By Steve Ford, WB8IMY

OSCAR 40 on Mode U/S—No Excuses!

If you're eager to experience satellite DXing, what's stopping you?

If you read the article by Ed Krome, K9EK, in the July *QST* ("Getting Started with AMSAT-OSCAR 40," page 42), you know that the OSCAR 40 satellite is now open for business. It's been a long time coming, but well worth the wait.

The history of this spacecraft reads like a soap opera. First we endured almost 10 years of planning, building and several disappointing setbacks. When OSCAR 40 finally soared into space last November, everything appeared to be working perfectly—until the big bird went ominously silent during an engine firing a few weeks later. As the late Jim Morrison of The Doors lamented, "This is the end, my only friend, the end."

Not quite.

The command team reestablished communication on Christmas Day 2000 and OSCAR 40 suddenly returned to the land of the living. The spacecraft had suffered serious damage, but almost all of its receivers were operational along with its powerful 2.4 GHz transmitter. As this article went to press, the OSCAR 40 team was still working on possible fixes for the remaining transmitters.

But for now, it looks like OSCAR 40 is going to be talking to us almost exclusively on 2.4 GHz and listening on either 435 or 1269 MHz. The most popular uplink/downlink combination so far is 435 MHz up and 2.4 GHz down, otherwise known as *Mode U/S*.

"I Don't Do Microwaves"

I don't know what it is about frequencies defined in "GHz" that makes some amateurs cringe. Yes, there was a time when working with microwave RF components was a considerable challenge. It still is if you are exploring the rarified upper reaches of the spectrum. But gear for the "lower end" of the microwave range is plentiful these days and easy to use. Despite this fact, I still hear objections such as:

- **It's too complicated.**

Oh, please! The 2.4 GHz receive equipment you need for OSCAR 40 is as close to plug-and-play as you're likely to get. My seven-year-old daughter has put together the receive side of my OSCAR 40 station. She compares it to playing with Lego blocks.

- **I don't have microwave test equipment.**

Neither do I. My "signal generator" is

My portable OSCAR 40 antenna system with the barbecue grill dish attached. The tripod was purchased at RadioShack and the PVC is courtesy of my local hardware outlet. I can set up my antennas in about 15 minutes.

This is yet another incarnation of my OSCAR 40 antennas, this time using the Down East Microwave helical antenna (the glaringly white plastic tube aimed at the heavens). I find that I achieve somewhat better performance from the dish, but the helical antenna does an adequate job—especially when I have the 2.4-GHz preamp in the line.

OSCAR 40's beacon. I point my antenna at the place in the sky where the satellite should be and *listen*.

● **I can't assemble and adjust a microwave antenna.**

Most of the antennas that hams are using with OSCAR 40 assemble with a screwdriver in about 15 minutes. No adjustments are required. In fact, some antennas come entirely preassembled.

● **It's too expensive.**

While UHF and microwave gear isn't free, it is a heck of a lot less expensive than your typical gee-whiz HF transceiver—especially if you shop smart. More about this in a moment.

Perhaps the best way to convince you is through my own experience. I've been on Mode U/S with OSCAR 40 for a couple of months now with a portable antenna system. With two antennas on my little tripod, I can sit on my backyard patio, cool beverage in hand, and talk to stations in other countries through a spacecraft that is more than 50,000 km distant. Believe me, Amateur Radio doesn't get much better than this.

First, We Must Listen...

You have a wide range of 2.4-GHz antenna choices. Ed Krome pointed out several vendors in his article, and you'll find them listed again in the "Resources" sidebar. My primary antenna is the so-called "barbecue grill" dish. It's lightweight and easy to manage with plenty of gain to boot. Another lightweight option is the helical design where the antenna element is wound like a bedspring. The helical model pictured in this article is from Down East Microwave (model DSH12-17) and it is encased in a PVC tube. Pick the antenna that is best for your particular situation—the one that gives you the most bang (gain) for the buck.

