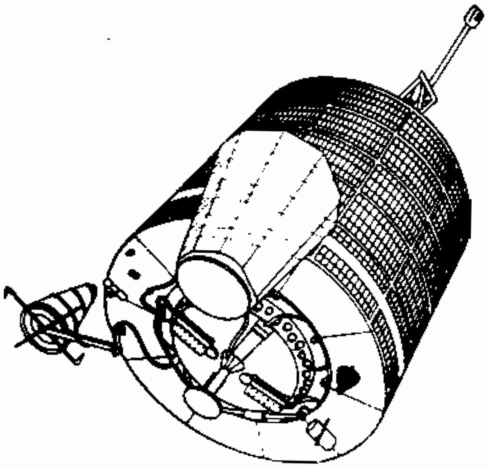
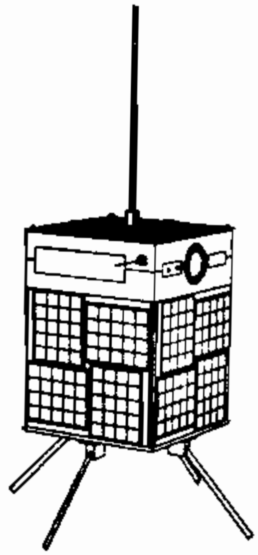
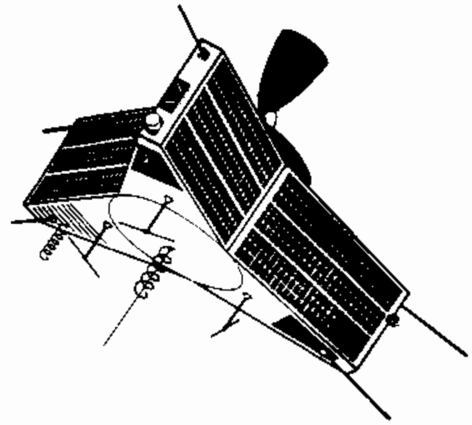
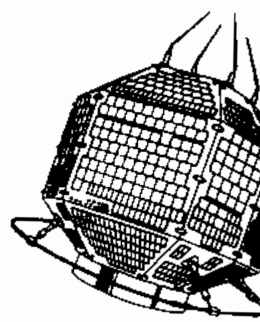
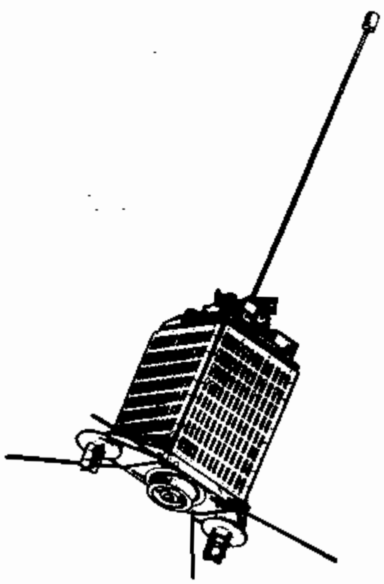
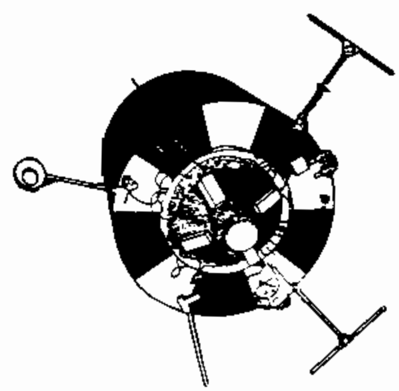




HOW TO WORK
THE AMATEUR RADIO SATELLITES

KEITH C. BAKER
KB1SF



HOW TO WORK THE AMATEUR RADIO SATELLITES
December, 1991

Compiled by:
KEITH C. BAKER, KB1SF

-INDEX-

FOREWARD

I've been a licensed amateur radio operator since 1976. In late 1990, I developed an active interest in amateur satellites. I soon found that a wealth of published research information about this facet of our hobby was available. However, simplified information about satellite frequencies in use as well as operating modes and techniques of the currently active amateur satellites tended to be scattered throughout several publications, guides and bulletins.

This pamphlet is my attempt to draw some of the more practical aspects of amateur radio satellite operation together into a single reference document for the casual listener or beginning user. It is not meant in any way to demean or replace the wealth of detailed research performed by other authors, some of whose superb works were used as background material for this document.

For this, the second edition of this work, I've incorporated many of the comments and suggestions (most of them overwhelmingly positive!) from users of the first edition. A pictoral of each satellite along with some of it's orbital data and international designations have been added where possible. In addition, I've adopted a "one-satellite-per-page" format, and left ample space for the user to jot down such information as personal or operational notes regarding times each satellite of interest is heard at their QTH, signal strength, or changes to the status of each satellite as they are published. This approach also allows users to place the document in a loose leaf notebook. Information for a particular satellite can then be easily removed for use as a quick reference tool while at the operating position.

Particular thanks go to Gerd Schrick, WB8IFM, Southwestern Ohio AMSAT coordinator (and my "Satellite Elmer"!) for his patience and helpful suggestions for improving this work.

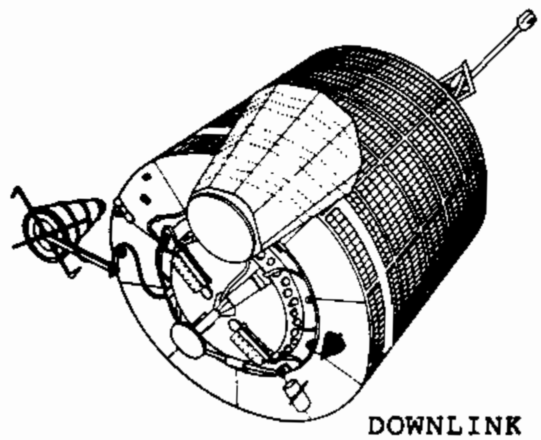
KEITH C. BAKER, KB1SF
Xenia, Ohio
December, 1991

RS-10/11

COUNTRY: USSR   NASA ID#: 18129; Intl: 87-54A   Launched: 23 Jun 1987

ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 82.9 Degrees
AVERAGE ALTITUDE: 991 Km
ORBITAL PERIOD: 104.9 Minutes



FREQUENCY AND MODE DATA:

	MODE	UPLINK	DOWNLINK	
CW/SSB	A	145.860 - 145.900	29.360 - 29.400	MHz
"	T	21.160 - 21.200	145.860 - 145.900	
"	K	21.160 - 21.200	29.360 - 29.400	
"	KA	21.160 - 21.200 & 145.860 - 145.900	29.360 - 29.400	
"	KT	21.160 - 21.200	29.360 - 29.400 & 145.860 - 145.900	
	ROBOT	21.200 &/or 145.820	29.403	
	BEACONS		29.357, 29.403, 145.857, 145.903	

NOTES:

RS-10 (and RS-11, which is currently turned off) are mounted on the same spaceframe, which also includes a Soviet navigation satellite.
This satellite is in a low Earth (about 600 miles) orbit, and can be worked with low power and simple antennas. I've come to call RS-10 the "novice band of the amateur satellites" for it is on this bird that most present day hams get their first taste of satellite work. The transponders have quite sensitive receivers on the uplink, and quite

powerful transmitters for the downlinks, so it is relatively easy to work. I also understand it's Russian builders sliced the passband into 10 4-Khz segments, each with it's own automatic gain control, to make it more forgiving when relatively overpowered uplinks from those fairly new to the satellite hobby are heard.

Another exiting feature of RS-10 is the ROBOT. The ROBOT is an automatic on-board QSO computer. To work it, send the following at about 20 wpm (I've found a memory keyer works best):

RS10 DE (YOUR CALL) AR

If the Robot hears you, it will respond with:

(YOUR CALL) DE RS-10 QSL NR (SERIAL NUMBER) OP
ROBOT TU USW QSO (SERIAL NUMBER) 73 SK

If you want a QSL, send the serial number the Robot sent back to you on your QSL via Box 88, Moscow.

RS-10 is currently active on Mode A, and the Robot uplink frequency now in use is 145.820 MHz. Even if you're not otherwise equipped to work them, both RS-10 and RS-12 (next page) produce strong downlink signals and are relatively easy to hear. Standard HF gear using simple dipole or vertical antennas will usually produce a workable Mode A downlink and/or beacon signal on 10 Meters for near overhead passes.

Working through either of these birds is a superb way to "cut your teeth" on amateur satellite operation, for they provide most of the experiences you'll need to find out if satellite work is really "for you"!

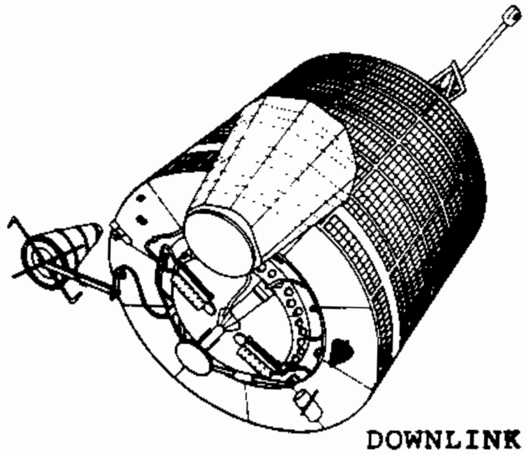
RS-10/11 OPERATOR NOTES:

RS-12/13

COUNTRY: USSR   NASA ID#: 21089, Intl: 91-07A   Launched: 5 Feb 1991

ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 82.9 Degrees
AVERAGE ALTITUDE: 985 Km
ORBITAL PERIOD: 104.8 Minutes



FREQUENCY AND MODE DATA:

	MODE	UPLINK	DOWNLINK
CW/SSB	A	145.910 - 145.950	29.410 - 29.450 MHz
"	T	21.210 - 21.250	145.910 - 145.950
"	K	21.210 - 21.250	29.410 - 29.450
"	KA	21.210 - 21.250 & 145.860 - 145.950	29.410 - 29.450
"	KT	21.210 - 21.250	29.410 - 29.450 & 145.910 - 145.950
	ROBOT	21.1291 &/or 145.8308	29.4543 &/or 145.9587
	BEACONS		29.4081, 29.4543 145.9125, 145.9587

NOTES:

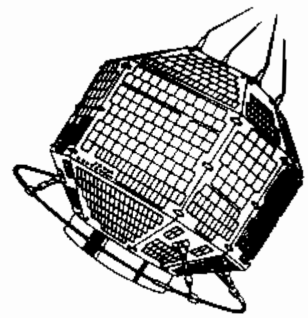
RS-12 (and RS-13, which is currently turned off) are "kissing cousins" to RS-10/11 in most respects. They are also "hitchhiking" on a Russian navigation satellite. However, RS-12 is currently using Mode K, which allows folks who have two HF radios, (or can cross-band a single HF radio) to get in on the action. If you're cross-banding, simply announce what frequency you're monitoring on the downlink. I haven't heard any ROBOT activity from RS-12...yet. Both RS-10 and RS-12 use linear non-inverting transponders. See my notes on satellite operations at the end of this listing for more on what a non-inverting transponder is and how to use it.

RS-12/13 OPERATOR NOTES:

FO-20

COUNTRY: Japan	NASA ID#: 20480, Intl: 90-13C	Launched: 7 Feb 1990

ORBITAL DATA:



ORBIT TYPE: Near Circular (Polar)
INCLINATION: 99.04 Degrees
AVERAGE ALTITUDE: 1328 Km
ORBITAL PERIOD: 113.2 Minutes

FREQUENCY AND MODE DATA:

	MODE	UPLINK	DOWNLINK
SSB/CW	JA	145.900 - 146.000	435.900 - 435.800
AFSK (FM) 1200 bps AX.25 Manchester	JD	145.800, 145.890, 145.910	435.910
	BEACON		435.795

NOTES:

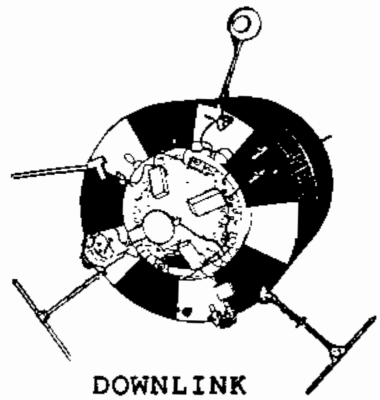
The FUJI OSCAR 20 is another low Earth orbiter with both a linear and a packet radio transponder on board. FO-20's linear, non-inverting voice transponder (Mode JA) has not been very active lately, and the Mode JA schedule is not widely published. This satellite was to be an upgraded replacement for another Japanese amateur satellite known as FO-12. Although FO-20 is bigger, with more solar panel area and a larger power budget than it's older brother, it is still subject to occasional periods of dormancy, due to long periods of darkness in some parts of it's orbit. When last heard, FO-20 was operating almost exclusively in it's AFSK packet mode (Mode JD).

