Working the Easy Sats

An Informal Introduction to the Amateur Satellite Program

and

Hints on Getting Started Using the More Easily Accessed Satellites

by

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Forward

This document was created as an attempt to provide a simple easy to read introduction to the Amateur Satellite Service and easily used "birds" now in operation. Why did I undertake this task? Simply put, I wanted to share the enjoyment I receive operating the satellites. I'll tell you up front, this type of operation isn't for everybody. Some people will find it too boring, some may see it as too much effort for the pay-off, and others may not like the fact that they can't work the birds whenever they want. Satellites are but one aspect of the total amateur radio picture. If you think you may want to give it a try, please do. You may find, as I did, that other operating habits and pursuits get pushed to the back seat. I also want to dispel the myth that getting on the satellites is expensive. True, it can suck your wallet dry if you let it, but name any other part of ham radio, or any other hobby for that matter, that won't. It need not be that way. I will be concentrating on the "Easy Sats", those satellites that do not require lots of extra hardware or big high gain directional antennas. These satellites can be worked very well with no more equipment than many hams already own.

I am only able to offer observations, hints, explanations, etc., on those facets of the hobby in which I am involved. So far, I have limited my efforts to the LEO's (Low Earth Orbit satellites), mainly on voice but with some digital work, so I am most able to speak of those. I have no first hand knowledge of AO-10 other than what I have read or by occasionally monitoring its downlink. Besides, this "bird" doesn't really fit into the category of "easy" and is beyond the scope of this paper. I will also be avoiding discussion of the digital satellites now in operation, as they require more specialized equipment.

This work is very personal. It details what I learned while trying to set up my satellite station. To that end, I ask that you view it as such. I am basically saying "I did it. You can, too. Come join the fun!"

Hope to hear you on the birds soon!

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Please note: I wrote this paper using Windows Write with an 11 pt. Arial font and a printer driver for the Cannon BJ-610 printer set at 360 dpi. As with all WYSWIG documents, what I print may not be the same as what you print. If you make a hard copy, feel free to repaginate and reset margins as necessary but please pass on any "soft" copies in the original format.

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An Introduction to the Satellites

Are you ready to get started? Great! Since this is the Amateur Satellite program, let's have a look at the Amateur Satellites. The first thing we'll notice is that there are quite a few of them and no two are exactly the same. Fortunately, there are enough similarities among some of the birds that we can conveniently group them. For lack of any better reason than this is how I think of them, I have divided all of the active satellites into the following four categories. Some of the satellites appear more than once because they operate in more than one manner.

1) Low Earth Orbit - Analog (CW and Voice)
   RS-10, RS-12, RS-15, FO-20, AO-27, FO-29
2) Low Earth Orbit - Digital
   AO-16, DO-17, WO-18, LO-19, IO-26, FO-29 (1200 Baud)
   UO-22, KO-23, KO-25, PO-28, FO-29 (9600 Baud)
3) High Earth Orbit
   AO-10
4) Occupied Spacecraft
   Mir/SAFEX II, SAREX (Space Shuttle)

At this time, nearly three quarters of the Amateur Satellites fall into the group we call "LEO - Low Earth Orbit". If we include the Occupied Spacecraft, which share the same orbital characteristics, we're left with only AO-10. One common feature of these birds is that they circle the earth many times a day and are usually available two or three times during one part of the day and as many times about 12 hours later. Due to their low orbit, and the sensitive receivers they all possess, directional antennas and lots of power are not required. Many Hams already own the equipment needed to work the satellites, they just don't realize it. That's one of the reasons I have written this paper.

Unfortunately, a disadvantage to a low orbit is that the satellites' footprints (area "seen" by the satellite at any one time) are small and their passes are short. Consequently, people who use these birds generally limit themselves to very short QSO's or even use the quick contact format similar to that used during contests. Do not let this dissuade you from trying them, however. They really are easy to use, and some of them, the Russian birds we call the RS series (for Radio Sputnik), are also relatively inexpensive to get on.

Since this is an introduction to the satellites, I'll be concentrating on what we call the Easy Sats. What defines an Easy Sat? Well, how about:

1) Easy to hear?
2) Easy to aim your antennas? (Not necessary if you're using omni's!)
3) Easy on the check book?

There are presently six analog satellites (RS-10, RS-12, RS-15, FO-20, AO-27, FO-29), one digital satellite (DO-17), and the two Occupied Spacecraft that meet these requirements. It is on these that we will concentrate. By the way, by "Easy on the check book" I mean that nothing is required to work these birds that can't be used for standard terrestrial Hamming: An HF radio and a 2m radio (preferably a multi-mode). Optional are a packet station for digital work and receive preamps. To be honest, maybe we should call FO-20, AO-27, and FO-29 "Almost Easy Sats" because they require a receiver, transceiver or receive converter for 70cm.

Now let's take a quick look at the satellites that are presently active in the Amateur Satellite Service. This chart is an expanded version of the ARRL Mail Server document SATFREQS.TXT. I have divided the satellites into the four categories I used above.

Amateur Radio Satellite Frequencies

Additional notes follow list

<u>Low Earth Orbit - Analog</u>

Designation	Frequencies (in MHz)	Transp/ Beacon	Mode	Notes (1)
RS-10 (RS-10/11, NORAD 18129) (2)				
Downlinks	29.357	B		CW
	29.360-.400	T	A	CW/SSB
	29.403	B		CW (Robot)
Uplinks	145.860-.900	T	T	CW/SSB
RS-12 (RS-12/13, NORAD 21089) (2)				
Downlinks	29.408	B		CW
	29.410-.450	T	K	CW/SSB
	29.454	B		CW (Robot)
	145.910-.950	T	T	CW/SSB
Uplinks	21.210-.250	T	K	CW/SSB
RS-15 (NORAD 23439)				
Downlinks	29.352	B		CW
	29.354-.394	T	A	CW/SSB
Uplinks	145.858-.898	T	T	CW/SSB
FO-20 (Fuji-OSCAR 20, NORAD 20480) (2)				
Downlinks	435.795	B		CW
	435.800-.900	T	J	CW/SSB
Uplinks	145.900-146.000	T	J	CW/SSB
AO-27 (OSCAR 27, AMRAD, NORAD 22825) (3)				
Downlink	436.800		J	FM Voice
Uplink	145.850		J	FM Voice
FO-29 (Fuji-OSCAR 29), NORAD 24278)				(also see 1200 and 9600 Baud)
Downlinks	435.795	B		CW
	435.800-.900	T	J	CW/SSB
Uplinks	145.900-146.000	T	J	CW/SSB
Downlink	435.910	B		FM Voice digitalker
Downlink	435.795	B		12WPM CW telemetry

Low Earth Digital
(1200 Baud) (4)

AO-16 (OSCAR 16, Pacsat, Microsat-A, NORAD 20439)

Downlinks	437.02625	T/B	J	1200 bps PSK SSB (sec.)
	437.05130	T/B	J	1200 bps PSK SSB (pri.) (Raised Cosine)
	2401.14280	B		1200 bps PSK SSB (Usually off)
Uplinks	145.900	T	J	1200 bps AFSK FM
	145.920	T	J	1200 bps AFSK FM
	145.940	T	J	1200 bps AFSK FM
	145.960	T	J	1200 bps AFSK FM

DO-17 (OSCAR 17, DOVE, Microsat-B, NORAD 20440)

Downlinks	145.82438	B		1200 bps AFSK FM/Dig Voice
	145.82516	B		1200 bps AFSK FM/Dig Voice
	2401.22050	B		1200 bps PSK (usually off)
Uplinks	None			

WO-18 (OSCAR 18, Webersat, Microsat-C, NORAD 20441)

Downlink	437.10200	B		1200 bps PSK (Telem,Image)
Uplink	None			

LO-19 (OSCAR 19, Lusat, Microsat-D, NORAD 20442)

Downlinks	437.125	T/B	J	1200 bps PSK SSB (secondary)
	437.127	B		CW
	437.154	T/B	J	1200 bps PSK SSB (primary)
Uplinks	145.840	T	J	1200 bps AFSK FM
	145.860	T	J	1200 bps AFSK FM
	145.880	T	J	1200 bps AFSK FM
	145.900	T	J	1200 bps AFSK FM

IO-26 (ITAMSAT, IO-26, NORAD 22826)

Downlink	435.867	T	J	1200 bps PSK SSB
Uplinks	145.875	T	J	1200 bps FM Digital
	145.900	T	J	1200 bps FM Digital
	145.925	T	J	1200 bps FM Digital
	145.950	T	J	1200 bps FM Digital

FO-29 (Fuji-OSCAR 29, NORAD 24278) (also see Analog and 9600 baud)

Downlink	435.920	T	J	1200 bps PSK SSB
Uplink	145.850	T	J	1200 bps AFSK FM
	145.870	T	J	1200 bps AFSK FM
	145.890	T	J	1200 bps AFSK FM
	145.910	T	J	1200 bps AFSK FM

Low Earth Digital
(9600 Baud) (5)

UO-22 (OSCAR 22, UoSAT, UoSAT-F, NORAD 21575)

Downlink	435.120	T	J	9600 bps FM
Uplinks	145.900	T	J	9600 bps FM
	145.975	T	J	9600 bps FM

KO-23 (OSCAR 23, KITSAT-A, NORAD 22077)

Downlink	435.175	T	J	9600 bps FM
Uplinks	145.850	T	J	9600 bps FM
	145.900	T	J	9600 bps FM

KO-25 (KITSAT-B, NORAD 22828) (6)

Downlink	435.175/436.500	T	J	9600 bps FM
Uplink	145.870/145.980	T	J	9600 bps FM

PO-28 (POSAT, NORAD 22829)

Downlink	435.278	T	J	9600 bps FM
Uplink	145.975	T	J	9600 bps FM

FO-29 (Fuji-OSCAR 29, NORAD 24278) (see also Analog and 1200 Baud)

Downlink	435.910	T	J	9600 bps FM
Uplink	145.870	T	J	9600 bps FM

High Earth Orbit

AO-10 (OSCAR 10, Phase 3B, NORAD 14129)

Downlinks	145.810	B		CW
	145.825-.975	T	B	CW/SSB
	145.987	B		CW (Usually off)
Uplinks	435.029-.179	T	B	CW/SSB

Occupied Spacecraft

Mir/SAFEX II (NORAD 16609) (7,8)

Downlink	145.800	T	FM Voice from Cosmonauts
Uplink	145.200	T	FM Voice to Cosmonauts
Downlink	145.800	T	1200 bps AFSK FM Digital
Uplink	145.200	T	1200 bps AFSK FM Digital
Downlink	437.95	T	FM Voice Repeater down
Uplink	435.75	T	FM Voice Repeater up
Downlink	437.975	T	9600 bps FM Digital down
Uplink	435.775	T	9600 bps FM Digital up
Downlink	437.925	T	FM Voice with crew, bulletins
Uplink	435.725	T	FM Voice with crew, up

Space Shuttle/SAREX (9)			
Downlink	145.55	T	FM Voice from Astronauts
Uplink	144.91	T	FM Voice to Astronauts
	144.93	T	FM Voice to Astronauts
	144.95	T	FM Voice to Astronauts
	144.97	T	FM Voice to Astronauts
	144.99	T	FM Voice to Astronauts
Uplink	145.55	T	1200 baud AFSK FM Digital
	144.99	T	1200 baud AFSK FM Digital

Notes: (1) Mode refers to the uplink/downlink band pair used, and is designated with a letter. Modes presently used are:

A 145 MHz up / 29 MHz down
B 435 MHz up / 145 MHz down
JA 145 MHz up / 435 MHz down - Analog modulation
JD 145 MHz up / 435 MHz down - Digital modulation
K 21 MHz up / 29 MHz down
S 435 MHz up / 2.4 GHz down
T 21 MHz up / 145 MHz down

Some satellites operate in more than one mode at a time, i.e. RS-12 in mode KT.

