learning curve

BY RICH ARLAND,* K7SZ

Working "The Birds"

One facet of the ham radio hobby that absolutely intrigues me is satellite communications, or SATCOM. I grew up with the space program. I can remember Alan Shepard's suborbital flight aboard Freedom 7 on May 5, 1961. I watched on a rather snowy TV picture as Shepard was fired into a sub-orbital spaceflight by a Redstone launch vehicle. I was 15 years old. I can visualize that flight like it was yesterday. Friendship 7 carried John Glenn on February 20, 1962 for three orbits, putting America's first astronaut in Earth orbit. Glenn's launch vehicle was a converted Atlas ICBM. By the end of the Mercury program in 1963, we had launched six American astronauts into space and recovered them all successfully! America's space program was on the move: Next stop, the MOON!

Gemini and then Apollo followed Project Mercury, each program pushing our fledgling space agenda further and further ahead, culminating in our landing of two astronauts on the surface of the moon in 1969. On that stifling July day I was on my way via the Japanese train system to work at the Fuchu Tech Control facility just north of Tokyo. Although we were discouraged from wearing our military uniforms while off-base, I was truly glad I had worn mine that day. I think I shook hands with every Japanese person on Honshu! They were not greeting me, but they were showing their love of America and the fact we had done something that had never been done in the entire history of mankind: putting humans on another planetary body. Even today, thinking back on this event and my train ride from Nishi-Tachikawa to Fuchu, I feel humbled by what Buzz Aldrin and Neil Armstrong accomplished. It was a great day to be an American!

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Clint Bradford, K6LCS (on right), at the Santa Barbara, California, hamfest a couple of years ago, helping a newly-licensed amateur (in striped shirt) make his first-ever ham radio contacts via satellite. (K6LCS photo)

Around the time that Alan Shepard flew in Freedom 7, a group of dedicated hams fabricated a small transmitter package and approached NASA and the USAF to find a ride into orbit for what soon became OSCAR-1. OSCAR stands for **O**rbiting **S**atellite **C**arrying **A**mateur **R**adio, and ham radio's first attempt to orbit a small transmitter into space was a success. Lofted into orbit on December 12, 1961, OSCAR-1 made ham radio history! Many heard the "HI" sent in CW by OSCAR-1 during the following 22 days that the bird was in orbit, including one 15-year-old soon-to-be licensed amateur radio operator, yours truly.

I never lost my interest in SATCOM. It wasn't until the early 1980s when I got really bitten by the SATCOM bug while stationed in England with the Air Force (ours, not theirs!). Sitting on my workbench was a 23-channel CB rig that I had just converted for 10-meter FM. I kept hearing something trying to break the squelch, so I opened the squelch and heard some CW! I had not calibrated the dial at that time, so all I knew for sure was that the rig was on 10 meters, somewhere around 29 MHz. The noise bursts (which are exactly what CW sounds like when being received on an FM receiver) were readable and eventually I pulled a callsign out of the mess: AO-7! AMSAT-OSCAR 7! Wow! Who woulda' thunk it?? To top it all off, the only antenna I had on the converted CB rig was a 5-foot piece of hook-up wire. You gotta love this hobby!

This extremely crude experiment led me to start actively listening for the downlink beacons on several of the Low Earth Orbit (LEO) satellites, also called "birds." It was fun. It was exciting. It was *different*! But most of all, it was habit forming. I was hooked.

Unfortunately, the days of the 1980s and '90s are long gone and with them the majority of the LEO birds that offered an inexpensive and relatively easy way to play in the SATCOM arena. Most of these satellites had on-board transponders in what was then called "Mode A," which was a 2-meter uplink and a 10-meter downlink. This was easy to do with a good HF receiver and a simple 2-meter CW or SSB rig as a transmitter. Antennas were not a big problem, and I utilized omnidirectional verticals on both 2 and 10 meters

for many years to work these SATs. Over the years, these satellites fell victim to air molecules (yes, there are air molecules in low Earth orbit), which produce a drag on the satellite, causing it to eventually slow down enough to fall out of orbit and re-enter the Earth's atmosphere. In short, the bird dies.

