the key issues on Apollo 13 was how to fit a square peg in to a round hole. The problem was solved by the Inflight Maintenance team. Photo credit–Philip Chien

Extended Duration Orbiter (EDO) shuttle missions, fourteen previous flights since 1992. But on STS-90 the system wasn't working properly and had to be shut off. The backup CO2 removal system uses Lithium Hydroxide (LIHO) canisters. The LIHO canisters occupy a fair amount of space, so long duration missions only carry enough backup canisters for a couple of days. If the IFM team couldn't come up with a fix the mission would have cut short by three days. It wasn't a life-critical situation like Apollo 13, but it was an impact on the mission's success.

By coincidence the lead flight director for STS-90 Al Pennington, also had a role in Apollo 13. Back then he was one of the INCOs–Integrated Communications Officer, the flight controller responsible for communications with the spacecraft.

While the astronauts slept the IFM team went to work. They had assistance from contractor Hamilton Standard which built the RCRS hardware and engineers at NASA centers who maintain and operate the shuttle's Environmental Control and Life Support System (ECLSS– pronounced "E-clis"). About 20 NASA, contractor, and Hamilton Standard personnel were involved in developing and double-checking the IFM.

The solution was extremely simple–use a piece of tape to close off a suspect check valve. But to get access to the RCRS system the astronauts had to remove four of the shuttle's lockers. The procedures were verified on the ground by astronaut Janice Voss, working in the shuttle simulator and following the same procedures which the crew would use in space. The one page procedure was uplinked to the crew via the shuttle's email/fax system.

The straightforward instructions called for the astronauts to remove the lockers, remove a hose clamp from a line, cover a nipple with an one inch piece of aluminum tape and replace the hose. As he was performing the procedure commander Rick Searfoss quipped, "It must be Saturday, time to work on our car like down on Earth." The comparison is apt, the tape blocked off the faulty valve, similar to how a mechanic might isolate a radiator hose on a car.

While the IFM team considers this to be one of the simplest, least complicated repairs, it was one with the biggest impact–preventing a mission from being cut short. When each shuttle flight's completed the mission control team which has contributed the most to the success of the mission has the honor of hanging the mission's plaque in the flight control room. For STS-90 the honors were shared by the IFM team and EECOM (Electrical, Environmental, Consumables Manager), the team actually responsible for the shuttle's carbon dioxide removal systems. One of the IFM engineers quipped "I suppose getting an award for an easy task makes up for the difficult tasks where you aren't recognized."

Other Memorable Fixes

There have been more challenging IFMs in the shuttle program. On STS-30 the crew had to replace one of the shuttle's general purpose computers (GPCs) with a spare. The crew had to remove several lockers and crawl into a very small space to access the avionics bays.

On the STS-39 mission a data recorder failed on the AFP-675 payload. Without a working recorder there was no way for the instruments to collect their data. The IFM team found a place where the crew could access data lines from within the crew cabin. But it was a tight fit and required disassembling several panels and correctly identifying the proper wires within their bundles. The crew was instructed to cut into the wires and install jumpers to connect the data from the instrument to the shuttle's Ku-band transmitter. The bypass permitted data to be transmitted to the ground in real time and saved the payload.

Of course an IFM doesn't have to be complicated or have a major mission impact. On STS-50 the SAREX (Shuttle Amateur Radio Experiment) antenna didn't have a good ground with the overhead window. So controllers asked astronaut Ellen Baker, KB5SIX, to wrap the antenna with several layers of aluminum tape to ensure a more snug fit and a better electrical ground. And on the STS-94 mission the DB-9 to DB-9 cable which connects the SAREX packet modem to its notebook computer couldn't be found.

Since the shuttle couldn't stop at a local Radio Shack and pick up a replacement cable, the next best thing was done. Pilot Susan Still squeezed a set of jumper wires into the computer's serial port and the modem's serial port creating a her own DB-9 serial cable in space.

WHAT'S NEW

by Wayne Mishler, KG5BI

Massive satellite phone system launched

The Iridium LLC company has put into orbit a huge constellation of communications satellites to offer worldwide telephone coverage and a variety of other communications services, including voice, data, fax and paging by September 23.

"We have achieved one of the critical milestones necessary to provide the first truly global, hand-held wireless phone service," says Dr. Edward F. Staiano, Iridium LLC vice chairman and CEO.

In all, 72 satellites have been launched for the Iridium system, 67 of which are operational. The performance level of these spacecraft is within the company's expectations and the parameters required for commercial service this autumn.

Iridium LLC has contracted with Motorola to operate and maintain the constellation for a five-year term commencing at commercial activation, with an option to extend the contract beyond the five years.

The constellation provides a platform for a worldwide digital wireless communications network that will combine the reach of low-earth-orbit satellites with land-based wireless systems to enable subscribers to communicate using handheld telephones and pagers virtually anywhere in the world.

TMI expands mobile packet and fax services

Ontario-based TMI Communications is adding to its telecommunications products which now include expanded mobile communications services and a new wireless facsimile service.

A new TMI packet data mobile communications service, carried by the MSAT satellite, became available this summer in the U.S., Canada, Mexico, and the Caribbean. The new product offers more flexibility at less cost. They call it "Specialized Services."

Essentially Specialized Services is a messaging protocol that works over the new TMI MSAT packet data network and allows for more efficient transmission of data packets. The real payload is a wider array of applications at a better price than can be provided by other systems.

Greatest impact will be in the transportation industry and emergency response sectors, especially in fleet management, credit card verification, dispatch, remote site data transfer, and sensor data gathering.

Another promising use is message broadcast. You send one message, and the TMI data hub broadcasts it near and far to remotes. This could be ideal for distribution of paging messages or for dissemination of vital information such as weather data to mariners.

In addition, TMI is introducing a new wireless fax service that will be carried by mobile satellite to Canada and the Caribbean. Approval is pending for distribution of the service in the U.S. and Mexico.

This new service brings satellite fax services to customers outside wired urban areas. It is ideally suited to the needs of oil and gas, mining, maritime, utility, construction, and leisure industries.

The system offers a fax mailbox feature which stores and forwards messages for subscribers, much like email is stored on servers, ensuring fax delivery even if the recipient is off-line when sent.

Satellite-friendly software speeds Internet connections

A new software product promises to increase throughput performance for Internet browsing and file transfer. The software was developed by FTP under contract with INTELSAT.

The software is a new enhanced satellite-friendly TCP/IP stack kernel for Windows 95 and 98. It will be used primarily by corporate users and ISPs to make better use of geostationary satellites for Internet traffic. It will be used in INTELSAT satellite links and high-speed terrestrial connections.