(2) RS-10 is a piggy-back package attached to COSMOS 1861
RS-12 is a piggy-back package attached to COSMOS 2123
FO-20 is a piggy-back package attached to JAS 1-B

(3) AO-27 is a dual purpose satellite, and is only available for Amateur Radio use at specific times. The parent satellite is EYESAT-1.

(4) All 1200 baud satellites except DOVE, WO-18, and FO-29 require the use of PACSAT protocol software such as PB/PG for DOS or WiSP for Windows. DOVE may be monitored with standard packet software. WO-18 needs Weberware. All 1200 baud satellites except DOVE require a PSK modem and SSB receiver.

(5) All 9600 baud satellites except FO-29 require the use of PACSAT protocol software such as PB/PG for DOS or WiSP for Windows. FO-29 may be accessed using standard packet software.

(6) Some element sets list NORAD 22830 for KO-25, but careful study since launch has determined that 22828 is the correct object.

(7) It is necessary to compensate for Doppler shift on both the uplink and downlink frequencies for the 70cm SAFEX II equipment. The 70cm voice frequencies require a 141.3 CTCSS (repeater) and 151.4 (QSO with crew) tone for access

(8) The 1200 and 9600 baud digital systems on Mir may be accessed using standard packet software.

(9) The astronauts listen to only one uplink frequency at a time and do not announce which one is presently active. The 1200 baud digital system may be accessed using standard packet software. SAREX is not active on all Shuttle missions.

The NORAD number listed by each satellite is a designation assigned by the North American Air Defense Command, a cooperative international group that includes among its duties the tracking of all space borne objects. This number is used by all popular tracking and pass prediction software to identify which satellites to process. As each mission's orbital profile is different, the Shuttle has not been assigned a permanent NORAD number.

Definitions

Before we go any further, we need to establish a common vocabulary. Some people would put this in the back, as an appendix or something, but let's face it, there are a lot of words and terms that we'll be using, some of them unique to the satellites.

ANALOG: A type of transmission where the intelligence (voice, CW, SSTV, etc.) is used to directly control the output of the transmitter. The opposite of DIGITAL.

AOS: Acquisition of Signal. This is the moment when the satellite comes into range and can be accessed. The easiest way to know you have achieved AOS it to listen for the beacons on the satellites that have them. The opposite of LOS.

APOGEE: The point in a satellite's orbit where it is farthest from the earth.

AZ/EL: Azimuth/Elevation. Used to describe the present location in space of a satellite. The Azimuth is the compass direction from the viewer and the elevation is the angle above ground. Also used to describe the type of hardware able to position antennas in both the horizontal and vertical planes.

BEACON: An automatic transmitter at the satellite. The beacon is usually located at the high or low end of the pass-band and will send out satellite identification and telemetry. Most beacons use CW.

BIRD: A common slang term for a satellite.

DIGITAL: A method of transmission where the intelligence is processed by some type of modem (a TNC, for example). Digital satellite communications are usually confined to the LEO packet satellites. The opposite of ANALOG.

DOPPLER SHIFT: The change in frequency of a received signal due to the motion of the satellite. This requires adjustment of the transmit or receive frequency, with the common practice being to change the higher of the two frequencies in use.

DOWNLINK: The transmission from the satellite to the earth station.

EARTH STATION: The equipment used to communicate with or through a satellite or spacecraft. Special earth stations, known as Control Stations or Command Stations, are able to manipulate the workings of the satellite.

FOOTPRINT: The area of the earth's surface which is visible to the satellite at one time. Generally speaking, the lower the orbit, the smaller the footprint.

FULL DUPLEX: The ability to transmit and receive at the same time. This is the preferred method in satellite operations because it allows us to hear our own signal and make frequency adjustments as necessary. (See DOPPLER SHIFT)

HALF DUPLEX: Using different frequencies to transmit and receive, but being able to do only one of those functions at a time. An example of half duplex operation is the use of a single HF transceiver for Mode K. Not to be confused with SIMPLEX.

INCLINATION: The angle of an orbit in relationship to the equator. Orbits with a low inclination are called equatorial orbits; those with higher inclinations are called polar orbits.

KEPLERIAN ELEMENTS (KEPS): A set of numerical data that describes a satellite's orbital characteristics. The use of this information allows tracking programs to determine where that satellite is at any one time, to predict passes, and plot ground tracks. Keplerian elements should be updated every few weeks for stable orbits and more frequently if the object's orbit is accidentally (re-entry or collision with another object) or purposely altered (orbital corrections or space craft maneuvers).

LEO: Low Earth Orbit. A name given to satellites with orbits in the 600 to 2000 kilometer altitude range. The LEOs normally circle the earth about every 1.5 to 2 hours. Their low altitude gives rise to a small footprint and their speed causes the pass to be of short duration.

LOS: Loss of Signal. The moment when the satellite can no longer be heard.

MODE: An indication of the operational parameters of a satellite, including frequencies used and types of modulation. These are noted with a series of letters.

A: 145 MHz up / 29 MHz down. SSB and CW.

B: 435 MHz up / 145 MHz down. SSB and CW.

JA: 145 MHz up / 435 MHz down. SSB and CW. The A means Analog.

JD: 145 MHz up / 435 MHz down. FM Packet uplink. PSK downlink on 1200 baud satellites, FM Packet on 9600 baud satellites. The D means Digital.

K: 21 MHz up / 29 MHz down. SSB and CW. In the US this mode is limited to Advanced and Extra Class licensees.

S: 435 MHz up / 2.4 GHz down. SSB and CW. Many people use receive converters for the downlink.

T: 21 MHz up / 145 MHz down. SSB and CW. Not much available for this any more, but sometimes RS-12 will be in this mode, or mode KT, with a 21 MHz uplink and downlinks on both 29 MHz and 145 MHz.

With the launch of Phase 3D in 1997, this type of designation will become obsolete. P3D will employ a matrix of receivers and transmitters which will be engaged at various times, so the shorter one or two letter combinations will be replaced with an indication of which TX and RX pair is active. For example, Mode J will become Mode V/U, for VHF up/UHF down.

MOLNIYA: A type of elongated orbit where, as the satellite nears its apogee, it seems to be almost motionless for long periods of time. Very good for long distance contacts.

OSCAR: Orbiting Satellite Carrying Amateur Radio. The original name for the satellite program. Project OSCAR was later replaced by AMSAT but the name still remains in the designations.

PASSBAND: When used in reference to a TRANSPONDER, defines the amount of radio spectrum that a receiver will accept and, consequently, the amount of radio spectrum a satellite's downlink will occupy.

PERIGEE: The point in a satellite's orbit where it is closest to the earth.

REPEATER: A radio system that receives a radio signal on one frequency and retransmits it on another, usually on a different band. Repeaters work with one signal at a time and should not be confused with a TRANSPONDER.

STORE & FORWARD: Technique used with the digital satellites in which a message or file is transmitted up to a satellite where it is stored. This information is then retransmitted and received by another station who requests it. Very similar to having a friend upload a file to your favorite telephone or packet BBS and letting it sit until you are able to log on and retrieve it.

TRACKING: The process of continuously adjusting the direction of antennas to keep them aimed at a moving satellite. Also the use of a computer program to generate and/or display the position of the satellite. Some of the more advanced satellite operators have the computer linked to the antenna aiming control boxes so this function is done without human intervention.

TRANSPONDER: Similar to a repeater, but a range of frequencies is converted from one band to another. This range of frequencies is known as the PASSBAND of the transponder. There are two types of transponders: Non-Inverting and Inverting. A Non-Inverting transponder will receive an USB (Upper Side Band) signal at the high end of the Uplink Passband and it will appear as an USB signal at the high end of the Downlink Passband. Examples of a Non-Inverting transponder are RS-10, RS-12, and RS-15. With an Inverting Transponder, to receive that same high end USB signal, you would transmit a LSB (Lower Side Band) signal at the lower end of the Uplink Passband. Examples of Inverting transponders are AO-10, FO-20 and FO-29.

UPLINK: The signals from the ground station to the satellite.

Special Considerations

I can hear you thinking "Whoa! I thought you said these were easy to work! That whole list of satellite specific words sure doesn't look easy to me!" There really isn't a problem here. All of these will come as second nature once you get on the birds. Like many things in life, it's hard to understand something if you don't know the terms. There are a few concepts we really should spend more time discussing, though, because they are unique to satellite operation. If we aren't at least familiar with them, getting started will be much more difficult

The biggest difference between satellite communication and the type of Hamming we are all used to is that you can't just pick up the microphone, start talking, and expect someone to be there listening. Working a satellite is more like working DX or holding a schedule with another Ham. For example, maybe you want to talk to your friend in another state. On HF you would ask yourself "What band can I use to get there and when will it be open?" You ask much the same thing on the satellites only it would be "What satellite can I use with my equipment and when will it be in a location where it is visible to us both?" Well, let's assume you have a station set up for Mode A. You know that Mode A is available on RS-10 and RS-15, so you fire up your computer, load your favorite pass prediction program, and see that you have a common window of visibility at 1330UTC on RS-10. At the appointed hour you fire up the radios and start talking to your friend.

Well, not really, and what's all this about computers and what are pass prediction programs? By their very nature, the LEO's are constantly moving. This can create quite a problem unless you have a way to determine where they will be at any given minute. There is a lot of math involved and you need to know such things as altitude, speed, direction, drag coefficient, and a bunch of other goodies that describe exactly a satellite's orbit. This information is generated by USSPACECOM and distributed through a variety of networks and can be downloaded from many bulletin boards. Fortunately, the orbital parameters of a satellite varies little on a day by day basis, so updating these Keplerian Elements (that's what they are called) only needs to be done every few weeks. In the days B.P.C. (Before Personal Computers), people had to manipulate this information by hand or with a calculator. Now programs exist that will take these elements, do all of the computations for you, and generate a list of pass opportunities. Most of the better ones will even show you this graphically. The quality of these programs varies, as do their hardware requirements and cost. Prices can range from free up to $90 or so and, depending on what you need, your computer could range from a monographics equipped AT to a Super VGA Pentium system. You will need an accurate clock for real-time tracking, and you should know your geographical coordinates (latitude and longitude). Don't worry too much about the latter; the better programs have a list of sites built in and you just need to pick your nearest major city. You will often hear this pass prediction called "tracking."

So now we know what satellite and when it will be coming over. We're ready, right? Well, we would be if it were exactly that easy. Going back to our example, let's compare the satellite with the band and the pass time with when the band is open. If either of those isn't present, you're out of luck, but if both are available, you still have to know the exact frequency. If you want to talk with someone specific, you had better agree on that ahead of time. Fortunately, most of us just want to communicate, or perhaps we're trying to achieve Worked All States on the satellites. Then it's just like we're used to operating; call CQ or answer someone else's.