The Boost that Refreshes

With the antenna out of the way (wasn't that quick and painless?) we have to consider what to do with the energy it collects. The signals from OSCAR 40 have traveled a long way to reach you and they are exquisitely weak. Your antenna gathers as much as it can, but you need to give the signals a righteous kick in the pants before you can really make use of them. In addition, you need to convert these microwave signals to lower frequencies that you can hear on the kind of receiver you're likely to own (maybe an HF rig or 2-meter CW/SSB radio). That's the job of the *downconverter*.

Downconverters are available from a number of sources. I actually own two models: One is a consumer-grade unit originally made for the R. L. Drake Company for use with terrestrial microwave TV. I picked this little gem up for $25 and modified it for ham applications (see my article "Microwaves in Your Back Yard" in the February 1998 *QST*). Similar TV downconverters are still available, though they are not always easy to find. Check out the Web site of Mark Fossum, N0NSV, at **www.markfossum.com/** and click on his "Mode S" link. Mark sells several models that you can modify for OSCAR 40 reception at bargain prices.

If you prefer the no-modification option, there are ready-to-go downconverters that you can buy right off the shelf. My plug-and-play model is the Down East Microwave 2400-144 RX. Another excellent product to consider is the UEK-3000 from SSB Electronic. These units convert the 2.4-GHz signals to 2 meters and they typically sell in the $200-$300 range. They are well engineered and come with comprehensive warranties.

Depending on the type of antenna you choose, you may find that the gain of the downconverter is not quite sufficient to render useable signals at your receiver. If this is the case, you may need to give the microwave energy a shot in the arm *before* it reaches the downconverter. I use a Down East 2.4 GHz preamplifier that gives the wispy signal a tremendous kick. Because the signal is still at 2.4 GHz, I need to get it to the downconverter right away, and over the shortest distance possible (common coaxial cable is like a sieve at microwave frequencies). To achieve this, I connect my preamplifier directly to my downconverter at the antenna. I power both units with dc sent through the coaxial cable, but you could also run a separate power cable.

Putting together a 2.4-GHz receive system is child's play—literally. My daughter attaches a preamp to a modified Drake downconverter in preparation for another OSCAR 40 session.

Getting the Signal to your Receiver

My "microwave" radio is an ICOM IC-706 Mk II transceiver. Like a number of newer HF rigs, the '706 offers 2-meter all-mode receive capability. This is ideal for use with the 2.4-GHz downconverter. I just tune to the converted microwave signal at 144 MHz and I'm ready to go.

Other options abound. You could put another downconverter in the line and convert the 2-meter signal to 10 meters. Down East offers a converter (the model 144-28) that performs this task nicely. With the signal now on 28 MHz, you can listen with just about *any* radio that is capable of receiving CW and SSB on 10 meters. One fellow I know uses a 30-year-old RadioShack shortwave radio to listen to OSCAR 40 in this fashion.

Also consider the VHF/UHF multiband all-mode transceivers. The modern-day models will set you back as much as $1600 new. If you have that kind of cash lying around, go for it! They are superb radios. On the other hand, you can find perfectly adequate models on the used market below $1000. The advantage of the multiband all-mode radio is that it offers several features that make satellite operating much easier—including the transmitter to generate your 435 MHz uplink.

After going to the trouble of receiving and converting the OSCAR 40 signal, don't make the mistake of squandering precious RF energy in lousy coaxial cable. Yes, the

Resources

AMSAT-NA
850 Sligo Ave, Suite 600
Silver Spring, MD 20910-4703
301-589-6062
www.amsat.org
Tracking software: **www.amsat.org/amsat/catalog/software.html**

AMSAT-DL (Germany)
Lots of AO-40 information. English is available for many sections.
www.amsat-dl.org

Down East Microwave Inc
954 Rt 519
Frenchtown, NJ 08825
908-996-3584
www.downeastmicrowave.com

SSB Electronic USA
124 Cherrywood Dr
Mountaintop, PA 18707
570-868-5643
www.ssbusa.com

Hamtronics
65 Moul Rd
Hilton, NY 14468-9535
716-392-9430
www.hamtronics.com

PC Electronics
2522-Q Paxson Ln
Arcadia, CA 91007
626-447-4565
www.hamtv.com

signal may be at 2 meters or even 10 meters, but every dB counts. Install low-loss coax between your downconverter and receiver. It is money well spent.