"In this regard, we see the INTELSAT system playing a major role in making the World Wide Web truly worldwide," says Conny Kullman, vice president for operations and engineering.

New options include a larger window size, which increases data throughput, improved recovery from loss of packets due to errors and congestion, and better handling of packets received out of sequence.

FTP Software will distribute this new release free to customers currently enrolled in the FTP maintenance plan.

The software, incorporated in FTP Software's TCP/IP Stack Version 4.0, is available to other corporate customers in a free 30-day trial during current promotional sales.

For information, send an email request to carla.thwaite@intelsat.int or bjg@ftp.com.

Motorists may be market for satellite radio

Will people accustomed to receiving free radio pay to receive satellite radio? At least two companies think that motorists will buy it and will be making satellite radio available in the U.S. during the next two years. A third company will be broadcasting to Africa, Asia, the Middle East, and South America.

In the U.S., a subscription to satellite radio will go for about $10 per month. Equipment will cost another $200 or so.

Expectations are that satellite radio will enjoy the same success as satellite and cable television. People subscribe even though local programming is available free via antenna.

More people listen to radio in their cars than in their homes, where television is king.

The attractions of satellite radio in the car will be CD-quality audio, no advertising, and diverse programming.

Broadcast Association introduces online source

The National Association of Broadcasters has launched a new online resource primarily for its members. It is an interactive guide for keeping member stations up-to-date on developments affecting the broadcasting industry. Members will find it in the members-only section of NAB's web site, www.nab.org.

Contents will include interviews and articles each month for station managers, webmasters, and sales staff.

NAB is partnered with *CIO* magazine, *The Antenna*, and *The Shop Interactive* to bring members up to date information on how to create an effective web site.

The site is available to members and prospective members and others for a one-month trial period. Contact NAB at 202-429-5300, or check out the NAB web site.

Trimble announces new GPS automotive products

A new GPS receiver for use in various mobile applications is now available from Trimble.

The receiver, known as the ACE II GPS Module, was announced at the 1998 Automotive show. It is an eight-channel receiver based on Trible's sixth generation GPS technology. Its designers say it offers the highest performance available in a miniature GPS receiver that works well in urban canyons, with sub-watt power consumption and accuracy of better than 2 meters.

The new design integrates a 32-bit microprocessor with a digital GPS chip. Signal acquisition reportedly is improved 30%. Power consumption is reduced by 16%.

Uses include car navigation systems, driver information systems, vehicle security and tracking, instrumentation, and data collection.

Another Trimble system, announced at the 1998 National Emergency Number Association 911 conference, employs GPS to turn traffic lights green for emergency vehicles.

Traffic signal preemption speeds response for fire trucks and police cars during emergencies. It also reduces traffic congestion for public transit vehicles by cutting travel times and improving schedules.

Sundial eases dish installation

So there you are, ready to install a new satellite dish antenna, with your trusty compass, protractor, cellular phone, power extension cord, willing helper, and a growing inclination to forget the whole idea and hire a professional installer.

Aiming the dish accurately at a tiny satellite 22,000 miles away is no easy task.

Richard Pauli, of Seattle, Wash., thought there must be a better way. So he designed Sundial Setup, an aiming device that uses the principles of a sundial.

"It's as easy as setting a sundial to the time of day," Pauli says.

His device mounts on the face of the dish. It looks like a hinged stick with marks on it. You set the device according to instructions, and then move the dish so the shadow meets the mark on the face of the disk.

"The entire process takes about a minute," he says. "Since it takes no electricity, it is safer."

According to Pauli, mounting the device on the dish is easiest with a computer, because you have to get the angles just right. Software for this is under development. He is working with manufacturers to pre-install the devices on dishes, with angles pre-set at the factory.

"I devised SunDial Setup for anyone to use," he says. "What was once a difficult, daunting, potentially costly task is not easy, intuitive, and amazingly inexpensive."

Massive new satellite will serve North American

A powerful new Canadian satellite weighing nearly 10,000 pounds (4,500 kilograms) will bring to North America a wide range of new broadcasting, telecommunications, and wireless communications services when launched in Europe at the turn of the Century.

Telesat Canada says the satellite, Anik F1, with an expected life span of about 15 years, will be the cornerstone of its North American satellite business.

Built by Hughes Space and Communications, in El Segundo, Calif., the satellite will feature 84 communications channels. Forty-eight will operate on the Ku band; 36 on the C band.

Plans are to capitalize on the World Trade Organization which liberalizes trade in telecommunications.

The launch is to take place at the spaceport in Kourou, French Guiana, using an Ariane 44L rocket.

New chip making process solves dilemma

A new method for processing semiconductor wafers, using a nonflammable, nontoxic, environmentally friendly solvent, could greatly reduce water use and lower the amount of hazardous waste produced by computer chip manufacturers.

Corrosive chemicals in the past have been needed in the photographic process of making chips. The new system uses carbon dioxide under pressure to do the same job.

The new process was developed jointly by the Los Alamos National Laboratory and the Hewlett-Packard Company.

Television is undergoing biggest change since color

High Definition Television, probably the most significant advancement in television since color debuted 40 years ago, is gaining momentum. In development for more than a decade, HDTV features theater-quality audio, richer colors, and the clearest ever video.

Consumers are anxiously awaiting HDTV, even though the cost of the required digital sets is considerably more expensive than traditional analog sets, and even though the industry is struggling to overcome interference and technical problems.

Several stations have already begun broadcasting HDTV programming, and affiliates of four networks serving the 10 top markets are expected to begin broadcasting by mid 1999. Others will probably follow early in the new millennium.

One of the companies leading the way, Missouri-based Unity Motion, which sells HDTV equipment and broadcasts a variety of high definition programming, says the technology is getting rave reviews indicating a ready market.

In June, Unity Motion made nationwide satellite broadcasts of general entertainment, sports, and movie programming. The purpose was to demonstrate the reliability of its HDTV delivery system. The broadcasts were viewed at several locations across the country.

A survey conducted by Unity Motion indicated that people are becoming interested in buying HDTV for their homes in the near future. People like the superior picture, CD-quality sound, and theater-quality "feel you are there" benefits of HDTV. High definition television is the closest thing to in-theater viewing, primarily because of the sound.

Unity's HDTV systems deliver high definition programming via satellite from a wide variety of sources, including networks, PBS, cable, premium channels, movie studios, and independent and international stations.

By this fall, Unity plans to be broadcasting HDTV programs around the clock. ST

SPACE WATCH

By Larry Van Horn

Stellar Cannibal Provides Missing Link

A newly-discovered star that is emitting rapid pulses of X-rays may be the long-sought missing link between old neutron stars that emit powerful flashes of X-rays, and older, rapidly spinning neutron stars that emit mainly radio waves.