Transponders and Satellite Passbands

Another comparison between satellite and non-satellite operation is that working satellites is very similar to working "split" on HF or "cross-band" repeat on repeaters, where you transmit on one band and listen on another. On HF, you are pretty much free to choose which two bands and which frequencies within those bands you wish to use. On the satellites, as on the repeaters, that choice has been made for you; that's what we mean by "mode". Unlike repeaters, almost all of the analog birds are actually "transponders" which listen to an entire segment of one band and retransmit it on another band (the exception is AO-27). Let us again go back to your planned QSO with your out-of-state friend. You chose RS-10, a Mode A satellite. RS-10 will accept an signal anywhere from 145.860 MHz to 145.900 MHz and retransmit it between 29.360 MHz and 29.400 MHz. These are known as the uplink and downlink passbands, and there is a direct relationship between them. A signal you transmit a 145.870 MHz will be rebroadcast by the satellite at (about) 29.370 MHz, 145.880 MHz comes down as (about) 29.380 MHz, etc. This is because RS-10 (as well as RS-12 and RS-15) uses what is known as a "non-inverting linear transponder".

You can easily graph this relationship, and it may not be a bad idea to do so. Using a ruler, draw two parallel lines of equal length, one exactly above the other. Look up the passband limits of the satellite in question. Note the lower limit of the uplink at the left end of the top line and the upper limit on the right end. Do the same for the downlink on the bottom line. What you end up should look something like this (all frequencies are in MHz):

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                        RS-10 Uplink Passband
  145.860       145.870       145.880       145.890       145.900
     +-----------------+----------------+----------------+-----------------+

     +-----------------+----------------+----------------+-----------------+
   29.360        29.370        29.380        29.390        29.400
                       RS-10 Downlink Passband
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Looking at this, you can see that if you want to meet your friend on a downlink frequency of 29.390 MHz, you just need to transmit on (about) 145.890 MHz.

Doppler Shift

Wait a minute! What's with this "about" stuff? Unlike terrestrial communications where it is possible to pick a frequency and stay there (+/- drift for older radios), there is a phenomenon known as Doppler Shift that satellite operators must take into account. Just what is this Doppler Shift and how do we deal with it? By way of another example, have you ever heard a train blowing its whistle as it passed by? Remember how the tone seemed to change with time? Obviously, the whistle wasn't actually changing; it was how you perceived the whistle that changed. This variance is a result of the relationship of the observer to a source that's moving. Well, that is what we call Doppler Shift. The same thing happens to signals coming from space, but because the signals we receive are transmitted as RF instead of audio and the signal source is traveling at about 17,000 miles per hour and not at 60 to 70 miles per hour like our train, we have to constantly tune our receivers or transmitters to make up the difference. On the Amateur satellites we've developed a de facto standard of changing the higher of the two frequencies. For example, if I'm listening to myself on the RS-10 downlink, I'll constantly fine tune my uplink because it is the higher of the two (145 MHz vs 29 MHz). Technically speaking, the satellite also sees a shift in the signal it is receiving, so I'm compensating for both. The apparent shift in frequency varies by band. On RS-12 with its 15m uplink and 10m downlink, the change is on the order of +/- 2.5 kHz. Up on FO-20 and FO-29, where the uplink is 2m and the downlink is 70cm, the shift grows to +/- 10 kHz.

The hardest part about Doppler Shift is finding your desired signal the first time, but even that isn't a major hassle. Let's go back to our RS-10 example. This time, let's say that you have a schedule with your friend and you have both agreed to meet on the downlink frequency of 29.390 MHz. You know that for that frequency down, you need to transmit on about 145.890 MHz. You also know that Doppler is going to be changing that somewhat, but how much you need to determine. What do you do? Listen for the RS-10 beacon, that's what. You consult the satellite information table and see that the beacon is supposed to appear at 29.403 MHz. Tuning there, you find the beacon, loud and strong, at 29.405 MHz instead. Ah, hah! The beacon is 2 kHz HIGHER than it should be. Now we're ready. Quickly, tune your receiver back down to 29.390. Next, correct your transmitter frequency by tuning it LOWER by 2 kHz to 145.888 MHz. Give a few quick dits on your key or announce your call and you should hear yourself. You may not be exactly on frequency, but you're pretty close. After that, just make minor corrections to your transmitter or receiver as necessary. (To accomplish this, it really helps to be able to listen to your downlink. That's one of the advantages of full duplex operation.) By the end of the pass, you'll notice that you are actually above your original non-corrected target frequency, but you've done it: you made another successful contact!

Sure seemed like a lot of trouble, didn't it? Don't worry; in time it will be second nature. You won't even have to hunt for the beacon, you'll just know where to start listening for your signal.

That sounds fine for the SSB/CW satellites, but what about those FM uplinks? Don't the satellites see a variance in those, too? Yes, they do, but their receivers were purposely built a bit broad so it isn't a problem. We worry ONLY about the downlink.

Antennas

Before we leave this topic, let's spend just a little time on the "best antenna" debate. Unless you have the time, space and inclination to put up directional antennas for the satellites, you must decide just how much of a compromise you are willing to make. If you run one of the pass prediction programs that lists the maximum angle the birds achieve when you can access them, you will see that most of the time they are no higher than 35 degrees or so above the horizon. Unfortunately, the closer to the horizon a satellite, the greater the distance from the observer, the higher the path loss and the greater the transmit and receive gain needed to successfully work the bird.

Verticals cover this well, especially ones with some gain. Be very careful with your choice if you go this way, though; some of the really high gain verticals are optimized for low angles of radiation and the signal strength falls off rapidly as your elevation angle increases. Another problem with verticals is that natural and man-made noise tends to be vertically polarized. With FM signals this isn't a problem, but with SSB and CW it is very apparent.

Dipoles also work well, especially for the Mode K uplink and Mode K and A downlinks, but they have a tendency to suffer from loss of gain off the ends. For good coverage using dipoles, it isn't a bad idea to have two at right angles from each other. The turnstile is a special nifty antenna composed of two dipoles fed in parallel by a 1/4 wavelength section of feedline at about 92 ohms. This will yield a total impedance of around 50 ohms making your receiver or transmitter happy. The horizontal radiation pattern is omnidirectional but its vertical angle of radiation varies by its height above ground. Like the dipole, you need to pay attention to this height. At about 3/8 wavelength above ground the pattern looks somewhat like a round balloon that has been put on a flat surface and is being slightly depressed in the top center. This gives more gain toward the horizon and less directly overhead where the closeness of the satellite makes it less necessary. The TR-Array is a favorite home brew application of the turnstile where the crossed dipoles are mounted above an artificial ground, such as a section of chicken wire in a frame. These are often used at 2m and above. Because the ground plane is part of the antenna system, it can be mounted well above the actual ground.

If you are fortunate enough to have beams, an old trick is to tilt them about 30 degrees up. This will still give you gain toward the horizon but increases the usable elevation. Don't feel you must tilt your antennas, though, especially if you are using a mono-bander or tri-bander for RS-12 or for the downlinks of RS-10, RS-12, or RS-15. Many satellite operators report excellent results in the standard "flat" horizontal orientation. The only disadvantage to using beam antennas is you will need to continuously correct their direction as the satellite moves by. On the LEO's, with their fast relative velocities, this may be a challenge for the new operator.

If you enjoy building at least part of your station, consider making your own antennas. At the frequencies used by the Amateur satellites, the sizes aren't bad and it is possible to obtain a lot of gain in a small (relative to HF) size. Antennas need not be expensive, so this is a good way to try out those "what if...?" and "I wonder..." theories without sacrificing your life savings.

No matter which antenna you decide to use, don't forget the importance of using a high quality, low loss transmission line and good connectors. Use the very best you can afford because, if you skimp here, you could loose a significant part of your signal as line loss. If it were only on transmit that this happened, you could make up for it with increased power (wasteful), but losses occur on receive, too. Every dB of attenuation from the antenna to the radio is a bit of the downlink you can't hear and the 3-6 dB loss possible from using the wrong coax can turn a marginal signal into one that simply isn't there. The connectors you use add to this loss in a subtle way by creating an impedance "hump" that acts like a little resistor in the line. At HF, and to some extent at 6m and 2m, we can get by with using the common SO-239/PL-259 combination, but at higher frequencies, such as 70cm and up, most equipment comes equipped with the Type-N connector. The Type-N, properly installed, will cause a very small mismatch, allowing all of the signal to makes its way to and from the antenna. One final point to be observed is to make sure that the connector/coax is well seated and well sealed when installed on the antenna. If you don't keep the weather out of the connection, your coax will become water-logged and then you'll really have line losses. One popular method is to wrap electrical tape tightly around the connectors, then use one of the many available hand-moldable compounds sold just for this purpose.

A Friendly Warning:

Once you have everything set up and start to make contacts on the birds, you may find that you'll be running that pass prediction program quite often so you can see when the next opportunity to talk ANYWHERE on ANY satellite comes up. It's kind of like getting bit by the radio bug all over again.

The Easy Sats

Okay, now we're ready to look at the Easy Sats. The next several pages will be a more in depth discussion of each satellite, including notes, observations and, in some cases, a bit of that bird's history. For lack of a better reason than it makes sense to me, I chose to review them in ascending order. Interestingly enough, the difficulty level rises with each, but only slightly. Mir and SAREX are presented last only because they have no numeric designator. Following this section, I'll discuss an easy upgrade path for your satellite career.

RS-10/11 & RS-12/13

RS-10/11 and RS-12/13 are in 990 km high polar orbits giving them a coverage circle(footprint) of about 6400 km, sufficient to reach significant portions of the United States at one time when the satellites are over the middle of the country. Passes over the eastern US give access to Europe, and Hawaii can be reached if the birds are over the west coast. Their low orbits carry them over the US six to eight times a day for 10-18 minutes at a time, with three passes spaced a little over 1.5 hours apart, and three more about 12 hours later.

Except for their differences in operating frequencies, RS-10/11 and RS-12/13 are very similar. In addition to their nearly identical orbital characteristics, both are actually "piggy backs", boxes that are bolted to larger Russian satellites and drawing their power from the parent satellites' systems, allowing them to have a higher power budget than most of the other LEO's. Because of this, many fledgling Amateur Satellite operators have their first satellite experience by monitoring their 10m downlinks using simple dipole antennas. In actuality, RS-11 is a backup to RS-10 and RS-13 is a backup to RS-12 and each shares the frame with its primary counterpart. For convenience, we will refer to these satellites just as RS-10 and RS-12.

Both satellites are equipped with 40 kHz wide analog (SSB and CW only) transponders, each divided into ten 4 kHz wide AGC controlled segments. Because of their very sensitive receivers, the builders used this "segmentation" technique to prevent one or two very strong signals from using up the entire downlink power budget. This works fairly well, but excessively strong uplinks can and will still be heard several kHz away. If you feel the need to increase your output power so you have a louder signal, consider working on your receiver set-up instead. No one likes an "alligator", and you may find that you are just talking to yourself because no one else wants to encourage poor operating practice. Remember: 100 watts effective output is all you need, and many enjoyable contacts are possible using much less.

A unique function of these satellites is an automated CW ROBOT, transmitting on the beacon frequencies. If you hear the ROBOT calling CQ, it will give the proper uplink frequency. Transmit the following at around 20 WPM (anything from about 12 WPM will work):

RS-10 DE (your call) AR

and the ROBOT will respond with

(your call) DE RS-10 QSL NR (number) OP ROBOT TU USW QSO (number) 73 SK

Don't forget to substitute RS-12 instead of RS-10 if you are working that bird.