FO-20 OPERATOR NOTES:

AO-21

COUNTRY: USSR/Germany   NASA ID#: 21087, Intl: 91-06A   Launched: 29 Jan 1991

ORBITAL DATA:



ORBIT TYPE: Circular (Polar)
INCLINATION: 82.9 Degrees
AVERAGE ALTITUDE: 983 Km
ORBITAL PERIOD: 104.7 Minutes

FREQUENCY AND MODE DATA:

	MODE	UPLINK	DOWNLINK
(XPONDER #1)	B	435.022 - 435.102	145.852 - 145.932 MHz
(XPONDER #2)	B	435.043 - 435.123	145.866 - 145.946
(BOTH W/SSB)			
RUDAK		435.016, 435.155 435.193, 435.041	145.983
BEACONS AND TELEMETRY			145.948, 145.822 (CW) 145.952, 145.983 (DIGITAL) 145.838, 145.800 (DIGITAL)

NOTES:

The AO-21 was, at this writing, still undergoing checkout in orbit. Like it's Soviet cousins, it's a "hitchhiker" on a Soviet geological research satellite. The Mode B transponders are inverting. The RUDAK will be a digital experiment whereby any one of eight different modes of uplink and downlink can be selected. These include BPSK from 400-9600 bps and/or CW, RTTY, FAX, FSK, along with FM digitized voice! Unfortunately, AO-21 has been plagued with interference problems from both the main payload as well as "hearing itself" in its uplink receivers. The RUDAK experiment has yet to be fully activated. Both the primary and secondary Mode B transponders have been cycled on and off a number of times in an effort to isolate and alleviate some of these problems. When its Russian controllers have them switched on, AO-21's Mode B transponders provide very strong 2 meter downlink signals. In any case, you can listen on 145.838 or 145.800 for the FM beacons. I've heard these beacons on a handheld during overhead passes!

AO-21 OPERATOR NOTES:

UO-11

COUNTRY: U.K. NASA ID#: 14781, Intl: 84-21B Launched: 1 Mar 1984

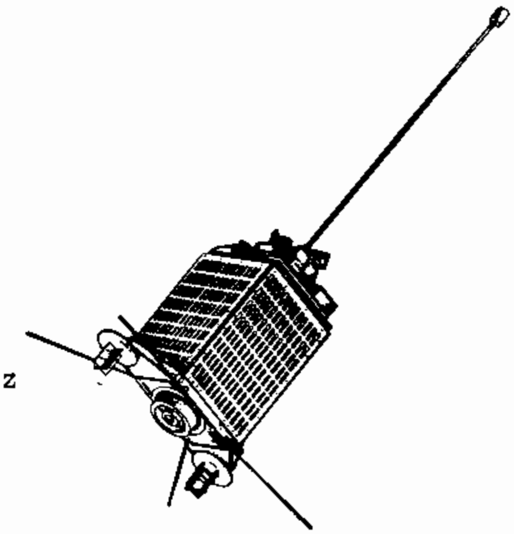
ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 97.8 Degrees
AVERAGE ALTITUDE: 669 Km
ORBITAL PERIOD: 98.1 Minutes

FREQUENCY AND MODE DATA:

VHF DOWNLINK 145.825 **MHz**

UHF DOWNLINK 435.025, 2401.5



NOTES:

UO-11 **is an** educational and **research satellite,** constructed **and controlled** by **students** and staff at the University of Surrey, England. It **is** the oldest **of** the UO series still in orbit. **There** are no uplinks, **but** the telemetry downlink on this low Earth **orbiting** satellite is really strong on 145.825 when it goes over. I've **heard** it on an FM handleld in the house!

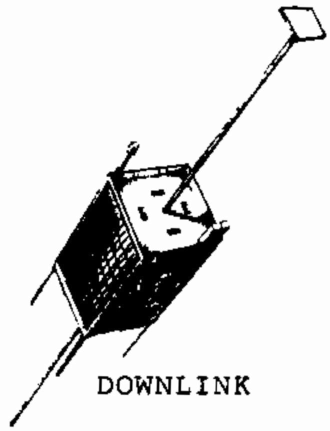
UO-11 OPERATOR NOTES:

UO-14

COUNTRY: U.K. NASA ID# 20437, Intl: 90-05B Launched: 22 Jan 1990

ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 98.6 Degrees
AVERAGE ALTITUDE: 794 Km
ORBITAL PERIOD: 100.7 Minutes



FREQUENCY AND MODE DATA:

	UPLINK	DOWNLINK
9600 bps FSK (FM)	145.975	435.070
1200 bps AFSK (NBFM)		435.070

NOTES:

Another product of research and development at the University of Surrey, this bird's called a "PACSAT", because it carries an open access packet transponder. However, the modem configuration for the uplink is not compatible with normal terrestrial FM packet modems that many of us are used to using. Operating through the packet transponders on these low Earth orbiting birds requires the use of a much more sophisticated modem arrangement.

The transponder on UO-14's brother, UO-15, (which was to have also included a CCD video camera for views of the Earth from orbit!) ceased operating soon after launch. These two, along with Oscars 16, 17, 18, and 19 (the MICROSATS described in the following pages) were all launched by a single Ariane 4 rocket by the European Space Agency from their Kourou, French Guiana launch facility in January, 1990. They each occupied what would have otherwise been ballast space on the rocket!

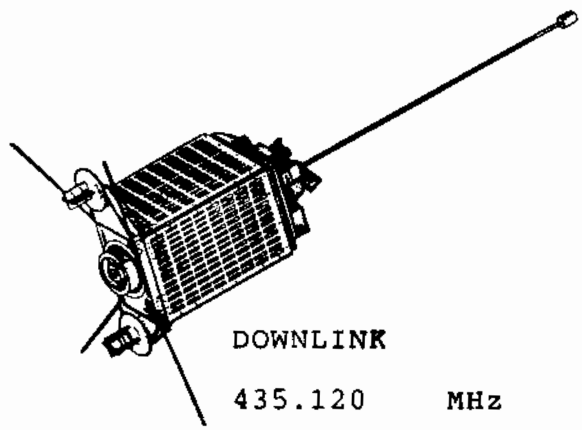
UO-14 OPERATOR NOTES:

UO-22

COUNTRY: U.K. NASA ID#: 21575 Intl: 91-50B Launched 17 Jul 1991

ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 98.5 Degrees
AVERAGE ALTITUDE: 770.9 Km
ORBITAL PERIOD: 100.2 Minutes



FREQUENCY AND MODE DATA:

	UPLINK	DOWNLINK	
9600 bps FSK (FM)	145.900	435.120	MHz
1200 bps AFSK (BACKUP)	145.900	435.120	

NOTES:

The newest of the UO series, UO-22's purpose is to support both amateur and non-amateur operation. It's primary non-amateur mission is to provide store-and-forward communications for a group called SATELLIFE. This organization was formed in 1985 to provide a non-profit electronic mail network for health professionals in developing countries. SATTELLIFE will use UO-22 to send and receive electronic mail and up-to-date medical literature to medical people in countries far removed from the larger population centers of the world. This store-and-forward medical communications technique is a direct application of store-and-forward communcations techniques developed and recently perfected using other satellites within the amateur satellite service.