The new star, called an X-ray pulsar, is designated SAX J1808.4-3658. It has greatly accelerated its own rotation at the expense of a nearby "companion" star by pulling gas from the companion onto its surface in a process called accretion. The fastest-spinning pulsar of its type ever seen, the newly discovered star is now rotating at more than 400 times per second (corresponding to a spin period of 2.5 milliseconds), making it the first known accretion-powered millisecond pulsar.

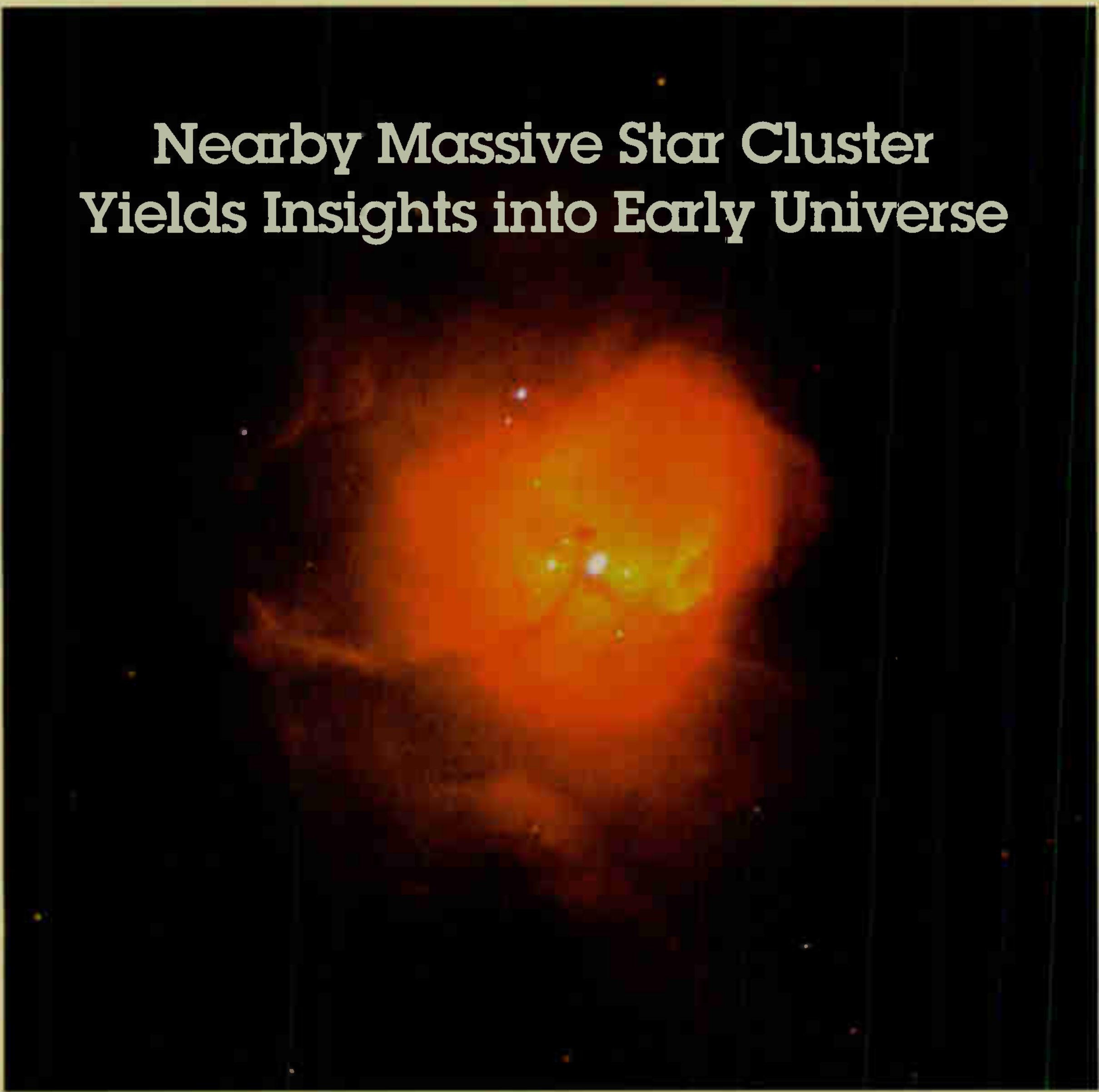
Millisecond pulsars are neutron stars (extremely dense, city-sized stars) that rotate very rapidly; most complete one rotation in less than eight milliseconds (8/1000 of a second). Accretion occurs when gas from a nearby star gets pulled into the pulsar's strong gravitational field. Two competing teams used NASA's Rossi X-ray Timing Explorer (RXTE) spacecraft to make the discovery.

"Astrophysicists have theorized for a long time that the only reason millisecond pulsars exist at all is that they get spun up by taking material from a companion star, but this is the first time one has been caught in the act. This has sometimes been called the Holy Grail of X-ray astronomy, and Rudy has at last found it!" said Dr. Michiel van der Klis.

"This 'stellar cannibal' is a leisurely diner," added Dr. Deepto Chakrabarty. "We estimate that it has been pulling material from its companion star for the last 100 million to one billion years. Over that time, the companion star may have lost up to half its mass. Currently, the companion is about 15 percent of the mass of the Sun." However, not all the companion's mass loss is due to accretion.

"In the case of the newly discovered pulsar, we found that its X-ray intensity is slightly fainter when it is on the far side of its orbit (with its companion between us and the pulsar). This is probably caused by an intervening 'fog' of material blown off the companion's surface–direct evidence for 'vaporization' by the pulsar," said Chakrabarty.

The new pulsar helps scientists resolve a mystery. Prior to the discovery, two populations of neutron stars with relatively weak magnetic fields but with otherwise different characteristics were known. There were old, accreting neutron stars, which are powerful sources of X-rays generated from the material they are gobbling up from their companions, and the group of radiowave emitting pulsars that are rotating very rapidly and slowing down gradually. Scientists suspected there was a connection between the two, and the discovery of this pulsar that is both emitting X-rays and spinning rapidly provides the link.



Nearby Massive Star Cluster Yields Insights into Early Universe

NASA's Hubble Space Telescope has taken a "family portrait" of young, ultra-bright stars nested in their embryonic cloud of glowing gases. The celestial maternity ward, called N81, is located 200,000 light-years away in the Small Magellanic Cloud (SMC), a small irregular satellite galaxy of our Milky Way. These are probably the youngest massive stars ever seen in the SMC.

The nebula offers a unique opportunity for a close-up glimpse at the "firestorm" accompanying the birth of extremely massive stars, each blazing with the brilliance of 300,000 of our suns. Such galactic fireworks were much more common billions of years ago in the early universe, when most star formation took place.