To receive a QSL card for your ROBOT contact, send the QSL number the ROBOT sent back to you on your QSL to:

Andrey Mironov	or	Werner Schroder, DF4XW
U1.V-Voloshinoj, d.11, kv.72	QSL ->	Hermesweg 29
Station Perlovskaya, 141014	manager	21075 HH 90
Moscow region, Russia		Germany

Please remember to send along an SASE with sufficient postage.

You may read from time to time about people who use their FM handi-talkies to operate CW on RS-10. Although this is possible, it is not encouraged. FM signals are very wide band and even though there is no effort to transmit audio, unless the microphone is totally disconnected, you will put an FM signal into the bird. Some newer 2m FM radios also have a problem with a slow lockup time for their synthesizers and the resultant signal is "chirpy".

As this is being written, RS-12 is in Mode KT, so downlinks exist on both 10m and 2m. The 2m downlink is very strong, far superior to the 10m version, and has the advantage that it gets rid of the requirement to have a separate HF receiver or operate "in the blind" using one HF radio in the half-duplex mode. Warning: RS-12's uplink straddles the Advanced and Extra portions of the 15m band, and working this satellite requires that you be properly licensed to operate here. Also, since this is an HF band, when the band is open expect a lot of terrestrial activity in the uplink passband area, so make sure that any stations you hear calling CQ are in fact looking for satellite QSO's.

RS-15

RS-15 is the latest (RS-16 is rumored) of the Russian Sputnik series of Ham Satellites. Despite a common heritage, there are several differences between it and RS-10 and RS-12. For the Mode A operator, newcomers especially, this can be a mixed blessing. Although a LEO like its brothers, RS-15's orbit is much higher and passes lasting up to 30 minutes are not uncommon. It's nice to be able to hold a conversation with someone and not have to worry about hitting LOS in mid-sentence. Another advantage of the higher orbit is that it provides a much larger footprint. When over Raleigh, NC the entire continental United States can be worked. When RS-15 is over the mid-Atlantic, it is possible to easily reach Europe.

Unlike RS-10 and RS-12, RS-15 is an independent satellite, not attached to a larger space frame. For a bird that weighs in at only 70 kg and is only about one meter in diameter, that means the craft has a very small power budget. Also, unlike the other RS satellites, please do not attempt to have your downlink on a par with the beacon; the power allocated to each of the 4 Khz subpassband channels is only about 0.4 W, and the beacons are running about 1.2 W. Many users of RS-15 find that a receive pre-amp can be of great benefit, often making the difference in hearing the satellite and making a contact, or just barely being able to tell that it is there.

Unfortunately, it was noticed soon after launch that the power output drop during times of heavy use, although anticipated, was much greater than had been expected. Investigation has revealed that the battery system just isn't holding up as wished. The satellite's orbit is also a factor in that the amount of time that it spends in eclipse (no sun reaching it to recharge the batteries) varies over a matter of weeks from about 12 minutes per orbit to over 30 minutes per orbit. When you add lowered recharge time to heavy usage, the power system just can't keep up and the signal drops out. In fact, the battery system has now degraded to the point that when the satellite is in total darkness, the transponder shuts down. As long as these limitations are taken into consideration, operation through RS-15 can be rewarding.

Another trait of this bird is the very apparent fluctuation of the downlink signal. RS-15 is not spin-stabilized, so the satellite is slowly tumbling in its orbit and the relationship of the ground stations to the satellite's antennas change. This imparts the flutter or "whooshing" that is characteristic of the signal.

The uplink and downlink pass bands for RS-15 and RS-10 are nearly identical. This can cause some confusion when both satellites are within range. To help keep QSO's on track, it is a good idea to announce which bird you are working through, both while calling CQ and during the contact.

DO-17

It's no coincidence that the first four "Low Earth Orbit - Digital" satellites are numbered consecutively; they were launched at the same time on the same rocket. Consequently, the satellites, known collectively as Microsats, orbit at around 800 km and complete one orbit in about 100 minutes. Each Microsat was created by a different group but utilized a common configuration: five aluminum trays bolted together to form a cube with solar cells covering the outside. Four of these trays (power system, on-board computer, transmitter, and receiver) appeared in each satellite. It was the fifth tray that made each unique. Of the four Microsats, we will concern ourselves only with DO-17. The others require extra equipment for their use and do not quite qualify as Easy Sats.

Also known as DOVE (Digital Orbiting Voice Encoder), DO-17 is perhaps the easiest of the Microsats to use. DOVE has no receiver accessible by the average operator, but its transmitter can be heard loud and clear. Originally designed as a good will satellite to promote world peace (the dove is the universally recognized symbol of peace), it was hoped that peoples in even the poorest countries could use simple receivers to hear messages of hope and understanding being broadcast from space. Many people have heard the tinny, mechanical intonation "Hi. This is DOVE in space". If you have an HT, there is a good chance you can hear DOVE, even using a rubber-duck antenna, although an external ground plane antenna would help things considerably. As this is being written, the Voice Experiment is turned off (see the sample telemetry below), but if you have a standard 1200 baud packet station you can at least see what's going on. DOVE's transmit frequency is 145.825 MHz, but Doppler Shift requires that you start listening at about 145.830 MHz, switch to 145.825 MHz a third of the way through the pass, then switch again to 145.820 MHz for the last third. Tuning isn't really critical, and the 5KHz steps offered on many FM only radios will work fine. Since you won't be actually connecting to DOVE, just turn "MONitor" ON, activate your receive buffer if you wish, then sit back and watch the data flow by. What you'll see will look something like this:

```
DOVE-1>TLM:
00:60 01:56 02:87 03:34 04:56 05:57 06:70 07:50 08:70 09:6C 0A:A1
0B:E6 0C:E9 0D:D6 0E:00 0F:24 10:D8 11:A8 12:00 13:02 14:B2 15:9F
16:82 17:7D 18:7D 19:7E 1A:7B 1B:5D 1C:84 1D:7F 1E:2C 1F:5C 20:A2
DOVE-1>STATUS:
80 00 00 1E 26 18 CC 02 00 90 00 00 0A 0E 3C 05 0F 31 01 0A 52
DOVE-1>LSTAT:
IP:0x25B2 o:0 l:3837 f:6778, d:0 st:0
DOVE-1>STATUS:
80 00 00 1E 26 18 CC 02 00 90 00 00 0A 0E 3C 05 0F 31 01 0A 52
```

DOVE-1>BRAMST:
20th March 1995 12:36 UTC
Voice experiment remains OFF.
The power is being tuned.
S Band has been turned ON but may be
OFF without notice during the tuning period.
73 Dove Command Team <vk7zbx>
DOVE-1>BCRXMT:
vmax=757390 battop=766771 temp=437013

By the way, there are programs available that will take this telemetry as input and decode it into text. You won't find any super secret messages, but will be able to see just what the state of the satellite is at that time.

FO-20 and FO-29

Fuji-2/OSCAR-20, or simply FO-20, is the second in a series of Japanese Amateur satellites. The orbit of FO-20 is slightly elliptical, so the satellite receives a large amount of illumination throughout most of the year. It also has an orbit altitude of 1320 km giving it a decent footprint.

When launched, FO-20 was operational in both the digital and analog modes, but now seems to be permanently set to analog. Just like the larger AO-10, the transponder on FO-20 is inverting, so whatever goes up on the low end of the uplink passband comes out on the high end of the downlink passband, LSB up becomes USB down, etc. Operating FO-20 is not any different from any other bird; just use about 100w EIRP and remember to tune the downlink for Doppler. Keep in mind the inverting transponder and you're all set. Not only will you transmit on LSB and receive on USB, but the frequencies track in opposite directions.

If you graph this type of transponder, the uplink passband's lower limit is over the downlink passband's higher end, and visa versa, like this (all frequencies are in MHz):

```
              FO-20/FO-29 Uplink Passband
145.900   145.925   145.950   145.975   146.000
   +-------------+-------------+-------------+-------------+

   +-------------+-------------+-------------+-------------+
435.900   435.875   435.850   435.825   435.800
             FO-20/FO-29 Downlink Passband
```

FO-29, launched in the fall of 1996, is virtually identical to FO-20 in regard to use of its analog transponder, even sharing the same passbands, so operation on this bird is no different than on its older sibling. Unlike FO-20, FO-29 is also active in the digital mode, with packet BBS's operating at both 1200 and 9600 baud. Only one mode is available at one time, operating on a "round-robin" schedule, so don't expect the linear translator to be available at all times.

Until you get used to it, you'll probably have the tendency to tune in the wrong direction. Also, bear in mind that by convention you should tune the receive frequency since it is the higher of the two being used, although some people do it the other way around and it will be necessary to operate "backwards". A proposal has been made and is being implemented in the top 20kHz of the downlink passband where computer control of the radio's transmit and receive sections are both tuned to maintain a frequency "at the satellite". This is made possible because many tracking programs are able to calculate the required Doppler shift offset and provide it through Terminate and Stay Resident programs (TSRs) to other programs which provide frequency data to the radio via a serial, parallel, or dedicated communications port. Of course this assumes that the radio in use is capable of computer control, but some older models and practically all newer models are so equipped The operator simply sets the desired frequency and lets the computer do the rest, getting rid of the necessity of tweaking for Doppler shift and allowing full concentration on the QSO itself, making this the perfect method for satellite carried nets and scheduled contacts. Right now, FO-20 and FO-29 are underutilized and non-automated contacts with their roving signals aren't too much of a problem so just do what you need to make the contact, but please leave the top part of the passband for the operators using computer control.

AO-27

The Microsat buss structure, such as is used on DO-17, proved to be very popular and other satellites were built using it. One of these is AO-27. It even has a similar orbit, with an altitude of about 793 kM and a period of 101 minutes. Unlike the Microsats, though, there are two factors that make AO-27 unique: it is not dedicated to the Amateur Satellite Service, and it is an FM cross-band repeater. AO-27 is actually an amateur payload aboard a commercial satellite known as Eyesat-1, which runs experiments for Interferometrics, Inc. of Chantilly, VA, USA. To preserve batteries and other demands on the satellite's resources, AO-27 is not constantly "on" but rather springs to life 18 minutes after entering sunlight over North America and remains on for 20 minutes. The control operators will let this schedule "drift" somewhat every few months, allowing more southerly stations to take advantage of the repeater. The satellite presently is operating in "power mode 2", which gives a signal of only approximately 600 mW but this is subject to change.

There are a few operating considerations with this bird that must be observed. First, the uplink and downlink are both FM. This may not sound like a problem, but remember that FM is far less efficient than SSB or CW. Although uplinks of 10 watts into a ground plane antenna will get you heard, the downlink may suffer from deep fades if you don't have a good receive set-up. AO-27 is another Mode JA bird, so you'll be listening on 70cm and a good receive pre-amp is a must. If you have a radio that allows tuning, the center frequency is 436.800 MHz, but don't forget the effects of Doppler Shift which will be +/- 10 kHz. If you have an FM only rig with 5 kHz steps, don't worry; just start listening high (about 436.805 MHz) and step down in frequency as the pass progresses. The uplink at 145.85 MHz requires no compensation. Second, as a repeater and not a transponder, only one person can talk at a time. The strongest signal will be captured by the satellite's receiver (just like on your local 2m repeater) and everyone else will be shut out. Third, as I mentioned before, the satellite's dual purpose use makes it available only when in sunlight and usually only when it is over North America (roughly North 74 degrees to North 5 degrees).