Finally, beware of frying your 2.4-GHz downconverter. If you're using a transceiver as your microwave receiver (like I do), it is remarkably easy to grab the wrong microphone and key substantial RF power directly into your sensitive downconverter. How do you avoid disaster? My technique is basic diligence. I make sure my IC-706 transceiver is powered up (and not accidentally transmitting!) before I attach the coax to the downconverter. I also disconnect the '706's microphone before operating. Perhaps some clever amateur will come up with a circuit to sense RF from the transceiver and automatically protect the downconverter. The proper design could even be written up as an article for a magazine…such as *QST!*

Tune for the Buzzsaw

I suggest you start your first OSCAR 40 listening session by searching for the *Middle Beacon*.

The quest for the Middle Beacon has nothing to do with spiritual enlightenment and everything to do with testing your receive system. OSCAR 40 has two S-band downlink transponders known as S1 and S2. The S2 transponder is carrying all of the activity at the moment. So, you want to hunt for the Middle Beacon of the S2 transponder. All the active frequencies are shown in Table 1, but if you can't divert your eyes from this riveting text, I'll tell you that the S2 Middle Beacon frequency is 2401.350 MHz. You'll know the signal when you find it. This beacon carries telemetry and its 400-baud PSK data stream makes an unmistakable buzzsaw sound.

Use satellite tracking software (see the list at **www.amsat.org**), or get pass predictions for OSCAR 40 from the Web at **www.heavens-above.com**. With the information the software provides, make your best guess at where and when the satellite will appear in your local sky. Aim your 2.4 GHz antenna in that direction and start tuning through the frequency range with your receiver. With luck you'll spot the beacon right away. Adjust your antenna aiming for the loudest beacon signal strength and you're done.

Unless you are monitoring the satellite as it passes near the Earth, the signal frequency should only drift slightly due to Doppler shifting. This is because the position of the satellite relative to your position is changing quite slowly. In fact, you may discover that you only need to re-adjust your antenna aiming about once every 30 minutes or so. This means that you can do away with the cost of an azimuth/elevation antenna rotator unless you absolutely *must* have the convenience of adjusting the antenna position from the comfort of your shack.

Table 1
Transponder Frequency Band Plan for AMSAT-OSCAR 40

Uplink Frequencies

Band	*Digital*	*Analog (SSB, CW)*
70 cm	435.300 - 435.550 MHz	435.550 - 435.800 MHz
23 cm (L1)	1269.000 - 1269.250 MHz	1269.250 - 1269.500 MHz
23 cm (L2)	1268.075 - 1268.325 MHz	1268.325 - 1268.575 MHz
13 cm (S1)	2400.100 - 2400.350 MHz	2400.350 - 2400.600 MHz
13 cm (S2)	2446.200 - 2446.450 MHz	2446.450 - 2446.700 MHz
6 cm	5668.300 - 5668.550 MHz	5668.550 - 5668.800 MHz

Downlink Frequencies

Band	*Digital*	*Analog (SSB, CW)*
13 cm (S1)	2400.650 - 2400.950 MHz	2400.225 - 2400.475 MHz
13 cm (S2)	2401.650 - 2401.950 MHz	2401.225 - 2401.475 MHz
1.5 cm	24048.450 - 24048.750 MHz	24048.025 - 24048.275 MHz