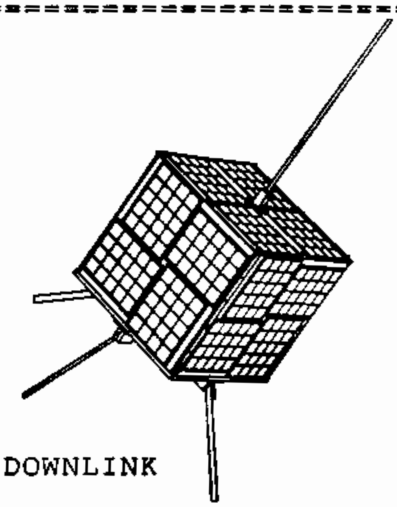
The amateur part of the mission will be similar to other UOSATS. Instead of providing a two way communcations service, it will transmit experimental data and telemetry. The most exciting aspect of this mission, however, will be it's use of an on-board charged-coupled device (CCD) camera. The camera has a 110 degree wide angle lens providing a field of view only slightly smaller than the satellite's communication "footprint". Images measure some 1600 by 1800 kilometers, yet provide a ground resolution of less than 2 km! As with other PACSATS, the modem and computer software requirements are different from normal terrestrial packet.

Many amateurs so equipped have been downloading UO-22 images and have been converting them into the more common VGA ".GIF" format. Several of these images have now found their way onto land-line computer bulletin boards, often listed under the "amateur radio echo" files area.

UO-22 OPERATOR NOTES:

AO-16 (PACSAT)

COUNTRY: USA NASA ID: 20439, Intl: 90-05D Launched: 22 Jan 1990



ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 98.6 Degrees
AVERAGE ALTITUDE: 793.7 Km
ORBITAL PERIOD: 100.7 Minutes

FREQUENCY AND MODE DATA:

	UPLINK	DOWNLINK	
AFSK (FM) 1200 bps **AX.25 Manchester**	**145.900, 145.920** **145.960**		**MHz**
Nominal PSK 1200 bps (SSB) **AX.25** BPSK		**437.02625**	
Raised Cosine 1200 bps (SSB) AX.25 BPSK		437.05130	
S Band 1200 bps **AX.25 BPSK**		2401.1428	

NOTES:

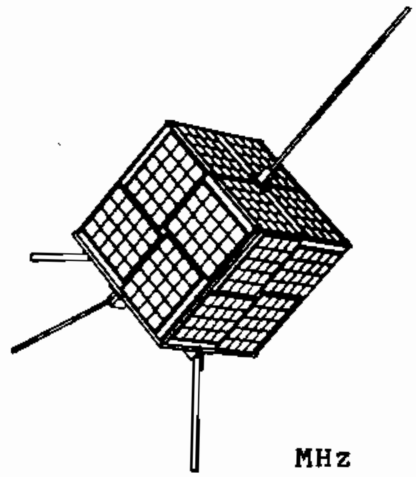
This **low Earth orbiter is essentially a "flying mailbox".** It's much like the packet BBSs most hams have used, except that the "host" computer is zipping along in low Earth orbit! It's not uncommon for hams in the USA to leave a message in the mailbox for a friend in Europe who then downloads it on the same or a following orbit! As with the UOSATs...a special packet modem is required to work this bird.

These satellites are called "MICROSATS" for good reason. PACKSAT, along with it's cousins, DO-17, WO-18, and LU-19 are small cubes measuring only 9 inches on an edge and weighing in at just under 20 pounds!

AO-16 OPERATOR NOTES:

DO-17 (DOVE)

COUNTRY: Brazil   NASA ID#: 20440, Intl: 90-05E   Launched 22 Jan 1990



ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 98.6 Degrees
AVERAGE ALTITUDE: 793.4 Km
ORBITAL PERIOD: 100.7 Minutes

FREQUENCY AND MODE DATA:

	DOWNLINK	
1200 bps AFSK (FM) AX.25 or Digital Voice	145.82516	MHz
1200 bps AFSK (FM) AX.25 or Digital Voice	145.82438	
1200 bps (BPSK) (1 watt)	2401.2205	

NOTES:

The DOVE (short for Digital Orbiting Voice Encoder) was designed as an educational tool to introduce school children (and the uninitiated) to amateur satellites. Unlike it's cousins, however, THIS ONE USES A STANDARD TERRESTRIAL FM PACKET MODEM for the 145 MHz frequencies! In addition, it's equipped with a digital voice encoder that, hopefully, will soon be activated. The idea was to build and fly a bird that required relatively simple equipment to receive. All that's required is a "normal" TNC packet modem and/or a "normal" 2 meter FM rig! However, before you get too excited, note that DOVE is a "downlink only" bird.

Now for some bad news. DOVE'S on-board computer "crashed" several months ago before it could be completely released for general use. Up to that point, it's 145.825 MHz "packet racket" was very strong on overhead passes, requiring only simple antennas to receive. I often got a copyable packet signal on my handheld...in the house! Information received was mostly telemetry, but a few one or two line "greeting" messages from it's Brazilian masters were also seen from time to time. I don't think the voice encoder was ever activated.

The good news is that DOVE is still very much alive! The 2400 MHz (S Band) command uplink/downlink was successfully reactivated soon after the "crash". As of this writing, work was underway by several dedicated hams to isolate and fix what appears to be a software problem. Once the software is fixed, DOVE's ground controllers plan to reload it's little brain (including voice software to make it "talk"!) and get the bird back up and operating for the rest of us to use and enjoy.