Mir/SAFEX II

Mir (Russian for "Peace" or "World") is an orbiting space station, and the first of our Occupied Spacecraft. Mir's orbit is equatorial, not polar like most of the Amateur satellites. At an orbital altitude of about 380 km., Mir's footprint is fairly small and the passes are correspondingly quick. Due to the low altitude, power requirements are small; a 10W FM transceiver and modest antenna will usually do the trick.

The amateur equipment aboard Mir is presently located in two different modules. The older 2M station operates with the call sign R0MIR on only one frequency pair with both a packet BBS and voice (145.800 MHz uplink/145.200 MHz downlink), and packet seems to be the predominant mode. Many older texts will reference a single frequency, 145.55 MHz, for both analog and digital work, but this was changed to the new pair in late 1996 by the European sponsors to help relieve contention with other operations there. Unfortunately, the new frequencies are very close to those used by other modes (such as APRS and terrestrial repeaters) in Region 2, which includes North America.

The newer station, a cooperative effort of German and Russian Hams designated SAFEX II and using the call sign RR0DL, operates full duplex in the 70cm band and has three modes available: 1) An FM voice repeater on 435.750 MHz up/437.950 MHz down with a 141.3 CTCSS tone, 2) a 9600 baud digipeater on 435.775 MHz up/437.975 MHz down (no tone), and 3) an FM voice channel pair on 435.725 MHz up/437.925 MHz down with a 151.4 CTCSS tone for QSO's with the Mir cosmonauts. It is on this last downlink that voice bulletins and announcements will be made. It might be helpful to remember that the 70 cm transmit and receive antennas are separate and located in different locations on the Priroda Module. This can account for some of the strange signal strength fluctuations you may experience.

Doppler for the 70cm band where SAFEX II operates is on the order of +/- 10 kHz and corrections must be made on both the uplink and downlink frequencies. Two ways to do this are computer control of the radios VFO's and the use of several memory channels with the appropriate Doppler compensated frequencies stored.

If you use the memory channel method, remember that at the beginning of a pass you will need to transmit higher and receive lower than the frequencies given and as the pass progresses the transmit frequency will rise while the receive frequency lowers. Here is an example of one way to do this, as posted to AMSAT-BB by Mike Seguin, N1JEZ, using an FT-736R, one of the more popular satellite capable radios, but valid for any radio that has memory channels and allows a programmable offset. Mike programmed 9 memory channels for +/- 8KHz doppler correction, using a sequence of standard memory channels (not Sat channels) set up as minus offset with tone encoding. Mike says to first program the downlink frequency, then enter the offset, making sure you are set for negative offset and tone encoding (141.3), then save to a memory channel. He sets the frequencies for each channel according to the list below.

MIR/SAFEX 70cm Doppler Correction

Dnlink (MHz)	Uplink (MHz)	Offset (MHz)
437.958	435.742	2.216
437.956	435.744	2.212
437.954	435.746	2.208
437.952	435.748	2.204
437.950	435.750	2.200
437.948	435.752	2.196
437.946	435.754	2.192
437.944	435.756	2.188
437.942	435.758	2.184

During a pass, start with the first channel, and tune up channel by channel as the pass progresses. Set the meter to DISC/ALC and keep the meter centered as well as possible on receive. You probably can get away with less channels, but if you have the available memories it is a good idea to use them.

Amateur radio activity aboard Mir is a diversion for the cosmonauts and not always available. In those instances where voice is being used, it seems that the cosmonauts prefer QSO's and not just the quick contest style contacts. This can be aggravating to those who just want to be able to say they've made a live space contact but PLEASE don't call them until they say they're ready for someone new. It doesn't hurt to be able to speak Russian, either. When planning your contacts with Mir, keep in mind that the cosmonauts operate on Decreed Moscow Time, (GMT +3 hours, with no consideration made for Daylight Savings Time). The scheduled free time for the Mir crew is 8PM to 12mid DMT (12 noon to 4PM EST), which means that they are usually asleep or working while passing over the US except for the late evening/early morning. However, Sundays are "days off" except during special events, so that might be a good time to try them.

The 2m Mir BBS is a simple operation and its buffer is small. Please delete any messages once you've read them, make sure you disconnect before you lose contact, and to avoid needless QRM (is there any other kind?) do not use an automated set-up to call. The same considerations should be observed when using the SAFEX digipeater.

QSL reports and requests for R0MIR (the 2m packet keyboard and voice callsign), R0MIR-1 (the 2m BBS), and RR0DL should go to:

N6CO
P.O.B. 1501
Pine Grove, California 95665
USA

N6CO is Dave Larsen (ex N6JLH), the QSL manager for Mir contacts in the USA. Dave is to handle only cards for R0MIR, R0MIR-1, and SAFEX II, so all older QSL requests must still go through Russia. QSL's should include date, time, and mode of contact. If the contact was with the packet personal message system, then the message number issued by the PMS should also be included. Please include a self-addressed and stamped business size envelope. This information is for amateur contacts only; cards for SWL reports will not be handled by Dave.

SAREX

SAREX, the Shuttle Amateur Radio EXperiment, is a cooperative effort of NASA, AMSAT, and the ARRL designed to expose school children to the space program by allowing them to talk to the astronauts aboard the Space Shuttle. Like the Amateur Radio operation on Mir, don't expect to be able to QSO with the astronauts whenever they are overhead. Even finding when the shuttle is passing can be a problem; the orbit is subject to change many times during a mission and keeping up with the necessary Kep file changes can be maddening. Sometimes SAREX isn't even active for the entire duration. Keep in mind, too, that the primary mission is SCHEDULED contacts with schools. This schedule is determined well before the shuttle launch and publicized, so keep an eye on the various magazines and bulletin boards for announcements. Don't give up on SAREX, though, they will contact individuals occasionally.

Unlike Mir with its 2m operation confined to one frequency pair, SAREX operates a non-standard "split", transmitting on 145.55 MHz and listening on 144.91, 144.93, 144.95, 144.97 and 144.99 MHz for voice contacts and 144.99 MHz only for packet. To avoid QRM, the astronauts don't announce which voice frequency they are listening on, either, so it's just the luck of the draw.

Two things to consider if you have been trying to hear the shuttle and have had no luck: 1) The shuttle is in an equatorial orbit and will usually be below the horizon for listeners well to the north and south of its path, and 2) The antenna system is mounted to a window and may be blocked by the body of the spacecraft in some of the attitudes it must assume during the mission. Don't give up; sooner or later it will happen.

To receive a QSL for a SAREX contact, send your card or report indicating the mission number, date, time in UTC, frequency and mode to:

ARRL Headquarters
SAREX QSL, STS #xxx (where xxx is the mission number)
225 Main Street
Newington, CT 06111-1494 USA

Be sure to include a self-addressed business sized envelope with sufficient postage affixed or the proper IRC's.

For more information on SAREX, see the instructions for accessing the ARRL Mail Server in the section "My Resources" and request "SAREXFAQ.TXT".

Working the Birds

You have probably heard someone make a statement that started "It goes without saying that..." which, by its very nature, indicates that something should be said. When we are talking about starting your satellite career, that "something" is this: Don't be in a hurry, spend some time to determine where you are in terms of experience and equipment (be honest), and think about what you wish to achieve. Once you know these things, you will have a better understanding of how to get started and what direction you will need to travel to reach your goals.

This is where I should be telling you about how easy and cheap it is to get onto the Amateur satellites. Well, I can't really do that. Is it easy and cheap? Yes, it is easy, and cheap is possible, but like every other aspect of our hobby, you can spend as much money as you want. It's just a matter of what you feel comfortable with. The point is, though, you don't have to spend a lot. You may not need to spend anything if you already have a radio, because the first step is to just listen. After that, your course is up to you.

First, take a look around your shack. What equipment do you already possess? Do you have a radio or radios that are "satellite friendly"? If not, are you willing to spend the effort and money to do so? Don't worry; chances are that you have something right now that you've been using and just never considered to be a part of an Amateur Satellite station.

At the risk of sounding trite, let me use a few more of those "old expressions" we often hear (and ignore) because they accurately represent what I feel is the best approach to becoming satellite active.

* First Things First - The best way to become involved is to listen. You don't have to have anything other than a shortwave receiver, police scanner, or 2m FM handi-talkie to do this. These aren't ideal, but they can be used to hear the downlinks and will help familiarize you with some of the basics: Determining passes and adjusting for Doppler shift. These will also give you an idea of the various patterns of QSO's to be found on the satellites which vary from one satellite to the next.

* Take It Easy - The reason I recommend starting with the Easy Sats is because they are, well...EASY! You can gain valuable experience here without risking a fortune or becoming so confused you quit and take up some other more mundane hobby. That doesn't mean the Easy Sats are only good as a starting point and should be abandoned later, either; some people start here and never leave.

. * One Step At A Time - Don't feel compelled to assemble a full satellite station in a short period of time. This will only lead to frustration as you spend more time wondering what to acquire next, when you should really be enjoying what you have. Each upgrade should serve as a building block for the next. Don't be in a hurry. Relish the entire experience. Have fun!

Have a 2m Radio?

Once you have acquainted yourself with the satellites by listening, it's time to start making contacts. Perhaps you don't have an HF rig, but are equipped for 2m FM. In that case, consider trying to work Mir or SAREX by voice. If you also have a 1200 baud TNC, copy DOVE when it comes over, or connect to the Mir BBS or digipeater. Simple stuff, and except that the other station is moving, not much different from your basic 2m operation. Just remember that, whether you're working voice or packet, the passes don't last long and there may be others wanting to do the same thing. Keep your contacts short, and if you're on packet, send a "disconnect" before you loose contact or the digipeater will be unavailable until its TNC retry count is exceeded and the TNC resets. Don't forget the effects of Doppler Shift; start listening high and tune down as the bird passes.

Have an HF Radio?

Maybe you have an HF receiver or transceiver. If so, you already have the ability to copy the 10m downlinks of RS-10, -12, and -15. The antenna you use for the downlink will make some difference, but use whatever you have; you might be surprised at how well you can pull in those signals from space with what you have now. If you find that you are having some difficulty hearing the passes, consider a receive pre-amp. At 29 MHz you can use one inside the shack, but a good practice is to mount it close to the antenna where the signal is greatest. A word of caution is in order here: make absolutely sure you don't transmit through your pre-amp unless it is designed for transceive operation; otherwise you end up with a very useless attenuator instead.

OK, so you've mastered the 10m downlink and are ready to take another step. If you are an Advanced or Extra license holder, try RS-12. To make easy contacts, it is helpful to have a transmitter or transceiver for the 15m uplink and a separate receiver or transceiver for the 10m downlink, although some Mode K operators use split VFO operation in a single radio by determining the downlink frequency and factoring in the proper shift. This works after a fashion, but as the bird moves and the frequency changes, it can be really hard to maintain a QSO because one or both of you are chasing the signal up and down the band. If you have a 2m SSB receiver or transceiver, then operate Mode T (or KT if both are on).

Have Both?