"This is giving us new insights into the physical mechanisms governing star formation in far away galaxies that existed long ago," says Mohammad Heydari-Malayeri who headed the international team of astronomers who made the discovery using Hubble's Wide Field and Planetary Camera 2.

Because the stars of the SMC are deficient in heavier elements, they too evolve much like the universe's earliest stars, which were made almost exclusively of primordial elements hydrogen and helium that were cooked up in the big bang. In fact, the SMC is a unique laboratory for studying star formation in the early universe since it is the closest and best seen galaxy containing so-called "metal-poor" first and second generation type stars.

Hubble's exquisite resolution allows astronomers to pinpoint 50 separate stars tightly packed in the nebula's core within a 10 light-year diameter - slightly more than twice the distance between earth and the nearest star to our sun. The closest pair of stars is only 1/3 of a light-year apart.

These observations show that massive stars may form in groups. "As a result, it is more likely some of these stars are members of double and multiple star systems," says Heydari-Malayeri. "The multiple systems will affect stellar evolution considerably by ejecting a great deal of matter into space."

He believes one of the members of the cluster may be an extremely rare and short-lived class of super-hot star (50,000 degrees Kelvin) called a Wolf-Rayet. This star represents a violent, transitional phase in the final years of a massive star's existence–before it ultimately explodes as a supernova.

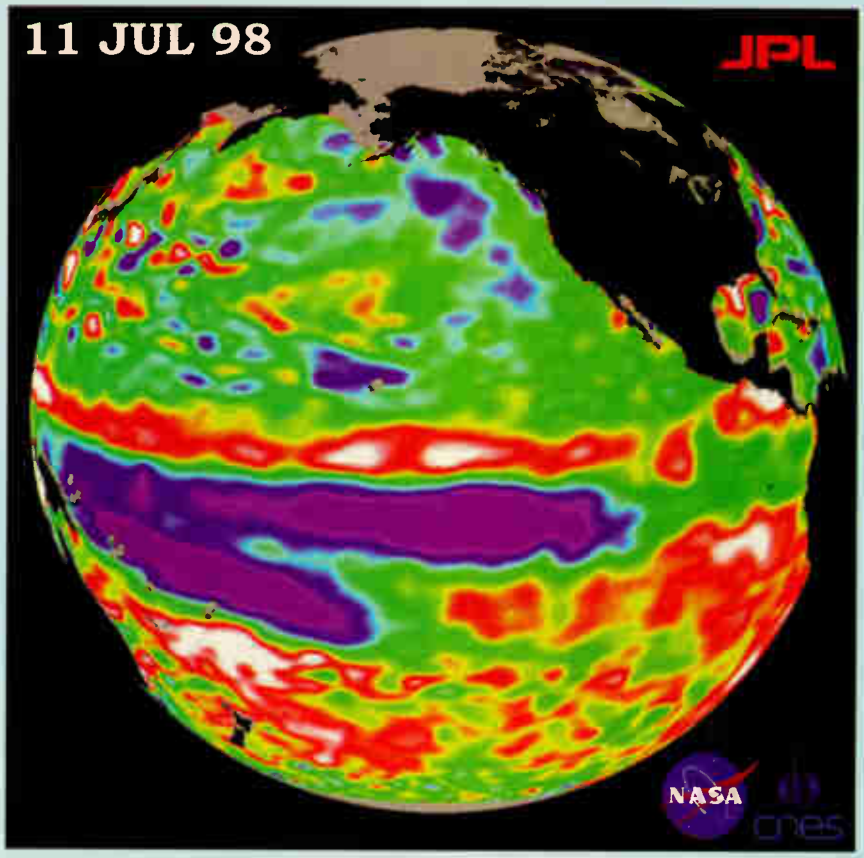
Before the Hubble observations, N81 was simply dubbed "The Blob" because its features were indistinguishable in ground-based telescopes.

By Larry Van Horn

New Data Shows Retreat of El Nino

New sea surface height measurements taken by the ocean-observing TOPEX/Poseidon satellite show the equatorial Pacific in a state of flux with the warm, high sea level El Nino-spawned waters in retreat and areas of colder, low sea level waters on the increase.

"Sea level is a measure of the heat stored in the ocean. In the last month or so, the tropical Pacific has been switching from warm to cold. Lower sea level indicates less heat, hence a colder ocean," said Dr. Lee-Lueng Fu, the project scientist for the U.S.-French TOPEX/Poseidon mission at NASA's Jet Propulsion Laboratory (JPL), Pasadena, CA. "It appears now the central equatorial Pacific Ocean will stay colder than normal for some time to come because sea level is about seven inches below normal, creating a deficit in the heat supply to the surface waters. It is not clear yet, however, if this current cooling trend will eventually evolve into a long-lasting La Nina situation."



An El Nino condition begins when steady westward blowing trade winds weaken and even reverse direction. This change in the winds allows a large mass of warm water that is normally located near Australia to move eastward along the equator until it reaches the coast of South America.

This displaced pool of unusually warm water affects evaporation, where rain clouds form — and, in turn, alters the typical atmospheric jet stream patterns around the world. The change in the wind strength and direction also impacts global weather patterns. The climatic event has been given the name El Nino, a Spanish term for "the Christ child," because the warm current first appeared off the coast of South America around Christmas.

The 1997-98 El Nino has been the strongest ever recorded. This phenomenon was responsible for record rainfall in California, heavy flooding in Peru, drought and wildfires in Indonesia, tornadoes in the southeast United States and loss of life and property damage worldwide. TOPEX/Poseidon's sea surface height measurements have provided scientists with their first detailed view of how El Nino's warm pool behaves because the satellite measures the changing sea surface height with unprecedented precision.

A "La Nina" (Spanish for "little girl") is essentially the opposite of an El Nino, where the trade winds are stronger than normal and the cold water that normally exists along the coast of South America extends to the central equatorial Pacific. A La Nina situation also changes global weather patterns and is associated with less moisture in the air, resulting in less rain along the coasts of North and South America. TOPEX/Poseidon will be able to track a potentially developing La Nina with the same accuracy.

"It may be too soon to say 'good-bye' El Nino and 'hello' La Nina, because the effects of El Nino will remain in the climate system for a long time," said Dr. Bill Patzert, a research oceanographer at JPL.

"However, if the Pacific is transitioning to a La Nina, we'd expect to see clear, strong indication of it by late summer or early fall–in approximately August or September–just like we did last year with El Nino. The strongest impacts of a potential La Nina wouldn't be felt in the U.S. until next winter." A La Nina does not automatically follow an El Nino, Patzert added.