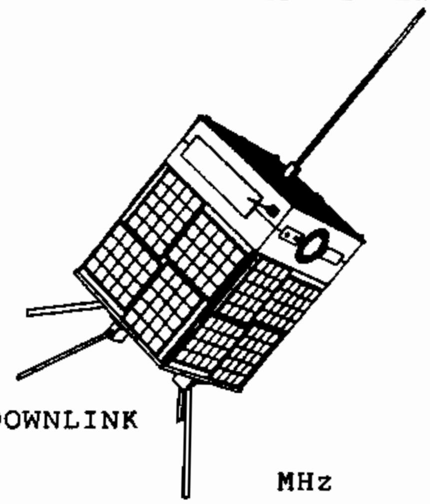
DO-17 OPERATOR NOTES:

WO-18 (WEBERSAT)

COUNTRY: USA NASA ID#: 20441, Intl: 90-05F Lauched 22 Jan 1990

ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 98.6 Degrees
AVERAGE ALTITUDE: 793.3 Km
ORBITAL PERIOD: 100.7 Minutes



FREQUENCY AND MODE DATA:

	UPLINK	DOWNLINK	
ATV NTSC (AM-TV)	1265.000		MHz
Nominal PSK 1200 bps BPSK (SSB) AX.25		437.07510	
Raised Cosine 1200 bps BPSK (SSB) AX.25		437.12580	

NOTES:

The WEBERSAT, built and controlled by hams at Weber State University in Utah, is an ATVer's delight! It carries an on-board Charged-Coupled Device (CCD) television camera that can "snap" a 350 x 350 kilometer Earth field of view. It can also register and store these pictures for later downloading. There are some scientific experiments on board as well.

Lately, the WEBERSAT has been sending back images of both the Earth and the Moon. There were some initial problems with the camera balance between light and dark, but these appear to be well on their way to resolution. However, like some of the rest of it's cousins, you'll need a special modem to decode both the telemetry and television images downlinked by WEBERSAT from orbit.

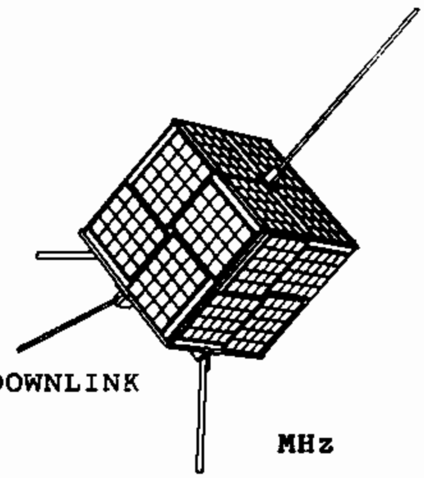
WO-18 OPERATOR NOTES:

LO-19 (LUSAT)

COUNTRY: Argentina   NASA ID#:20442, Intl: 90-05F   Launched 22 Jan 1990

ORBITAL DATA:

ORBIT TYPE: Circular (Polar)
INCLINATION: 98.6 Degrees
AVERAGE ALTITUDE: 793.1 Km
ORBITAL PERIOD: 100.7 Minutes



FREQUENCY AND MODE DATA:

	UPLINK	DOWNLINK	
1200 bps AFSK (FM) AX.25 Manchester	145.840, 145.860 145.900		MHz
Nominal PSK 1200 bps BPSK (SSB) AX.25		437.15355	

BEACONS

Raised Cosine 1200 bps BPSK (SSB) AX.25		437.12580
CW (12 WPM) Telemetry (750 mw)		437.125

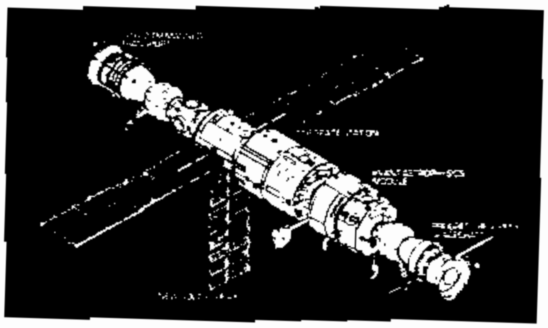
NOTES:

The LUSAT, like the PACSAT and UO-14, is another "flying mailbox". As with it's brethren, this low Earth orbiter also requires a special modem to downlink, and operates in much the same way.

LO-19 OPERATOR NOTES:

MIR

COUNTRY: USSR NASA ID: 16609, **Intl:** 86-17A Launched 18 Feb 1986



ORBITAL **DATA:**

ORBIT TYPE: Circular (Equatorial)
INCLINATION: 51.6 Degrees
AVERAGE ALTITUDE: 397.8 Km
ORBITAL PERIOD: 92.5 Minutes

FREQUENCY AND MODE DATA:

	UPLINK	DOWNLINK
1200 bps AFSK (KM) **AX**.25	145.55	145.55

NOTES:

U2MIR was very active **from the Soviet Space Station Mir** in 1991. The op until recently (named Musa) has been operating a packet BBS using normal terrestrial FM packet under the call "U2MIR-1". Musa returned to Earth in the **Summer** of 1991, but his replacement continued the packet BBS **tradition,** signing with the call **"U5MIR-1"**. Mir has been like an international **airport** recently, having had **visits** from a Japanese, a Briton, and most **recently,** an Austrian, who was **also** a ham and brought along some more amateur **gear for** the permanent occupants to use.

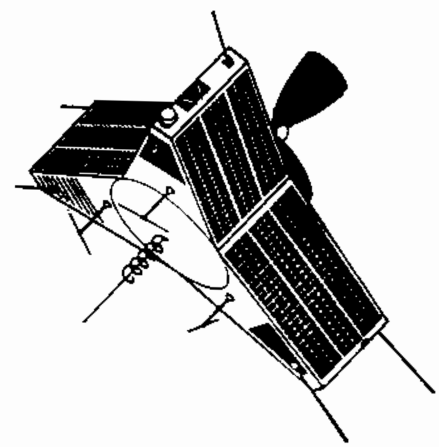
Connecting with the Mir takes patience. I got several "U5MIR BUSY'S" on multiple passes over several days before I finally got that coveted "CONNECT" on my screen. I've also heard U5MIR using voice on the 145.55 downlink, so you might listen for FM voice before you attempt a packet connect. Hearing perfect Russian coming from your 2 meter FM rig takes some getting used to!

Mir changes it's orbit frequently, based on the many scientific experiments it has on board. It's important to have the very latest set of Keplerian Orbital elements for use in your tracking. (More about what Keplerian elements are and how to obtain them in the final section).