If you have a means of generating a CW or SSB signal on 2m as well as a 10m receiver, then you're ready to get on the Mode A satellites, RS-10 and RS-15. If you don't yet have a 2m multimode transceiver, you may want to consider getting one. The reason I suggest the 2m multimode is obvious if you're interested in satellite work; it will get you onto not only RS-10 and RS-15, but there are other birds where 2m transmit is necessary. Many Hams, particularly the new No-Code Technicians, start out with HT's and eventually find they want to get something more. The 2m multimode at home will allow them to remain on their favorite repeater or FM simplex frequency while trying something new. Besides, there is a lot of 2m DX to be worked on the low end of the band!

If you can generate the RF, chances are you can hit the bird. Don't sweat it if you can't afford a big expensive new 2m base; there are used units to be found if you look. Some are mobiles, but what does that matter? Have you heard the old saying "It's not the age or size of the car that counts, it's how well you drive it"? Substitute "radio" and "operate" for "car" and "drive" and you'll get the idea. You won't need a lot of power to communicate through the satellites. In fact, you'll need AT MOST 100W EIRP; it's usually much less. Take into consideration the power out from your radio, feed line and connector loss, and antenna gain.

Note to my No-Code readers: Don't worry that you don't normally have access to the HF bands. You aren't transmitting on 10m, the satellite is, and the sponsoring group is responsible for meeting the licensing requirements for HF. Think of it as using someone else's station.

All We Need Now is 70cm

So far we've looked at the equipment needs for using DOVE, Mir, SAREX, RS-10, RS-12, and RS-15. Once we discuss FO-20, AO-27, and FO-29, we've covered all the Easy Sats. Access to these last three requires only one more thing: a way to receive the 70cm downlink. This means you'll need either a 435 MHz capable receiver/transceiver or a converter with your 10m receiver/transceiver. If you go the latter route, bear in mind that the satellite allocation on 70cm goes from 435 MHz to 438 MHz. This really isn't a problem if your HF radio has general coverage capability, but if it doesn't you will need a converter that has selectable local oscillators. That will allow you to have, for example, one position that converts 435 - 436.7MHz and the other 436 - 437.7 MHz to the standard 28 - 29.7 MHz 10m band. If you use a converter, you can save money by mounting the converter at the antenna instead of using a pre-amp because most converters have plenty of output gain to help overcome line loss at 10m. If you opt to use a 70cm transceiver, you will also be able to work SAFEX on Mir but will need a pre-amp. Either way, heed the warning I gave you previously: DON'T TRANSMIT THROUGH YOUR CONVERTER OR PRE-AMP! (That's twice. Don't say you weren't warned.)

That's All, Folks!

Well, what do you know? We've covered all the Easy Sats! Pretty painless, wasn't it? If you already had some or all of the necessary equipment it didn't cost too much either. The really great part is that you are now an Amateur Satellite Operator and, with the addition of just a little more equipment, you can work the rest of the Amateur satellites, too. Keeping with the concept of the Easy Sats, I won't go into detail on this but if you're really interested, read "More Boxes, More Sats" coming up next.

More Boxes, More Satellites

Even though the intention of this paper is to introduce the reader to the Easy Sats, there are other types of satellite operation that I feel I should mention. Although they don't quite fit the criteria of "easily used" put forth in my introduction, and they will add some cost to your satellite station, many Hams will want to progress upward and we can't leave these out.

The Mode JD Satellites

Another mode, in fact the last one available on the LEO's, is Mode JD. As you may have guessed, the "D" stands for Digital and there are two different sub-modes based on the data rate. At present you have the opportunity to work 1200 baud, which requires one more piece of equipment, or 9600 baud, which may require simple modifications to your radios.

The easier of the two is the former, 1200 baud, and for this we have available AO-16, WO-18, LO-19, IO-26, PO-28, and FO-29. The added piece of equipment is known as a PSK modem and is attached outboard to your TNC. If you are lucky enough to have one of the multimode TNC's now available you have one already. I say this is the easier of the two because it is basically a matter of "plug and play"; attach the cables and you're ready. Notice that the PSK downlink is a SSB mode, so you'll need a receiver capable of SSB reception. Remember that since the bird is moving you'll experience the phenomenon of Doppler Shift. By design, most PSK modems have the ability to change the received frequency using the frequency step functions built into the microphone connector of many modern radios. DO-17 (DOVE), discussed earlier, is technically a Digital Satellite, but it does not require a PSK modem and its output is in the 2m band, so it does not qualify as a Mode JD satellite.

Using the 9600 baud birds (UO-22, KO-23, KO-25, PO-28, FO-29) might require modifications to the transmit and receive circuitry of your radios for the same reasons that apply to terrestrial high speed links. Simply put, until the recent appearance of radios specifically designed to handle the increased throughput, all signals were routed through the microphone and speaker connectors, and the waveforms at 9600 baud got distorted too much. What was required was minor surgery to inject the audio after the microphone and pick it off at the discriminator. This was no big deal on some rigs but caused many a headache on others and should to be considered when you set up your Mode JD station. Some of the 9600 baud FM TNC's will require that you manually change frequency, too, or you can run a program that will do your radio tuning. It's a bit harder if done by hand, but if you keep an eye on the DCD LED, you will be OK. It takes a little practice, but it can be done. By the way, this is another reason to be careful in the selection of your receiver; FM-only radios usually tune in 5 KHz steps and that is just too great a jump to stay locked on to the signal for digital work, although for analog contacts it will usually be ok.

One final word on working digital satellites is in order. Once you have all of your equipment on line, you will need a way of talking to the satellites or you won't get anywhere. FO-29, when it is in digital mode, is actually not much harder to access than your local packet BBS. Using your favorite packet program, just change a few of the TNC's parameters and connect to 8J1JCS. That's it! Don't forget to disconnect before you lose the signal, though. WO-18 is a read-only satellite that transmits high resolution earth images. The reception and processing of these images requires special software available from Weber State University.

With the exception of WO-18 and FO-29, the present Mode JD digital birds operate in the "store and forward" mode. You upload your messages or files and they get stored until someone else asks for them. To do this correctly, your modem must be capable of KISS operation, and you will need a suite of programs named "PB/PG" (for DOS) or WiSP (for Windows). I got on these satellites with WiSP, a really slick piece of work available on many BBS's and FTP sites. Note that this isn't freeware; it is shareware and is registered with AMSAT. Current cost is a $50 donation to AMSAT and worth every penny! It is quite amazing sitting back watching the broadcasts scroll across the screen, hearing your 2m rig key up, and seeing your call pop up in the queue.

If digital satellite work interests you but you aren't sure that your interest is sufficient to warrant the added expense of a PSK or 9600 baud modem, there is a way to try out these modes using only your computer and land-line modem. There are stations, known as SatGates or Satellite Gateways, that consist of a digital satellite station connected to a land-line BBS. Using these, anyone can call in and have a look at the currently available directories and files that reside on whichever satellite the SatGate is configured to operate. In addition, most SatGate operators, upon confirmation of a users valid Amateur Radio license, will issue the caller a password that allows uploading of files and messages to the satellite. Operation in this manner isn't as "real time" as a sitting in front of your computer during an actual satellite pass but, since digital birds operate as "store and forward" file servers anyway, this isn't a big inconvenience.

Mode B on AO-10

Let us now look at the last Amateur satellite (AO-10), and the last common mode of operation (Mode B). If you prefer to talk with people using your mouth instead of your fingers, this is a perfect excuse for buying a 70cm transceiver or transverter instead of just a receive converter. Don't think I'm badmouthing CW, either; you can find it here, too. Just don't expect to find packet. This bird is presently the "big boy" of the Amateur Satellite program, the only Molniya satellite since AO-13 re-entered the atmosphere in December, 1996. It has a high orbit and is available for hours at a time so once you are set up to work Mode B, you just sit back and start making contacts. As a result of an unfortunate collision with part of its launch vehicle, AO-10's high-gain antenna was damaged and all transmission and reception is now done through lower gain omnidirectional antennas. Later, AO-10's on-board computer suffered a shutdown due to radiation damage and the orientation of the spacecraft is no longer controllable. Finally, some of the batteries have failed so, unless the satellite is receiving alot of sunlight, its power system problems will take it out of service. As a result, if you are usingAO-10 and you notice that the downlink is FMing, please cease operations immediately. If the power supply gets too low, what is left of the on-board control may reset with unknown and possibly fatal results. (Once when this happened, the non-functional high-gain antennas were reconnected. Only with great effort was the control team able to recover and switch back to the omnis.)

You won't have much luck working AO-10 with your LEO antennas; it's just too far away and the signal strengths too weak, although some people report success by working it when it is close to the horizon and somewhere near perigee. (The satellite is moving very quickly during perigee and behaves much like the LEO's so the resultant Doppler shift is quite high. Take into account that the transponder is inverted so you are "correcting backwards", you can see how difficult this may be.) Common uplink antennas include 44 elements (two 22 element beams crossed at right angles to each other and fed 90 degrees out of phase to get a circular polarization) and helixes, which by design also are circularly polarized. Common downlink antennas are similar to the uplink antennas except the crossed beams are usually 22 elements.

You may be asking yourself why you should even bother equipping your station with directional antennas or a 70cm SSB/CW transmitter when they are only used for AO-10. There are two big reasons, and one of them can actually be a benefit for using the Easy Sats. First, and of immediate importance, is that the same directional antennas you use for Mode B can also be used for Mode JA and JD, increasing the efficiency of your transmitting and receiving systems. The 2m antenna will also be useful for your Mode A uplink and Mode T downlink. When there's no satellite available, you'll find those directional antennas really enhance your terrestrial work, too. The second reason is that you'll really want to work Phase 3D after it's launched, and this equipment will be necessary. (P3D will also be equipped with 1.2 GHz, 2.4 GHz and higher subsystems, but that's well beyond the scope of this paper.)

Auto Tracking and Tuning

Although not necessary for Easy Sat communications, there are controllers available that will attach to your computer and tune your radios for you. (Assuming your radio is compatible with such equipment. Many newer rigs are.) These are an added expense, and need only be considered if you decide to take the plunge and get into satellite communications in a big way. Most of these controllers will also interface to your antenna rotor. Taking input from a tracking program, the controller/tracker hardware will do all of the tuning and pointing, freeing the operator to concentrate on making contacts. Properly set up, one of these tuner interfaces can overcome the 9600 baud Doppler shift problem, too. Keep this in mind when you pick a tracking program. Almost all of the popular tracking programs can talk to the majority of the hardware through TSRs and standard system calls, but not all have this capability. Check before you buy.

Well, there you have it. We have now had a look at all of what is available for the Amateur Satellite operator. Some of these, the Easy Sats, we discussed in detail. The remainder we looked at briefly. We call the Easy Sats by that name for a reason: they are easy to use. Once you have mastered these, there is plenty more to accomplish in your new career as an Amateur Satellite operator. What I have offered is but one possible upgrade path; there are others. Whatever you decide, it's up to you. Good luck and have fun!

After the QSO: QSL Cards, Grid Squares and Certificates

It has long been said that "The QSL is the last courtesy of a contact" and this is just as true when operating through the satellites as it is when we make any other QSO. Although not required, and often shunned as antiquated or "too expensive" with today's often rising postage rates and the cost of getting cards printed, there is nothing quite like a wall of cards to remind you of past conversations, long and short, with those other like-minded folk who share a common interest in satellite communication.

The "too expensive" argument can be quite persuasive for some people, but there are ways to help keep costs down. For starters, don't feel that you have to take the concept of a fancy pre-printed card as gospel; many people print their own on their home computers, and a printed or hand-written sheet with the required contact-confirming information is just as valid as a slick four-color printed piece of cardboard. They aren't as fancy, but they're just as valid for our needs.