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@Entertainment's Wizja TV, which delayed its start because of the merger talks, but which has three transponders testing on Astra.

Canal Plus and its Norwegian partner Telenor will probably dominate Scandinavia with their Canal Digital package, when it is marketed. The other major satellite broadcaster in the Nordic region, Kinnevik, has chosen not to pursue digital plans, with the exception of a specialized Internet access service on Sweden's Sirius satellite. Canal Digital uses two of Telenor's satellites at 1 degree West, Intelsat 707 and Thor 2 (the new Thor 3 will join the service soon). Currently there are 33 channels on five transponders, plus 12 video-nearly-on-demand channels on another. All use Telenor's Conax encryption.

One market where Canal Plus is conspicuous in its absence is Britain, but taking on Rupert Murdoch and his British Sky Broadcasting is no easy task. British broadcasters are preparing to launch their services, most as part of Sky Digital, via Astra 1D at 28 degrees East. This interim satellite will soon be replaced by Astra 2A, which will be backed-up by Sweden's Sirius 3 on special lease for a year after it is launched in October. Some BBC services will be part of Sky Digital, others will be free-to-air channels.

According to reports, Sky has chosen a digital operating system that is incompatible with ordinary European MPEG-2 receivers. This may just concern the interactive services which are supposed to be part of an additional service called British Interactive Broadcasting. The TV channels will be using a Murdoch-owned CA system unlike any other used in Europe. I'm uncertain if the free-to-air BBC channels will actually be viewable without the Murdoch CA-module. When I first accessed Astra 1D, there were BBC channels listed, but I was unable to tune in anything other than teletext. More recently the BBC channels have been missing, and the only uncoded outlets have been Sky tests, either test patterns, promos, or relays of the Sky News channel.

Other Offerings

These are the major European digital satellite services. There are many other digital channels from individual stations in various countries scattered among the transponders, those from Western Europe usually on Astra; Eastern European, North African and Middle Eastern broadcasters on the various Eutelsat satellites; and those from Scandinavia on Sirius and Thor. Telia in fact has several transponders on Sirius, apparently to help reach its various cable headends. But a company spokesman has told me they are considering making these available for home services as well.

There are a number of channels typically found on many of these systems, such as: National Geographic, CNBC, Travel, VH-1, MTV, Sci-Fi, Nickelodeon, Eurosport, Euronews, BBC Prime, BBC World, Discovery, Animal Planet, Hallmark, Disney, and Bloomberg Television.

Most services also offer at least 30 themed audio music channels from Music Choice Europe, which outlasted rival DMX to become the only provider of such services in Europe.

There are a number of features available on the Telia cable system that are not included in Canal Digital's offerings. There's a very good system of messages from the company, describing updates, new channels, closed channels, service interruptions for maintenance, and so on. There are six simple video games, like Solitaire, which my children played with for about a week. Telia also offers what it calls "mini-surfing," which sounds like Internet access, but is limited to a few web pages from the Swedish service of CNN and weather news from Telia's own Website. It's actually not as comprehensive as the teletext offerings on many of the channels.

Most interesting are nine channels of PPV movies, a system which works very easily. Canal Digital's counterpart is the coming video-near-on-demand service, which apparently will offer fewer films, but with more frequent starts. Telia also offers something called home shopping, but that turned out to be an ordinary TV shopping channel, with no interactivity.

I still haven't mentioned some of the hardware features of the Mediamaster. Like the Telia box, it includes a 9600 bps modem for connection to telephone lines for return communications. Both Telia and Canal Digital promise super fast Internet access at some indefinite date in the future. With Telia, the return path will ultimately be over the cable, which is one place where digital cable is far superior to digital satellite systems. For one thing it's much faster, for another using the cable means you don't block the phone line.

Both boxes have RS-232 outlets for connecting to PCs, printers, or high speed modems. The Telia box has a parallel port (listed as "for coming services"), while the Mediamaster 9600 model has an SCSI port for connection to CD-ROM players "or other high-speed data equipment." Unfortunately my loaner machine was a model 9602, without this port although I'm not sure what I would have done with it anyway).

One problem I know I'm going to have to face is taking out the CA-module when I have to return it and the receiver to their respective owners. As far as I can tell, it's wedged in tight, and I will have to use a pair of needle-nosed pliers to get it out. This makes switching between providers with different Conditional Access systems difficult (which may be the idea). Future generation receivers may come with two CA-slots. Thank goodness for simulcrypting.

Bottom Line

My basic feeling here is that when you've switched to digital, be it cable or satellite, there's little incentive to go back to the analog world. The Telia box is far easier to use, and when the service adds Internet access the cable will be a much better way to connect.

Satellite offers lots of channels the cable company doesn't give you, and offers the possibility of subscribing to different services from different providers. This can be especially useful for immigrants or people with a particular interest in another country. Except for the hard time I had downloading channels, which may be because I lacked the necessary Smart switch, the Nokia was easy to use, and generally faster than the cable box.

I don't know exactly how things are playing out on the other side of the Atlantic, but in Europe, digital is here now. It's already better than analog and can only get better as new services are added. ST

Deploying the Iridium Constellation

Continued from page 23

TABLE 8: ORBITAL DATA FOR CZ-2C SECOND AND THIRD STAGES

Launch	Test Flight		Cluster 8		Cluster 11		Cluster 14	
Stage	2*	3/SD*	2	3/SD	2	3/SD	2	3/SD
Incl (Deg)	86.23	86.35	86.29	86.22	86.39	86.31	86.35	86.27
Period (min)	93.07	92.83	93.00	92.97	92.93	92.75	93.01	92.94
Perigee (km)	230	178	179	210	177	196	179	208
Apogee (km)	620	648	663	630	659	623	664	629
Arg of Perigee (Deg)	149	162	170	136	171	160	170	158

The stage designators follow those assigned by Goddard Space Flight Center: based upon the orbital data for the later missions, it appears that the two stages from the test flight (*) have been interchanged.

For all of these pieces the perigee altitudes and arguments of perigee are close to those of the CZ-2C second stage (normally with a perigee ~30 km below the SD final orbit), but apogees reach out to around 800 km. What these objects represent is not known, but it is likely to be linked with the separation system of the second stage from the SD.

Unless politics intercedes, with three CZ-2C/SD launches of operational Iridium satellites being successfully accomplished there are seven launches still to take place which will replenish orbital planes with new satellites as in-orbit failures or other problems might dictate.

Description of the Iridium Constellation

As mentioned earlier in this article, it appears that USSPACECOM has switched the international designators of some of the Iridium satellites so that their names no longer correspond with those used by Iridium Inc. The satellites involved are thought to be those noted in Table 9. When launched the USSPACECOM names appear to have coincided with the SV numbers, but it was only with the subsequent maneuvering of the satellites that the mis-identifications crept into the system. For the sake of simplicity the USSPACECOM numbers will be used here, but when erroneously-numbered satellites are discussed in the subsequent text both the USSPACECOM and Iridium SV numbers will be quoted.