MIR OPERATOR NOTES:

AO-10

COUNTRY: USA/Germany NASA ID#: 14129, Intl: 83-58B Launched 16 Jun 83



ORBITAL DATA:

ORBIT TYPE: Molniya (High Elliptical)
INCLINATION: 25.9 Degrees
PERIGEE ALTITUDE: 3895 Km
APOGEE ALTITUDE: 35550 Km
ORBITAL PERIOD: 11.65 Hours

FREQUENCY AND MODE DATA:

	MODE	UPLINK	DOWNLINK
CW/SSB	B	435.030 - 435.180	145.975 - 145.825
BEACONS			145.987, 145.810

NOTES:

Known as Phase IIIB before it's launch by the European Space Agency (ESA) in June, 1983, this OSCAR was designed for launch into a high elliptical orbit. This orbit, called a Molniya orbit, would place the satellite over one spot on the Earth for up to several hours at a time. This orbital configuration also meant that almost half of the Earth could "see" the satellite at the same time. Unlike the low Earth orbiting satellites that usually have a "footprint" on the Earth about the size of the United States, this satellite would enable consistent, long haul DX communication, because the "footprint" would now cover roughly half the Earth! This orbit would also virtually eliminate the frantic "hurry up" style of operating to which most amateur satellite operators had grudgingly become accustomed. The birds would now be visible from their QTH for hours on each pass, rather than just a few fleeting minutes!

But such luxury would not be without cost. At it's farthest point, the satellite would be over 25,000 miles away from Earth, meaning high gain antennas and higher power levels would be required to get a workable signal up and through the bird. Also, even though radio waves travel at the speed of light, the over 50,000 mile round trip would create a signal path delay of about 1/4 second on the downlinked signal. It would take some time for many satellite operators to get used to simultaneously speaking and listening to their own voices returning in their headphones a quarter second later!!

The first Phase IIIA launch ended in disaster when the Ariane booster malfunctioned, dropping the bird in the Atlantic. Phase IIIB, later to become Oscar 10, met with somewhat better fortune, surviving the launch and first burn of it's "kick" motor just fine. However, we later learned that Oscar 10 had bumped the booster upon separation, damaging one or more of its antennas. In addition, its tangle with the booster apparently caused other internal injuries, because the second and subsequent "kick" motor firings never happened. This left Oscar 10 in a lower inclination elliptical orbit...one that would not provide the intended coverage and stability nor the solar panel illumination needed to sustain full operations.

Within a few years, it also became evident Oscar 10's brain was beginning to go. Radiation hardened computer chips were not readily available when Oscar 10 was launched, and many believe radiation was now "frying" it's little brain as well.

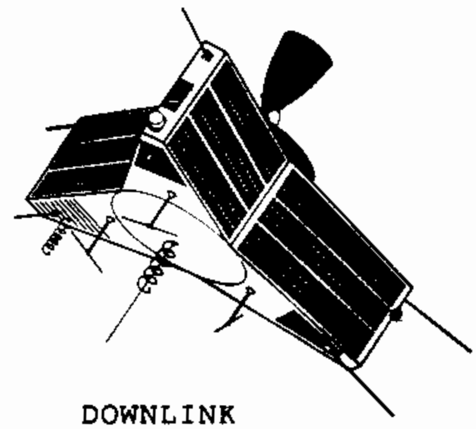
So today, Oscar 10 is "sort of" operational. It has long outlived it's estimated life, so we shouldn't complain. The bad news is that it is slowly tumbling and permanently stuck in mode B with only it's omnidirectional antennas working. Also, Oscar 10 must undergo long periods of dormancy while it's batteries slowly recharge from what little sunlight it's solar cells are now getting. The good news is that AO-10 still provides worldwide DX opportunities to those with a little patience, despite the fact that it is a tumbling, "brain dead" spaceframe stuck in an odd orbit!

First, listen for AO-10's 145.810 MHz beacon. It's a steady, unmodulated carrier. Best time to try and work the bird is just when it is rising or setting, as it's low power "omni" signals will be easiest to hear in that part of it's orbit. However, users are asked NOT to attempt to use the mode B transponder if the beacon is raspy or if it (or your downlink signal) appears to be FMing (shifting in frequency).

AO-10 OPERATOR NOTES:

AO-13

COUNTRY: USA/Germany NASA ID#: 19216, Intl: 88-51B Launched 15 Jun 88



ORBITAL DATA:

ORBIT TYPE: Molniya (High Elliptical)
INCLINATION: 56.6 Degrees
PERIGEE ALTITUDE: 734.9 Km
APOGEE ALTITUDE: 38074 Km
ORBITAL PERIOD: 11.44 Hours

FREQUENCY AND MODE DATA:

	MODE	UPLINK	DOWNLINK	
CW/SSB	B	435.420 - 435.570	145.825 - 145.975	MHz
"	J	144.425 - 144.475	435.990 - 435.940	
"	L	1269.330 - 1269.620	435.715 - 436.005	
"	S	435.601 - 435.637	2400.711 - 2400.747	
	RUDAK	1269.710	435.677	
	MODE B BEACON		145.812 & 145.985	
	MODE J & L BEACON		435.651	
	MODE S BEACON		2400.325	

NOTES:

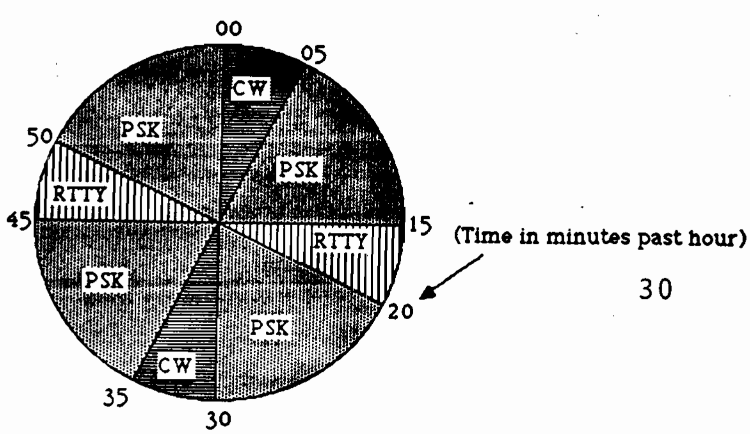
Launched in June, 1988, Oscar 13 is now carrying the bulk of the long haul DX available via amateur satellite. It is the current, and much improved brother, to Oscar 10. However, unlike it's older sibling, Oscar 13 managed to achieve it's intended Molniya orbit and become fully operational. Because of it's high elliptical orbit, it can be used by operators in both the Northern and Southern Hemispheres for hours at a time. In addition, the various transponders for each mode can be automatically turned on and off at different points in it's orbit. This helps optimize the mode in use with its corresponding downlink antenna gain.