To help keep postage costs down, consider using one of the many available QSL Bureaus. The two most popular for satellite operators in the United States are run by AMSAT and the ARRL, but there are others, some commercial and others voluntary. These Bureaus, working in conjunction with their counterparts in other countries, will accept your cards (properly sorted by whatever standards they require), merge them with cards from other Hams going to the same country, and forward them in bulk. The receiving Bureau will take these cards, sort them out by call sign, and deliver them to their final destination. This process may take a while, so please be patient. Many other countries don't enjoy as efficient a mail system as we do and it may take months or even years for your card to get there, or for cards you are expecting to reach you.

Just how does the bureau system work? For the North American satellite operator, the AMSAT-NA Bureau is the way to go, and it works like this:

For outgoing QSL's, arrange your cards alphabetically by call sign and send them to

AMSAT QSL Bureau
c/o Walt Rader WA3DMP
3702 Allison Street
Brentwood, Maryland 20722

Cards sent within the US are free and cards going out of the country are $0.10 each.

To receive cards from the bureau, send several #10 envelopes with one unit postage to the same address. Print your callsign in the upper left corner. All mailings are sent at the end of the month and you will get yours within a few days after that. If you are patient enough to wait until a few cards have arrived before your envelope is sent, immediately under your callsign on the envelope write the number of cards that should accumulate before being sent. Don't forget to keep track with how many envelopes you have left at the bureau; cards not sent out after six months are destroyed.

One difference between the cards we send and receive on the satellites and those for HF QSO's is the inclusion of the Grid Square, a set of four or six characters that define just where on Earth we are located. The use of Grid Squares, or more correctly the Maidenhead Grid Square Locator System, grew out of the older QRA system used in Europe that was developed to give some challenge to making contacts using the short range VHF and UHF equipment of the day. When ranges for contacts on these frequencies began to increase with improvements in equipment and more operators, it was discovered that the QRA coordinates could be duplicated in locations outside of Europe.

A conference was held in Maidenhead, England and the entire planet was divided into a grid of 324 large areas, or Fields, each covering 10 degrees of latitude by 20 degrees of longitude. Each of these Fields was further divided into 100 Squares of 1 degree by 2 degrees. This is where we get the name Grid Squares. Each is denoted by a two-letter/two-number combination in the format XXYY, where XX is one of the 324 fields and YY is one of the 100 grids within that field. For example, Raleigh, North Carolina is located in Grid Square FM05, but so are several other nearby towns. To further help pin-point locations, many operators will take advantage of a third designation (zz) appended to the grid square that is the result of breaking the grid square into sub-squares of 5 minutes by 2.5 minutes. Using the full six character locator will usually give an indication of less than a few miles of where a station sits. My complete Grid Square, based upon my geographical coordinates, is FM05pp. In fact, I'm the only Ham that can make that statement! If you live in a sparsely Ham-populated area, you might be able to make a similar claim.

So what do we do with this magical information? We put it on our QSL cards, that's what, and hope other satellite operators do the same. It may seem like just another bit of extraneous information now, but when we talk about Certificates and Awards later, you'll see the importance.

How do you go about finding out which Grid Square you are in? There are several ways of doing this. The most obvious method is to find a local Satellite or VHF/UHF operator and just ask. If that isn't possible, buy or borrow a copy of the ARRL published Grid Square Map or reference book which lists many domestic and foreign locations and their Grid Squares. This won't give you enough precision to determine your sub-grid but it will meet the requirements of knowing which grid you are in. If you can't find out your Grid Square either of these ways, perhaps you can find what your geographic coordinates are and plug them into one of the many available conversion programs. It wouldn't hurt to know this information anyway; you'll need it to set up whatever tracking program you will be using. (In fact, if you're filling out a QSL, you've already made at least one contact, and unless you just happened to turn on your radios and heard a pass in progress, you've already configured your tracking program.) Other methods to consider are the use of topographical and street maps, CD-ROM based trip routing software, and even getting a fix with a Global Position System (GPS) receiver.

Now that you know your Grid Square and have it on your QSL card, what other benefit is this information? First and foremost, it's because other satellite operators will be giving you theirs and requesting yours. But why, you may ask? Like other aspects of Amateur Radio, there are certificates and awards available for the satellite operator and one of these, the *VHF/UHF Century Club* award from the ARRL, is very popular. The VUCC, as it is often called, was created as an incentive for HAMs to populate the VHF and UHF bands and recognizes the successful completion of contacts with other Amateurs in at least 100 different Grid Squares, with endorsements for each additional 25 Grids worked. The basic *VUCC* award stipulates that these contacts be made on a single band from six meters and up, but there is a Satellite Endorsement which counts ALL satellites (even RS-12 with its 15m up/10m down configuration) as one band. Achieving satellite contacts from 100 different Grid Squares isn't hard, either, for an operator who puts in a little effort.

What about those cards that come in that don't have the Grid Square on them? Do you just discard them and hope you work someone in that Grid at a later date? Not necessarily. The requirements for the VUCC only stipulate that you make a concerted reasonable effort to determine the Grid Square. This can include looking up the location on a map, writing them a letter, calling on the phone, or just about anything else. This is another good reason to have a collection of maps, but if you want to keep the stack of maps to a minimum, consider one of the trip routing CD-ROMs mentioned earlier. Just make sure that whatever CD-ROM you buy will output coordinates; not all do and cost isn't a good indicator of how well they will serve our non-traditional purpose. I have two that I use and neither cost me over $30.

Aside from the *VUCC*, there are a number of other certificates that are popular. Another, although not specific to the satellite program and lacking any endorsements for us, is the ever popular *Worked All States* from the ARRL. Believe it or not, it isn't as easy as it may sound, particularly on the LEO's. Look at the footprint of any satellite during a typical pass and, with the exception of RS-15, you'll see that only a portion of the country is covered. This can be a real challenge for operators on either coast and often pulling in those last few (and hoping they get confirmed) can be a time consuming frustrating project.

All of this sounds very interesting, but what about AMSAT? Don't they offer any awards or certificates? They are, after all, the satellite folks and you would think that they would offer something to help promote the program, wouldn't you? Yes, you would, and you would be right. AMSAT offers a number of certificates, ranging from the *Satellite Communicators Club* available for making just one satellite contact, through the *K2ZRO Memorial Station Engineering Award* given out for participating in a difficult test of station receiving capabilities, to the *W4AMI Satellite Operator Achievement Award* for making at least 1000 contacts with any station on any satellite. Other awards include, but are not limited to, the *OSCAR Satellite Communications Achievement Award*, the *OSCAR Sexagesimal Award*, and the *OSCAR Century Award* given for proof of contact with 20, 60, or 100 different U.S. or Canadian call areas or DXCC countries.

Any others? Sure, but the list is growing constantly, so the best bet for the Satellite Award Hunter would be to contact AMSAT and the ARRL for further details. Address and phone numbers for both can be found in the section "My Resources" near the end of this paper. An updated list of most known satellite certificates and awards is printed occasionally in The AMSAT Journal, the official publication of AMSAT-NA.

<u>"How One Ham Got On the Satellites"</u>

Theory is nice, but it's application that really counts so, if you'll indulge me, I'll tell you a bit about my satellite set-up and some of the successes (and failures) that I've had.

For pass prediction/tracking I have three favorite programs that I run on my 386SX PC. The first program I use is called *AOS_US,* which is out of Germany and distributed as freeware, but the user is encouraged to make a small donation to AMSAT-DL to benefit their Phase 3D fund raising effort. I like this program because I can feed it a Keplerian Element file tailored to my operating needs and it will create a listing of pass opportunities for all the satellites I use. The listing can be for an almost unlimited length of time and can be sent to a disk file or directly to the screen. I also appreciate how *AOS_US* allows me to generate one file for all of my satellites of interest. I can then print this out and keep it near my operating position for quick referral.

My second pass predictor is called *STSOrbit Plus*. This piece of shareware will allow you to visually track up to 30 satellites at a time on a graphical display, resembling NASA Mission Control's "big board." My favorite part of this is the "multiple satellites at once" display which allows me to visually see where all of my favorite satellites are at one time and watch as they progress in their orbits. *STSOrbit Plus* will run without a coprocessor, but having one really helps.

My last pass predictor is *InstantTrack*, available from AMSAT. It will graphically plot only one satellite at a time, but its code is tight and the program is FAST! IT is a natural for running on older AT style machines because it just doesn't need the horsepower required by a lot of the newer programs.

(I do use other software, including *NOVA* for automatic radio control and *WiSP* for digital satellite communications, but I won't discuss those here. More information on these and other software packages available through AMSAT can be found in the Software handout available from AMSAT HQ. See the section on AMSAT later in this paper for the address and phone number.)

Now let's talk about the hardware.

For Mode K: (RS-12)
Transmitter: 15m up   Kenwood TS-690S
Transmit antenna: Dipoles, one oriented E-W, one N-S.
Both at about 6 meters.
Receiver: 10m down   Uniden HR-2600
Receive antenna: Turnstile at 4 meters

This set-up works very well. The Uniden was pressed into service when an older HF rig I was using bit the dust. The front end is a bit wide, and I can hear my uplink desensing the receiver a small amount, but once the bird is up over about 15 degrees, copy is no problem. In the first month of operation on this satellite I worked 28 states.

For Mode T: (RS-12)
Transmitter: 15m up Kenwood TS-690S
Transmit antenna: Dipoles, one oriented E-W, one N-S.
Both at about 6 meters.
Receiver: 2m down Yaesu FT-736R
Receive antenna: Eggbeater at about 5 meters

I was very pleasantly surprised when RS-12 was switched to Mode KT and I had the opportunity to try out the 2m downlink. The biggest impression I had was that the signals seemed much stronger than those on 10m. At first I thought this might just be due to my particular antenna and receiver combination, but conversations with others saw many of them expressing the same opinion. Be warned, though, that it is quite possible for one person in a QSO to be listening on 10m and the other person to be listening on 2m, so if both people are not tuning their receivers (per standard practice), then the whole conversation will become a matter of signal chasing. I quickly discovered this and learned to compensate accordingly. Even then, I found it best just to keep the other person tuned in even if it meant my own signal came back to me "off frequency" or disappeared all together.

The first thing you might notice is the FT-736R. This Multiband Multimode radio, although it has been out for a while, is still offered new and costs as much as a good HF rig. Don't be alarmed, though; it isn't necessary to run out and spend big bucks to work Mode A. I sometimes use a Kenwood TM-255A, a multi-mode mobile I bought a while back, and I have also used a TS-700 and IC-251A, both old and affordable. The reason I upgraded was because the TM-255A is usually in the truck, I sold the TS-700, the Icom had a few proprietary parts in it that decided it was time to fail, and a newer radio was affordable at the time. Listen to a few passes and hear what folks say they're using. You might be surprised.

You may not recognize the Eggbeater. This is manufactured by M^2 (M Squared) and consists of two vertical loops that are oriented at right angles and fed 90 degrees out of phase. This produces a somewhat omnidirectional pattern in the horizontal plane that becomes circularly polarized as you pass over head. The entire pattern looks somewhat like a hemisphere that has had the top depressed a bit. I got the Eggbeaters because I wanted an uplink antenna that wouldn't need to follow the satellite as it passed over and had minimum nulls. I bought one for 2m and one for 70cm, and I don't regret having them, but think I could have had just as good performance at lower cost. My first 2m antenna was one of those creations made from a mobile 5/8 wave on a ground plane. It was my original satellite antenna but suffered from an unexpected impact with the ground. (I dropped it from the roof accidentally. OOPS!)