Not all is lost, however, as there are several LEO birds that carry equipment that make it possible to communicate through the satellites via V/UHF FM! Now *that* is cool!

Before we go any further, let's take a closer look at the lexicon of terms you'll encounter in the amateur satellite communications arena.

Our first acronym is **LEO**, short for **Low Earth Orbit** satellites. From the Earth's surface outward, between 160 to 2000 km, is referred to as low earth orbit. Anything in orbit above that 2000-km distance is considered a middle or high Earth orbit. Currently there are several LEO birds available for today's budding amateur SATCOM enthusiast who has a dual-band VHF/UHF handheld. At these distances the signals from the satellite coming back to Earth are relatively strong and easily picked up by most radios of today.

Another couple of unique SATCOM terms are **uplink** and **downlink**. The uplink is a block of frequencies from your Earth station that you transmit on to get "up" to the satellite. Obviously, downlink is a block of frequencies that are used from the satellite "down" to your Earth station. Often you will see these chunks of frequency spectrum expressed as **Modes**. Instead of saying "2-meter uplink and 70- centimeter downlink," many SATCOM ops refer to this particular grouping as **Mode V/U**, as in VHF uplink and UHF downlink. Since the actual up and downlink frequencies are well published, when you say **Mode V/U** you are automatically talking about 2 meters up and 70 cms down. Mode U/V would be the reverse of Mode V/U: 70 cms up and 2 meters down. Pretty easy!

Orbital period is yet another SATCOM unique term. This is the time that it takes for the satellite to circle the Earth. LEO birds have an orbital period of around 90 minutes. This is calculated once the orbit of the satellite has been established and is part of the unique set of numbers, called **KEPS**, (short for **Keplerian Elements**), that is used to compute the time the satellite will appear at your local horizon (called **Acquisition of Signal,** or **AOS**) and when it will drop below your local hori-

zon (called **Loss of Signal**, or **LOS**). These two sets of times are critical in establishing contacts on a LEO sat. The closer the "pass" is to being directly overhead between AOS and LOS, the longer talk time you will have.

One cardinal rule regarding SATCOM: always, *always* use just enough power on your uplink transmission to hit the satellite reliably. Anything over and above that is wasting power. Also, using large amounts of uplink RF can block other stations from accessing the satellite and limit your number of potential contacts.

You'll also encounter **apogee** and **perigee**: the high point and low point, respectively, in the satellite's orbit. This isn't all that critical when we speak of LEO birds, but there are other satellites out there that have highly elliptical orbits called **Molniya** orbits which have a very low perigee and an extremely high apogee, allowing many hours of access time when they are above your local horizon.

Thanks to Clint Bradford, K6LCS, Area Coordinator for AMSAT and keeper of the <www.work-sat.com> website, for graciously offering the accompany-

Work Satellites with your HT!

By Clint Bradford, K6LCS, Area Coordinator for AMSAT

Most hams already have the necessary equipment to work FM amateur satellites. This guide offers all the information you need to "work the birds." All cited resources—and a lot more info—are available to you at: <http://www.work-sat.com>

If you have 2M and 440 capabilities (either "split frequencies" in one HT, or two radios), you can work FM amateur satellites! For example, for satellite SO-50's VHF/UHF (V/U) mode, the UPLINK frequency (to SO-50) for FM voice is 145.850 MHz.* The Downlink freq (from SO-50) is 436.795 MHz.

First, you need to know WHEN and WHERE the satellite will be passing over your location. There are several commercial computer programs that will tell you. In the home office, I use MacDoppler. Outside, though, I use PocketSat on my Palm PDA or iPod touch/iPhone. On my netbook, Nova for Windows and SatPC32 are amazing. But free of charge info is also available online at <www.amsat.org> or <http://heavens-above.com>.

Plug in your longitude and latitude coordinates on either or both of these sites, and you can access amateur satellite pass information.