For those interested in "chasing DX", AO-13 operation offers a whole new way to "work a new one". Active amateur satellite enthusiasts frequently operate from "rare" countries, and Oscar 13 is the "bird of choice" for many of the locals as well as for exotic DXpeditions. Within the last month, for example, I've heard operators in Togo and Iraq, quite literally, beg for contacts! "Pileups" similar to those on the lower bands, where the din grows ever louder as more and more kilowatts are thrown into the fray, are rare. Satellite transponders tend to equalize downlink signal strengths, so a higher power uplink really doesn't help you much. (More about THAT "no-no" in the "operational notes" section!) Rather, satellite DX operations are much more neat and orderly, where anyone who's signal is above the noise level usually has an equal chance to work the "rare" one.

For those who are not equipped with steerable antennas, Oscar 13's beacon can often be heard on a simple 2 meter vertical antenna as the satellite rises and sets. In addition, those desiring to actually work AO-13's mode B transponder without a steerable antenna will find the times that the satellite rises and sets as the best time to try your hand at it. There are three reasons for this. First, at these times, the satellite is relatively close to the Earth (and your QTH!) Second, the satellite's high-gain directional antennas are usually shut off, which eliminates much of the downlink QSB (called "spin modulation") caused by the motion of the satellite. Third, the satellite is positioned within the optimum beamwidth (ie, close to the horizon) of your normal terrestrial antennas. Long before I erected my current satellite antennas, I made several contacts through both AO-10 and AO-13 using Ringo Ranger antennas on 440 and 2 meters that were simply side-mounted to my HF tower. Granted, my signal wasn't strong...but I was strong enough to complete a contact!

Oscar 13 is not currently configured to operate the RUDAK experiment. However, Modes B, J, L, and S are being supported. The beacon can be heard sending RTTY, CW or PSK (which has a "growling" sound). The CW beacon is slow ... about 5 WPM... so it can be easily copied. The CW beacon lists AO-13's transponder schedule and other bulletins.

AO-13 BEACON SCHEDULE:



AO-13 OPERATOR NOTES:

OPERATIONAL NOTES

In order to communicate through an amateur radio satellite, you first have to FIND it! There are many ways to do this. One can simply tune the beacon frequency in on a receiver and wait for the satellite to pass overhead. Most low Earth orbiting (LEO) amateur radio satellites are in polar orbits. That is, they move from south to north (or north to south) over the Earth's poles. They also tend to make an overhead, or near overhead, pass over a specific point on the Earth twice a day. Once you've heard the bird, you can pretty well tell that it will be passing overhead again roughly twelve hours later. This "hit or miss" approach works fine for casual monitoring and operation. However, serious satellite work requires something more sophisticated.

Back in the days before personal computers, many satellite operators used a simple graphic tool called an OSCARLOCATOR. If you knew certain things about the satellite's orbit, you could then compute and plot the orbital path with your OSCARLOCATOR. The azimuth and altitude information thus derived helped you aim your antennas as the bird passed overhead. A few satellite operators still rely on their trusty OSCARLOCATORs and if you don't have ready access to a personal computer, this tool will work nicely.

With the advent of personal computers, however, tracking satellites has become much easier. Today, several satellite tracking programs are available, as shareware as well as purchased software, in a variety of different computer formats. AMSAT, a registered trademark of the Radio Amateur Satellite Corporation, an international nonprofit group that builds and supports many of the amateur satellites we use, is an excellent source for many of these programs. I'll talk more about AMSAT in a bit.

If you're really serious about satellite tracking, you should also find a reliable source for updated Keplerian elements. "Keps", as they are commonly called, are derived from observations of each satellite's orbital motion. (Kepler, you may recall, discovered some interesting things about planetary motion back in the 17th century!) Today, NORAD, the North American Aerospace Defense Command, keeps track of most everything in Earth orbit. Periodically, they issue this information to the National Aeronautics and Space Administration (NASA) for release to the general public. The information is listed by individual catalog number of the satellite (that's the "NASA ID#" I've included with each satellite's description in the text!) and contains a series of numeric indicators that describe how the satellite is moving around the Earth.

Without getting into the complex details of orbital mechanics (or Kepler's laws!), suffice it to say that these indicators are what your computer software (or your OSCARLOCATOR calculations) use to update and plot the predicted paths of satellites. The latest Keplerian elements for amateur radio satellites are often listed on many dial-up and amateur radio packet bulletin boards, or they can be obtained from AMSAT, the ARRL (if you include a return envelope!) or from NASA directly.

Now that you've found the satellite, and have a reliable way to know when it's in range of your QTH, you next have to learn how to work through its transponder. A transponder is the circuit that receives your uplink signal and then retransmits it on the downlink...much like your local FM repeater does. However, unlike your repeater, which has a specific input and output frequency, a transponder receives and then retransmits A WHOLE BAND of frequencies...commonly called the "passband". Satellite transponders come in many "flavors". Voice transponders are usually classed as inverting or non-inverting. If the satellite has a non-inverting transponder, when your uplink frequency is on the high end of the uplink passband, your downlink signal will also be in the high end of the downlink passband. Conversely, in an inverting transponder, when your uplink frequency is on the high end of the uplink passband, it will get inverted and come out on the lower end of the downlink passband. Put another way, inverting transponders make mirror images of the signals they pass. This holds true for the sideband sense as well. In an inverting transponder, LSB signals come out as USB signals (which, by the way, is the common operating preference on most inverting amateur satellite transponders!) Fortunately, CW will be CW regardless of the transponder's variety! Note that RS-10, RS-12 and FO-20 use non-inverting transponders. AO-10, AO-13, and AO-21 use inverting transponders.

Common operating practice on amateur satellites with linear transponders is to first listen for your own signal on the downlink. One of the first things you will discover is that working through a satellite transponder is a full duplex operation, much like talking on a telephone. This means that others can usually hear you as well as you are hearing yourself. Finding your own signal on the downlink the first few times can be tricky. However, I've found that placing your transmit frequency somewhere in the transponder's passband and then tuning your RECEIVER while transmitting on the uplink to find yourself works best. This also prevents swishing your transmit frequency (a big "no-no"!) across other QSOs that may be already going on in the passband. Once you've located your signal, calling CQ is acceptable, and the convention of CW operations in the low end of the passband with phone operation in the upper part of the passband generally holds for satellite work as well.