The operational Iridium system will comprise six orbital planes, each with eleven operational satellites and one spare satellite to allow back-up capacity when a satellite fails and until a replenishment launch takes place. With the deployment of the fifteenth cluster a total of 72 satellites had been launched, with twelve in each orbital plane. For convenience, here the orbital plane ascending node longitudes (calculated at July 1.0, 1998) are identified as follows:

237.95ºE	Plane A
269.55ºE	Plane B
301.13ºE	Plane C
332.74ºE	Plane D
4.35ºE	Plane E
35.97ºE	Plane F

The longitudes quoted are the mean values of all of the satellites located at or close to the operational altitude of 775-789 km: the standard deviations for the six groups are either 0.02º or 0.03º. Table 1 includes the orbital plane into which each cluster of Iridium satellites was launched. It will be seen that the five separations between the orbital planes are 31.6º.

With eleven operating satellites around each orbital plane the spacing between satellites should be ~33º. Table 10 shows the status of the Iridium constellation at the beginning of July 1998, and this shows how the spacings around the orbit alternate from one orbital plane to the next. Using the two-line orbital elements, the actual spacings between satellites around the orbital planes range from a minimum of 31º and a maximum of 35º.

It will be noted that the satellites in orbital planes A and B are generally off-set around the orbit by +5º when compared with planes C/E and D/F. The interlacing of the two orbital plane triplets (A, C and E with B, D and F) is clear from Table 10: the mean off-set between corresponding slots (eg, A1 and B1) is 15.5º.

At the beginning of July 1998, the orbital locations of the satellites did not reflect a fully-deployed system. Orbital planes A, B, C and E were complete, but with Iridium 75 still drifting in Plane A as a spare. In plane D Iridium 5 is allocated to slot 9, but USSPACECOM orbital data indicate that the satellite is in a 100.24 minutes orbit and Iridium 51 is drifting as an in-orbit spare. And in Plane F slot 6 was empty.

Two satellites failed to maneuver up to the operational altitude of 775-780 km: Iridium 21 hardly maneuvered from the deployment orbit and is stuck in a 627-643 km orbit with its orbital plane ~10º to the

TABLE 9: LIST OF SATELLITES POSSIBLY MISIDENTIFIED BY USSPACECOM

Catalog Number	International Designator	USSPACECOM Name	Iridium SV
24838	1997-030C	Iridium 10	9
24839	1997-030D	Iridium 9	10
24871	1997-034C	Iridium 18	20
24872	1997-034D	Iridium 20	18
24905	1997-043C	Iridium 24	46
24966	1997-056B	Iridium 37	35
24968	1997-056D	Iridium 35	37
25105	1997-082B	Iridium 46	24
25169	1998-010A	Iridium 50	52
25171	1998-010C	Iridium 52	54
25172	1998-010D	Iridium 53	50
25173	1998-010E	Iridium 54	53

TABLE 10: STATUS OF IRIDIUM CONSTELLATION: JULY 1, 1998 AT 0000 UTC

Plane	A	B	C	D	E	F	Slot	LAO (Deg)
1	6	23*	34	42	25	72*	28	56
2	39	22*	19	20	57	74*	55	53
3	72	69*	61	43	90	68*	60	16
4	105	26*	35	41	123	67*	59	14
5	138	49*	4	38	156	66*	58	13
6	170	48*	8	–	188	65*	57	12
7	203	47*	7	15	221	64*	33	52
8	236	24*	6	17	254	63*	32	9
9	269	45*	5	44	286	62*	31	10
10	301	25*	36	39	319	70*	30	54
11	334	71*	37	40	352	73*	29	50
Non-Operating Satellites								
		46	27		11	18, 21		
Spare Satellites, Drifting Close to Constellation Altitude								
	75			51				

The orbital planes are identified using the alphabetical designators listed in the text: the slot numbers are simply based upon the closest satellite in the system to the equator having passed northbound. "LAO" is the longitude around the orbit for each set of satellites: those marked * are off-set by +5º around the orbit. The empty slot is identified by "—". Satellites are identified using the USSPACECOM numbering system.

west of the standard for plane F at the beginning of July; similarly, Iridium 27 hardly maneuvered from the deployment orbit (546-560 km) and its orbital plane was 4.6º to the west of the standard for Plane C.

A review of the Iridium satellites published in *International Space Industry Report* (May 21, 1998, pp 12-13) quoted an Iridium spokesman as confirming that five satellites had been "lost" as of May 8, 1998, although the company had declined to release details.

In addition to Iridium SV 21 and Iridium SV 27 (USSPACECOM correctly identifies these satellites), the article states that Iridium SV 11, Iridium SV 20 (identified as Iridium 18 by USSPACECOM) and Iridium SV 24 (identified as Iridium 46 by USSPACECOM) have failed, and the articles states that "communications, thruster and momentum wheel failures have been affecting some of the satellites."

The orbital data from USSPACECOM shows that Iridium 18 (SV 20) is in an orbit very slightly below the operational constellation, with a period of 100.38 minutes, while Iridium 46 (SV 24) is in the operational 100.40 minutes orbit.

At the beginning of July 1998, four satellites were in orbits which were just below the main constellation where the satellites have orbital periods of 100.40 minutes:

Iridium 5	Plane D	100.24 min
Iridium 11	Plane E	100.08 min
Iridium 51	Plane D	99.83 min
Iridium 75	Plane A	98.64 min

According to USSPACECOM orbital data, Iridium 5 had been placed in the normal 100.40 minutes operational orbit after launch, but during January 1998, a series of maneuvers starting about January 6 initially increased the orbital period to a maximum of 100.46 minutes on January 10, on which date the orbital period was lowered to 100.17 minutes and the satellite has remained in an orbit close to this through to the end of June 1998, when the period was 100.24 minutes. As noted above, despite this apparent non-nominal orbit, the satellite is assigned to slot D9 in the constellation.

A similar series of maneuvers started about August 21, 1997, with Iridium 11, with a peak orbital period of 100.49 minutes was reached on September 6, when the period was reduced to 100.15 minutes: by the end of the month the period had been further reduced to 100.08 minutes, where the satellite has remained. This is one of the satellites which is believed to be now "dead."

Iridium 51 was in the operational orbit until May 16, 1998, when a series of maneuvers lasting until May 19 reduced the orbital period to 99.81 minutes. It is acting as an in-orbit spare for the system.