For Mode A: (RS-10, RS-15)
Transmitter: 2m up Yaesu FT-736R
Transmitter antenna: Eggbeater at about 5 meters
Receiver: Kenwood TS-690S
Receive antenna: Same as Mode K

How does this set-up work? Very well. I've been on Mode A for a while now and have worked over 30 states on RS-10 and RS-15. The QSO's number well over 150. (You start to hear some of the same calls. After the newness wears off you actually start having conversations with these fine people. I can recognize many by voice now, even if they're not quite on frequency.)

For Mode JA: (FO-20, AO-27, FO-29)
Transmitter: 2m up Yaesu FT-736R
Transmit antenna: Eggbeater at about 5 meters
Receiver: 70cm down Yaesu FT-736R
Mirage KP-2 Mast Mount Pre-amplifier
Receive antenna: Eggbeater at about 5 meters

The only new equipment here is the pre-amplifier, and the 70cm version of the Eggbeater. Following common practice I have the pre-amp mounted directly below the antenna with the +12 volts needed by the pre-amp supplied by way of the feedline. A module inside the shack couples the voltage to the line which is then picked off by the pre-amp. This is a good arrangement as it requires no additional lines be run and the pre-amp can be controlled remotely. Like many new pre-amps on the market, there is also an RF sensor built in which will switch the pre-amp out of line during transmit. As an option, preferred by many, the +12 can be removed by applying a signal from the transmitter's PTT line.

My success on Mode JA is not nearly as good as on the other modes, but of the three I seem to be having more luck on FO-20. I have several contacts under my belt but I still fall victim to correcting in the wrong direction like I mentioned earlier and wind up frantically trying to re-acquire my own signal. There is also a problem with polarization differences between the Eggbeater and the FO- satellites. The Eggbeater has Right Hand Circular Polarization but FO-20 and FO-29, with their antennas mounted so they spin around the satellite's axis of rotation, seems to have a signal that is Left Hand CP for the first half of the pass. If you remember that there is a substantial cross-polarization penalty, you can see how a marginal signal will simply disappear.

My AO-27 contacts are even fewer and I seem to get a lot of quick fading. I can't even hear my downlink until the satellite is above about 50 degrees elevation, so I'm probably being blocked by my surroundings and I am confident that raising the Eggbeater for a better view of the sky would help a lot. I have also noticed the problem common to FM birds where one or two strong stations tend to monopolize the repeater.

I think a little antenna work will help greatly. Still, I am making contacts and having fun on Mode JA. Ultimately, I want to upgrade my system to include directional antennas and automatic control. By the way, I use this same setup on Mode JD with great success, but the digital nature of that mode helps substantially.

Incidentally, before buying the FT-736R I used a receive converter with my TS-690S for the 70cm downlink. Translating the displayed frequencies was a minor task, but it worked. Before learning how to operate the Yaesu's "Satellite Mode", I even used the TM-255A on the uplink and just used the FT-736R as a receiver. Don't feel you have to use a special radio designed for satellite operation; what you have or what you can afford will be fine.

I didn't mention Mir/SAFEX II or SAREX because I haven't worked either. I have monitored Mir from time to time, but it isn't one of my priorities. I have yet to have the pleasure of a SAREX contact. Owing to the highly changeable nature of the shuttle's flight profiles the Keplerian elements often change daily. I'm just too lazy to keep up with them when I have so much else going on with the other satellites.

Am I satisfied with my satellite abilities? Yes and No. Yes, I am, because I'm having a lot of fun with what I have, I'm making contacts almost daily (I do have other interests and obligations), I'm making new friends, and I'm taking part in the future of Ham Radio. No, because I know that there is more, and I sometimes get impatient. Ah, well, there is always tomorrow, isn't there? I think I'll save some challenges for then.

My Resources

When I started in my Amateur Satellite career, as with many activities in which I partake, the first thing I did was read. We are fortunate that there are many good sources of information available, and I found the following to be invaluable. I referenced these often while researching this paper, but I must warn you that these are just "the tip of the iceberg". Any questions that I couldn't answer by reading were quickly addressed by posting my queries to the AMSAT-BB (see below).

A greatly expanded version of this section is available from AMSAT HQ as the handout "Sources of Information About the Amateur Satellite Program". I highly recommend obtaining a copy. In it you will find data about more books, nets, World Wide Web, ftp, and telnet sites, magazines, newsletters, and software available through AMSAT.

Books

The AMSAT-NA Digital Satellite Guide, 1994, G. Gould Smith, WA4SXM, et al

Available from AMSAT HQ. An introduction to operating through the packet satellites, including the use of the DOS programs PB and PG, which are included on diskette.

The ARRL Handbook for Radio Amateurs, 1997, Paul Danzer, N1II, editor, satellite section edited by Robert Diersing, N5AHD

Available from the ARRL and other sources. Although not totally devoted to satellite operations, the Handbook covers practically everything that an Amateur needs to know. Filled with theory, applications, and construction articles. The 1997 edition contains 39 pages on satellite communications, including updated information on digital satellites. A "must have" book. The new Handbook on CD contains actual sound files from several Amateur satellites.

The ARRL Satellite Anthology, 1996, Rich Roznoy, KA1OF, et al

Available from the ARRL and other sources. A compilation of articles on satellite operation previously published in QST Magazine, the AMSAT Journal, and the World Wide Web.

A Beginner's Guide to OSCAR 13, 1989, Keith Berglund, WB5ZDP

Available from AMSAT HQ. A thorough "how to" of what was required to use OSCAR 13. Includes data on the satellite, how the elongated Molniya orbit affects the operator, and how to set up your station. OSCAR 13 is gone now, but much of what is included has relavence to OSCAR 10, too.

How to Use the Amateur Radio Satellites, 1995, Keith Baker, KB1SF

Available from AMSAT HQ. Describes each of the currently available satellites, Mir and SAREX. Includes several pages on the requirements for working the satellites, plus some "do's and "don'ts" to make your operating more enjoyable.

The RS Satellites Operating Guide, 1995, G. Gould Smith, WA4SXM

Available from AMSAT HQ. An overview of working RS-10, RS-12, RS-15, and Mir. A very good introduction to satellite work.

The Satellite Experimenter's Handbook, 1990, Martin Davidoff, K2UBC

Available from the ARRL and other sources. Considered by many to be "the book" on operating the Amateur satellites. Contains the history of the program, theory, and construction articles.

E-Mail Resources

AMSAT mailing lists

There are several of these, each with a specific purpose:
ANS - official AMSAT News Service bulletins
AMSAT-BB - the AMSAT "bulletin board" list
KEPS - Keplerian element distribution
AMSAT-DC - the Washington, DC AMSAT group
SAREX - Information on the SAREX project

Send E-Mail to listserv@amsat.org with a message telling which lists you wish to subscribe to, your call sign, and your E-Mail address. These lists are manually maintained so allow a few days for your requests to be processed.

ARRL Mail Server - send an E-Mail message to info@arrl.org. In the message body, put "send index" (new line) "quit" (both without quotes). You will receive the most recent index of all files available on the Server. Be warned that the index is large and will be sent in two parts. There are several good text files here on working the satellites, as well as information on many other topics.

On-Line Resources

http://www.amsat.org/ - The World Wide Web AMSAT-NA connection. Has information on AMSAT, articles, photos, and a link to the AMSAT ftp site for downloading software. This is the best place to start when looking for Amateur Satellite information and links to other sites.

http://www.arrl.org/ - Home page of the American Radio Relay League. Contains lots of information on becoming a Radio Amateur, plus links to sites for practically any Amateur related activity. Also has links to ftp servers for downloading software.

AMSAT

No discussion of the Amateur Satellite Service would be complete without a mention of AMSAT, the world wide organization of Amateur Satellite operators and supporters. AMSAT, or the Radio Amateur Satellite Corporation as it is officially known, is an almost entirely volunteer group, with the few paid employees being limited to office staff. (AMSAT-NA has but one, our tireless office manager Martha "Martha@amsat.org", without whom we'd be in big trouble. Thanks, Martha!) Everyone else, from the President, through the Area Coordinators, and down to the good people who manage the booths at Hamfests, freely give of their time and efforts. Many of the most ambitious satellite projects to date have been sponsored by the various AMSAT organizations and are funded entirely with contributions.

If you will take a few moments and go back to the section "My Resources", you will see that many of the books are published by AMSAT. AMSAT is a non-profit organization and all moneys derived from the distribution of these materials is channeled back into the program. Practically all of the programs and literature available from AMSAT were donated by their respective authors. The few that are commercial in nature are offered because they fill a need not otherwise available or because their general excellence and value to the Amateur Satellite operator has already been determined. Even with these, though, AMSAT does not make a profit; anything received above their actual cost is kicked back into the operating fund.

Use of the Amateur Satellites is obviously not limited to members of AMSAT, but I heartily encourage everyone to consider joining. At this time, membership in AMSAT-NA is $30 per year, with Lifetime memberships available. Membership includes the bi-monthly magazine "The AMSAT Journal." To join AMSAT, for more information on their program, goods and services, or to get the name of your closest Field Operations volunteer, please contact:

Radio Amateur Satellite Corporation (AMSAT)
850 Sligo Avenue, #600
Silver Spring, MD 20910-4703

Telephone: (301) 589-6062
Fax: (301) 608-3410

In closing...

When I first started thinking about writing this paper, it was to be a brief history of how one Ham, me, got onto the satellites. It just sort of grew. In the future, I hope to have both an expanded version and one that is much more brief. You have made it this far; others may not. If I have generated even a little interest in the Amateur Satellite program, then my efforts have met with success. I did it; so can you!

In the way of legalities, I must tell you that AMSAT is a registered trademark of the Radio Amateur Satellite Corporation, a really great organization of which I am proud to be a member. Please consider joining.

The information in the section "My Resources" has been greatly expanded into a companion handout titled "Sources of Information About the Amateur Satellite Program" and was first distributed by the AMSAT folks at the 1996 Dayton Hamvention. This document is constantly being revised, so you may wish to contact Martha at AMSAT HQ and ask for the latest copy.

I want to say Thank You to the following for providing encouragement and input to me as I was developing that listing: Keith Baker KB1SF, Cliff Buttschardt K7RR, Joe Holman AD7D, Jim Jefferson KB0THN, and Omri Serlin AA6TA.

Special thanks to Barry Baines WD4ASW and Mike Seguin N1JEZ for proofreading this paper in its many incarnations, providing even more encouragement, and not laughing too loudly at my obvious errors of spelling and style.

Well, I guess that about does it. You may remember that I said I don't know much about AO-10. That is my next goal. I'm learning now and the great thing is I already have most of my station assembled for Mode B! I can generate a 70cm signal so I just need to work on my antennas. Then maybe get some rotators. Then an auto-steering box. Then... Well, you can see where this is headed. I'm also looking forward to the launch of Phase 3D in the latter part of 1997, which should prove to be much easier to work for lots of people owing to its various available modes, sensitive receivers and increased output power.

I truly hope to see you on the birds soon. And please, if you hear someone calling "CQ Satellite from Whiskey Alpha Four Yankee Mike Zulu, Fox Mike Zero Five, North Carolina", give me a call. I'd love to hear from you.

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