Since a satellite is a moving target, you can also tell rather quickly when (or if) your signals are going through the transponder, particularly on the low Earth birds. The signals will exhibit a pronounced doppler shift, just like the changing pitch of a train whistle as it approaches and then passes. Common practice during a satellite QSO is to slowly shift your TRANSMIT frequency on the uplink as the doppler effect shifts your downlink signal. This will also prevent an inadvertent shift of your QSO into someone else's QSO.

Next, a word about signal strength and signal reports. While signal reports and S-meter readings are often exchanged on satellite contacts, they have to be "taken with a grain of salt". That's because downlink signal strengths have to be considered in relationship to the satellite's position, the pointing angle of it's antennas (also called the "squint angle") as well as the satellite's current load. In addition, the number of other QSOs going on in the passband at the same time as yours and the power available for the transponders (not to mention the rest of the satellite) will directly affect EVERYBODY'S downlink signal. As you might guess, these conditions all change radically as the satellite moves through it's orbit. It's quite possible to have your downlink signal be "king of the hill" using a low power uplink during one QSO and then down in the noise with the same power level during the next.

In addition, if either operator has a receiver pre-amplifier in line (as is often the case for AO-10 and AO-13 operation) then the downlink S-meter reading becomes even more suspect! Even "low-noise" preamplifiers tend to shift the S-meter reading upward. This means if you have a noise level from a pre-amplifier generating an S-4 reading, then an S-6 signal ought to get an S-2 report...not an S-6! Bottom line: Satellite work is weak signal work. What's most important is for your downlink signal to simply be strong enough to be readable...period.

With this in mind, and as the on-board power to run a satellite's transponder is not usually large to start with, it's VERY important to UPLINK WITH ONLY ENOUGH POWER TO PRODUCE A READABLE (ABOVE THE NOISE) DOWNLINK SIGNAL! Overpowering your uplink signal beyond this point will not appreciably improve the strength of your downlink signal. It will, however, "pump" the satellite's AGC and reduce the overall downlink power available for others using the transponder. Unfortunately, all it takes is one overpowered uplink signal to drastically cut the strength of everyone else's downlink signal. As you might expect, such activity will NOT make you a popular camper, for "crocodiles" are about as welcome on the birds as "lids" are elsewhere in amateur radio! It follows that if you're looking for an "S-9 plus" ego trip, you WON'T find it working the Oscars!

So how much power is enough? Most of the low Earth orbiters (like RS-10, RS-12, the PACSATS, as well as AO-21 and FO-20) can be easily worked with simple antennas and a few watts. I've met with great success on the RS birds using nothing more sophisticated than a Ringo Ranger and about 5 watts of power on the Mode A uplink (and an old tube-type HF rig hooked to a dipole on the downlink). 10 to 20 watts to a vertical or beam antenna (including the old "wire-coat-hanger" variety) on the 2m or 440 uplinks to these birds should be more than enough to be heard well above the noise without excessively pumping the transponder.

Working through AO-10 and AO-13, however, takes a little more power, more specialized high gain antennas, and a lot more finesse to produce a reliable uplink signal. Here, the answer to the "how much power?" question depends more on what you hear and the relative signal strength between your own downlink and that of another signal. As the differences in antenna configuration, distance from the Earth, operating mode requirements, battery condition, useage and orbital parameters of these birds are so great, knowing how much power to use on these uplinks can be a real challenge. One rule of thumb that I've found helpful is to first listen for and then note the signal strength of the satellite's beacon. I then adjust the output power of my uplink signal so that my downlink signal strength through the transponder is never greater than that of the beacon. Using this technique, I've found I've needed as little as 5 watts, and sometimes as much as 90 watts, to achieve the same downlink signal strength as the beacon through AO-10 or AO-13. While not absolute, in most cases use of this technique will help prevent you from "hogging" the satellite's precious downlink power from others.

Another BIG "no-no" is running FM through the voice transponder. FM signals occupy a much larger bandwidth and take a significantly greater portion of the transponder's precious output power than do CW and SSB signals. While some have met with moderate success through RS-10 by keying the PTT circuit on an old 2 meter FM radio, this often produces a wide (and VERY "chirpy"!) CW signal on the uplink. Either way, your signals will gobble up lots of downlink power, and stick out like a sore thumb. Just imagine how obnoxious you would sound running sideband through your local FM repeater and I think you'll catch my drift! There's a lot of good, used, all-mode VHF/UHF gear on the market these days. To avoid others questioning your birthright, I strongly suggest you resist the temptation for "cheap charlie" workarounds until you're equipped to use the birds in the manner for which they were designed.

And finally, a word about AMSAT. Satellite operators usually think of AMSAT much like their local repeater group. Most of us who have used VHF or UHF FM repeaters for a while know that it takes resources....time, effort, and MONEY.....to keep the local machine up and on the air. An amateur radio satellite is, in many ways, simply another repeater. However, these repeaters are placed on a lot higher "ground" and take hundreds, if not thousands, of hours of donated effort and resources by hundreds of people to build and launch one. Even though much of the labor and materials to put one together are donated to the cause, launch costs are now being measured in the millions of dollars. That's where AMSAT comes in. While hams by no means must be members of AMSAT to use any of the birds (AMSAT puts them up there for ALL of us to use and enjoy), it follows that if you become a regular satellite user, then you should feel the obligation to share the burden of their birth and upkeep. Your membership in AMSAT is the best way to insure new birds will continue to be built and launched. In addition, AMSAT publishes a WEALTH of knowledge in printed form and offers deep discounts on computer software programs for it's membership. Put another way, the nominal cost of AMSAT membership is a small price to pay to perpetuate an activity that's, quite literally, out of this world!

So there you have it. I hope this primer has been helpful in giving you some tips on how to listen for and use amateur radio satellites. It may take some time, effort and a nominal investment to get your first satellite station up and running. However, as you've probably seen by now, you may already have some or most of it assembled if you've done any HF work at all.

The first time you hear your own voice come back down through a satellite transponder can be as thrilling as your first amateur QSO..."sweaty palms" and all!! It was for me.

See you on the birds!

BIBLIOGRAPHY

The following are excellent reference works for those who want more information about the amateur radio satellite program. Copies of these documents can usually be obtained from the Radio Amateur Satellite Corporation, P.O. Box 27, Washington, D.C., 20044 and/or the American Radio Relay League, 225 Main Street, Newington, CT 06111.

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