After launch, Iridium 75 was maneuvered from its original 97.40 minutes orbit to one with a period of 98.65 minutes, this being reached on May 25, 1998. No further upward maneuvers of the satellite have taken place through to the end of June and it is classified as an in-orbit spare satellite.

The first launch to replenish the Iridium constellation using a CZ-2C/SD vehicle is due to take place in July 1998, with subsequent replenishment launches using both the CZ-2C/SD and the Delta-2 (7420) vehicles. Iridium Inc is expecting that the constellation will be fully operational by the time that they are ready to begin full commercial operations in September 1998.

Acknowledgements

Unless credited otherwise, all of the orbital data used in this article are based upon the two-line orbital elements made available by the Orbit Information Group (OIG) at the Goddard Space Flight Center, and I would like to thank the OIG staff for the continued access to this data. However, because of the confusion with misidentifications of some Iridium satellites by USSPACECOM, it is possible that some of the apparent orbital maneuvers by the satellites have been misinterpreted by this writer.

By Russell Steele

GPS On the Road

Would you recognize an Intelligent Transportation System if it was parked in your driveway? Never heard of ITS? Few citizens have. Those that have show little interest, even though the US Department of Transportation launched a major initiative in 1991 to integrate vehicles and highways into Intelligent Vehicle Highway Systems. This label was later shortened to Intelligent Transportation Systems (ITS) reducing the emphasis on highway centered solutions to traffic congestion.

The 1991 Intermodal Surface Transportation Efficiency Act called for a system capable of reducing traffic congestion and improving air quality and traveler safety. After spending millions on research and demonstration programs, citizens are not clamoring for automated highways with autonomous vehicles, automatic mayday systems nor handheld multi-modal traveler information systems. As one ITS Consultant noted, "More people know about alien abductions than they do about ITS."

While few products carry the "ITS" label, consumers and businesses *are* being offered products that implement ITS concepts. Many of these "telematic" products, combining GPS position and timing with radio communications, are improving transportation efficiency, enhancing traveler safety and increasing customer satisfaction. However, these onboard systems are not often recognized as ITS products.

Some consumer related ITS products offered in high-end-cars are: GM's OnStar, Ford's RESCU and Siemens' TetraStar. Transit vehicles equipped with GPS systems are providing better customer service and increased efficiency. Long haul trucking companies are using GPS to improve fleet management, reduce thefts and monitor driver and vehicle performance.

Small businesses are also adopting GPS technology to improve efficiency and customer satisfaction. A few months ago, I ordered some new rain gutters. When the LeafGuard estimater Lance Bellows arrived in his pickup truck, he had a home built console in the passenger seat which holds a Compaq laptop computer, with a DeLorme Tripmate GPS sensor on the dashboard. According to Bellows, this under $200 system saves him forty-five minutes to an hour every day, allowing one more customer visit each day. However, according to Bellows, the best feature was improved customer service. If delayed by traffic, he can call on the cellphone and give an updated arrival time.

Siemens, TetraStar Traveler Information System display unit.

Consumer vehicle applications

General Motors' OnStar service is a hands-free, voice-activated cellular phone, combined with a GPS navigation set. The driver is linked to a service center where operators can locate the car on a computer workstation display and respond to the user emergency. When an air bag deploys, the car's system automatically notifies the OnStar Center of the vehicle location. The operator can call the car to check on the occupants' condition. Depending on the need, the operator notifies the nearest emergency response unit, or dispatches a tow truck to the scene of the accident.

Also, OnStar subscribers can get immediate remote diagnostics of the vehicle's engine, power train and brake system; if a warning light flashes on the car's instrument panel. The system also detects any unauthorized entry into the vehicle and tracks the stolen vehicle. Using GPS navigation information relayed by cellular phone, the service center can notify the police of the vehicle's location. OnStar is a 24 hour a day, seven-day-a-week service in all 50 states and Canada.

While GM has OnStar, Ford has developed its own onboard emergency communication system for the Lincoln Continental, called Remote Emergency Satellite Cellular Unit (RESCU). Lincoln Continental's overhead console has a button for requesting a tow truck or ambulance. When one of the buttons is pressed the integrated hands-free, voice-activated cellular phone automatically sends an electronic message to the Lincoln Security Response Center. This message includes the longitude and latitude obtained from the vehicle's GPS navigation system. This is also a 24-hour, seven-day-a-week service.

RESCU's capabilities are more limited than OnStar's. RESCU does not have convenience features such as directions, remote unlocking, theft tracking, and hotel/restaurant services. However, Motorola Telematic Information Systems and Visteon Automotive Systems (a subsidiary of Ford Motor) recently announced a new vehicle emergency messaging system, designed for aftermarket installation on selected new vehicles. The system offers emergency and roadside assistance, turn-by-turn route guidance; theft-tracking assistance, theft alarm and door unlock capabilities like OnStar.

The Seimens TetraStar Traveler Information System is a more stand alone system with a GPS sensor and an internal gyroscope for accurate vehicle positioning. It provides turn-by-turn navigation instructions from on board data. The system includes a four inch LCD display, on-board computer with roadway database and map displays. TetraStar was showcased during the 1997 Summer Olympics in Atlanta. In a Battelle Research Center survey of participants, better than 80 percent of the respondents would consider installing TetraStar in their vehicles. Some 86 percent felt the system reduced overall stress brought on by traveling and 96 percent said that TetraStar, in general, made driving easier for them.

According to a recent Strategis Group

survey of the Automatic Vehicle Location market, technological improvements and declining prices are expected to boost the number of passenger cars equipped with telematics from 58,000 in 1998 to over 1.2 million by 2003.

Transit vehicle applications

Bus fleet operators need to know where their buses are, and whether drivers are meeting route schedules. Real time vehicle tracking systems accomplish this by coupling GPS navigation systems with radio communication links. In a demonstration, Kansas City saved $400,000 in operating expenses and cut the response time to emergencies from four minutes to one minute, by installing AVL technology on 200 buses.

Commercial trucking applications

Loaded trucks are a favored prey of thieves. Today large corporate truck fleets, (J.B. Hunt, Schneider National, and Yellow Freight), all rely on AVL technology. However, less than 1 percent of the 5.7 million private fleets carry automatic locating systems for reporting a trucks' locations to dispatchers. When an AVL equipped truck is stolen, the truck's exact whereabouts can be reported to the police by the dispatcher ... assuming the system is not disabled.

The adaptation of the truck-tracking technology to a theft-recovery system is a natural, but far from its only use. The Iowa Department of Transportation is working on a program to log the miles interstate truckers run in each state, for fuel-tax reports. On-board computers with GPS sensors can also track a driver's service hours and make an electronic log that's easier to keep and harder to fake.