The one "absolute" for success is to open up your squelch. We are talking about "weak signals" from 500+ miles away, so don't expect the satellite to be strong enough to break squelch like your local repeater. Sure, it's a little noisy, but that's part of the process: That noise is an aid in locating the satellite. When the frequency starts to exhibit quieting, that's a sign that you are capturing the satellite's signal.

Improve your HT's stock antenna (most are rated at NEGATIVE 2–3 dB!). For BNC connectors, Pryme's AL-800 will make the difference. For SMA, the Diamond SRH-320a or Smiley 270A are better performers. Using an Arrow dual-band Yagi or Elk log-periodic is better. If you prefer to homebrew your antenna, go to the worksat.com Web site's ANTENNAS page for construction article links. A fun project is the tape measure beam—for about $20 in parts!

Set up your radio to tune for the Doppler Effect on the downlink. Start listening above the center frequency; you will acquire the satellite sooner and clearer. When the downlink gets scratchy or fuzzy, tune down 5 kHz at a time and reception should be clearer. Only transmit when you can clearly hear the satellite. Follow the signal down in frequency as the pass continues *(but continue transmitting on the same frequency—ed.)*. Tables 1 and 2 show how I have programmed my HT for working the AO-27 and SO-50 satellites, respectively.

Ch #	Name	TX Freq	CTCSS	RX Freq	CTCSS
101	27 +2	145.850	None	436.805	None
102	27 +1	145.850	None	436.800	None
103	27 MID	145.850	None	436.795	None
104	27 -1	145.850	None	436.790	None
105	27 -2	145.850	None	436.785	None

Table 1. Here's how K6LCS has programmed his radios for AO-27. No CTCSS required. Successfully working AO-27 takes an "extra step" in planning, as you need to check its operating schedule to make sure it will be ON for your chosen pass. Links to that scheduling program are on the worksat.com site. Note that only the receive frequency changes.

Ch #	Name	TX Freq	CTCSS	RX Freq	CTCSS
201	50 +4	145.850	67.0	436.815	None
202	50 +3	145.850	67.0	436.810	None
203	50 +2	145.850	67.0	436.805	None
204	50 +1	145.850	67.0	436.800	None
205	50 74	145.850	74.4	436.795	None
206	50 MID	145.850	67.0	436.795	None
207	50 -1	145.850	67.0	436.790	None
208	50 -2	145.850	67.0	436.785	None
209	50 -3	145.850	67.0	436.780	None

Table 2. Here's how Clint has programmed his handheld radios for SO-50. SO-50 does require a tone of 67.0 on the uplink. If you KNOW the satellite is there, but you do not hear anyone else, then you might need to turn its ten-minute timer ON by sending it a couple seconds of 74.4 Hz on your uplink! (Channel 205 above is Clint's "wake-up" frequency.)

Don't hold your whip antenna upright. Held in a vertical position, your transmitted signal is hitting land-based receivers. You need to tilt your HT's antenna so that it is perpendicular to the airborne satellite. Very few of the ham satellites are land-based (grin), so you must TILT your antenna about the same amount as the satellite's ELEVATION. You'll quickly get the hang of it and hear the difference! You'll have better results with a modest beam or Yagi.

Ideally, we should all be working the satellites in full duplex mode, where we can simultaneously listen to the downlink as we are transmitting. Although this method is preferred, it is not mandatory: Carefully monitor the downlink, and wait for a break in the conversations to announce yourself. You might find it helpful to record your sessions for later review and logging. Even if you don't make a contact during a pass, a recording can help you recognize the callsigns and voices of other operators. Pocket recorders or smartphone apps are great for this. If working full-duplex, use an earpiece or headphones to monitor the downlink.