Problems to be overcome

Selective availability. GPS satellites broadcast two signals, one military and one civilian. In order to deny adversaries the accuracy that we provide our own soldiers, the civilian channel employs selective availability (SA), enabling the military to control signal accuracy. When SA is set to its highest point, it limits the civilian channel accuracy to a radius greater than 100 meters. Normal SA settings produce accuracies within 100 meters. With SA set to zero, accuracy should be within 15 meters.

Single frequency. Transportation agencies and business are building mission critical functions which rely on GPS timing and navigation signals. Mission critical safety systems require a backup capability; especially for aircraft operations, train separation monitoring for positive control, and large ship operations in bad weather. Therefore, two or more GPS signals are desired for these mission critical applications. Two signals can also improve reception when signal levels are marginal.

Standards. Standards are a major ITS issue. A great many standards have reached the point of public comment and balloting. However, even as industry praises the standards process, an undercurrent of reservations and concern regarding the standards impact on the market is slowing progress. Once again, as we experienced in the computer and video industry, consumers may be called upon to set the final standards with their checkbook and credit card.

Some solutions on the horizon.

After months of delay, the House and Senate passed the compromise ISTEA reauthorization bill, which is now dubbed the "Transportation Equity Act for the 21st Century" or TEA-21. President Clinton signed the legislation on 10 June, which includes a nice present for GPS users. TEA-21 includes funding for a nationwide differential GPS system.

Nationwide Differential Global Positioning System (NDGPS)

When complete, the NDGPS will provide nationwide differential signals from 66 sites around the country. It will be integrated with three existing Federal differential GPS systems: the Coast Guard's DGPS system used in harbors and major rivers, the National Geodetic Survey's Continuously Operated Reference Station (CORS) system for tracking shifts in the earth's crust, and the National Oceanic and Atmospheric Administration's Integrated Precipitable Water Vapor System for collecting real-time water vapor data.

To reduce the cost and accelerate NDGPS deployment, TEA 21 directs the Air Force to transfer its 53 Ground Wave Emergency Network (GWEN) sites to the Department of Transportation in 1999, when they are scheduled to be decommissioned–an excellent use of our tax dollars. This 30 million dollar system of 66 stations will provide dual frequency differential coverage, 99.9 percent availability and 1-5 meter accuracy.

Second Frequency

The Department of Transportation (DOT) and Department of Defense (DOD) have agreed to provide a second frequency for civil use. This second civilian GPS frequency will improve reception, location accuracy and provide a backup for mission critical applications. The second civil frequency will be included in Block IIF upgrades and is referred to as L5. Although none of the candidate frequencies, 1205 MHz or 1250 MHz, was considered mutually acceptable to all federal agencies, DOT and DOD reaffirmed their commitment to provide the second frequency for civil use.

National standards

The TEA-21 legislation, like its predecessor ISTEA, continues to emphasize the development of a national architecture and standards for ITS. TEA-21 directs the US DOT to: "develop, implement and maintain" a national architecture and standards for ITS, using standards-setting organizations; such as the Society of Automotive Engineers, Institute of Electrical and Electronic Engineers, and others.

More significantly, TEA-21 requires additional actions by DOT to identify critical standards, and then ties federal funding for ITS projects to adherence to those standards. The DOT is empowered to establish "provisional" standards if, by January 1, 2001, any such critical standards are not adopted and published by the appropriate standards development organizations.

ITS future benefits

Increased GPS accuracy and reliability will benefit the whole user community. It will create opportunities for innovative products we have yet to imagine. Someday NDGPS on a chip will be embedded in our palm computers, cellphones and wristwatches. None will have an ITS label, yet their heritage can be traced to ITS legislation and research.

Contacts:

Motorola Telematic Information Systems, MTIS. 1303 E. Algonquin Rd., Schaumburg, IL 60196; Tel: 847/480-6846

Visteon Automotive Systems, a subsidiary of Ford Motor, The American Rd., Dearborn, MI 48121; Tel: 313/322-3000

Ford, Lincoln Commitment Customer Assistance Center, 1-800-521-4140

General Motors, OnStar Communications Tel: 248/ 269-1334

Siemens Automotive Corp., 2400 Executive Hills Dr., Auburn Hills, MI 48326; Tel: 810/253-1000; Fax: 810/253-2998

Battelle Research Center, 505 King Avenue, Columbus, OH 43201-2693; Tel: 614/424-5189, Fax: 614/424-3260

The Strategis Group, Stephan Beckert, Tel: 202/530-7500, Fax: 202/530-7550

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SATELLITE TIMES ADVERTISERS' INDEX

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 (ascending 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

E-mail address: st@grove.net

A Kindly Look Back; A Hopeful Look Ahead

By now each of us has said goodby to Alan Shepard in his own way. The obituary of this American space hero brought back memories for all of us–images of our fragile earth from space, the deafening thunder of Launch Pad 39, the spellbinding vision of an American walking on our natural satellite.

Those of us who listened to the communications spectrum thrilled to the rhapsodic voices from space as history was being made. The frequency 15.016 MHz USB is indelibly etched into our memories; once used for capsule-to-ground Gemini communications, it is now part of the U.S. Air Force Global HF radio system.

Perhaps your thoughts drifted with mine back to those pioneering days, a time when limitless funds were allocated to the "Race for Space." It was time for America to make up for the political mistake of avoiding an earlier launch which would have been on a military vehicle.

I recall watching a black-and-white Walter Cronkite transfixed as he tracked the benign Russian Sputnik beeping its way across the Atlantic toward the American east coast; we were certain that the evil empire had hostile intentions with that orbiting weapon! We all breathed a collective sigh of relief as it quietly disappeared over the Pacific Ocean just a few minutes later.

The transition of the 1960s to the 1990s carried with it both grief and glory. We swelled with pride in 1961 as Alan Shepard inaugurated Project Mercury, racing skyward aboard a primitive Redstone rocket, and we felt our pulses quicken as John Glenn circumnavigated the earth. We shared the pain of losing three of our Apollo heroes in a pre-launch test, and stood in mute disbelief as we felt an explosion rip through our hearts as it disintegrated the *Challenger* mission.

But pride and progress outbade disaster and failure, and America held tightly to the baton of space exploration. From near space to deep space, U.S. technology has been in the forefront for nearly four decades.

But the race has slowed. Russian economic collapse has virtually eliminated their space program, and Congressional priorities have changed on this side of the great oceans as well. There are profits to be made. Space exploration has given way to space exploitation, and we must now ride with the times, not with the astronauts.

Will we see a renaissance in space? A new vision? Will more heroes like Alan Shepard and John Glenn emerge from the fabric of our techno-culture? I fervently hope so. Space is not just a commodity, it is our future.

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