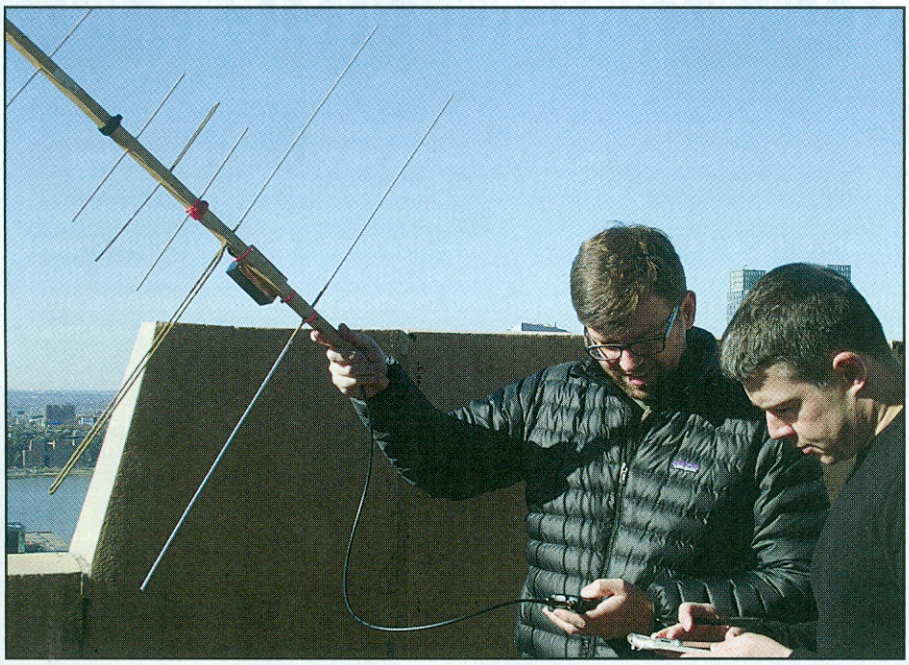
Knowing your grid square—and having a grid square map—is a quick way of identifying locations of what you will hear. The ARRL and Icom have grid square maps. Icom's is free and available at many ham radio stores.

It just takes a little preparation and planning for working amateur satellites. Not every pass is workable with an HT; don't go after the sub-10° elevation passes as you start "working the birds." Choose your passes wisely: Working higher elevation passes will give you better results and longer "talk time." When you clearly hear others, listen for a break in the action and use the ITU approved phonetics to announce your callsign, grid square, and op mode: "KILO-SIX-LIMA-CHARLIE-SIERRA, DELTA-MIKE - ONE-THREE, handheld."

Check work-sat.com for the satellites' home Web pages to make sure the sat is in the mode you can work with your setup!

Ask questions! Find an elmer in your club for support, or use the Work-Sat.com Yahoo Group for any questions and join AMSAT-NA! Membership isn't that expensive, and members are entitled to discounts on satellite tracking software and publications. Support the sats by supporting AMSAT!

Access this Web site for all citations, links, resources, and updates: <http://www.work-sat.com>.



A handheld radio and a handheld beam antenna are all you need to work some FM satellites. This antenna is a homebrew "Cheap Yagi" designed by CQ Antennas Editor Kent Britain, WA5VJB. Here Dave Clausen, W2VV, and Bill Ward, KD4ISF, try to work SO-50 from a hotel balcony in New York City. Note the angle of the antenna, as described in the text. (W2VU photo)

ing sidebar information on working the FM satellites for the neophyte SATCOM operator for inclusion in this column. Clint can be reached at: <www.worksat.com> or via e-mail at: <clint@clintbradford.com>. Also, to answer the most often-posed question: "Yes, it really is that easy!"

That's a wrap for this month. I hope Clint and I have stirred your interest and you'll take advantage of the opportunities to put your handheld rigs to use as SATCOM Earth stations. Next month: Hittin' the bush with K7SZ! Be there or be square (I always wanted to use that!)

73, Rich, K7SZ

This photo is on K6LCS's QSL card. It was shot at the Los Angeles County fair while working three countries (US, Canada, and Mexico) on a single pass of an FM satellite. Power out was just 2 watts. (K6LCS photo)