Telemetry Beacons

Band	*General Beacon (GB)*	*Middle Beacon (MB)*	*Engineering Beacon (EB)*
13 cm (S1)	2400.200 MHz	2400.350 MHz	2400.600 MHz
13 cm (S2)	2401.200 MHz	2401.350 MHz	2401.600 MHz
1.5 cm	24048.000 MHz	24048.150 MHz	24048.400 MHz

The "shack end" of my OSCAR 40 station. At the left is the IC-451 all-mode 70-cm transceiver. My IC-706 transceiver (right) serves as the microwave receiver. I can operate from this desk or, when the spirit moves me, I can drag everything out to the patio for a little "satellite *al fresco*."

By the way, if you are curious about the information contained in the beacon signal, it won't cost you a penny to eavesdrop if you already have a sound-card-equipped computer. Get on the Web and go to **www.qsl.net/ae4jy/** and download the latest version of *AO40RCV*. This clever piece of software designed by Moe Wheatly, AE4JY, uses your sound card as a modem to convert the receive audio from the beacon to information on your computer monitor. Just watch the numbers and you'll instantly know the "health" and status of the satellite.

Time to Transmit

Monitoring OSCAR 40 is fun, but it only takes you so far. In my case, I grew weary of listening to everyone else enjoying themselves after the first week. Unfortunately, I owned no 435-MHz transmitting gear whatsoever. Zip. Nada. Not even a decent antenna. What to do?

Using Ed Krome's article as my guide, I figured that I needed to generate about 50 to 100 W to an 11-element Yagi antenna. I also needed to be able to transmit and receive *simultaneously* so that I could hear my own signal coming back from the satellite. This would allow me to compensate for Doppler shifting, and to make sure I was uplinking on the correct frequency. OSCAR 40 uses *inverting* transponders, which means that if you want your signal to appear in the upper portion of the downlink passband, for example, you must transmit in the *lower* portion of the uplink passband. In addition, if you want to be on upper sideband (USB) on the downlink, you need to transmit in lower sideband (LSB) on the uplink.

If I could have shelled out the cash for one of those nifty multiband, multimode transceivers, I would have been all set. They operate in full duplex and many automatically link the uplink and downlink VFOs so that they track one another in backward fashion, which effectively removes the inverting transponder confusion factor. Of course, the multimode aspect is important because you must use CW or SSB with OSCAR 40—FM is *verboten* on this bird.

Alas, my wife peeked at the budget figures and started imitating Commander

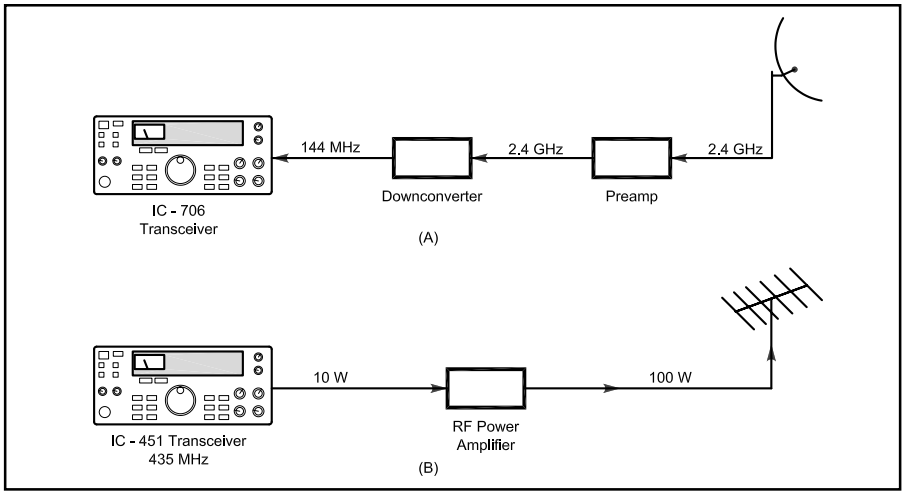
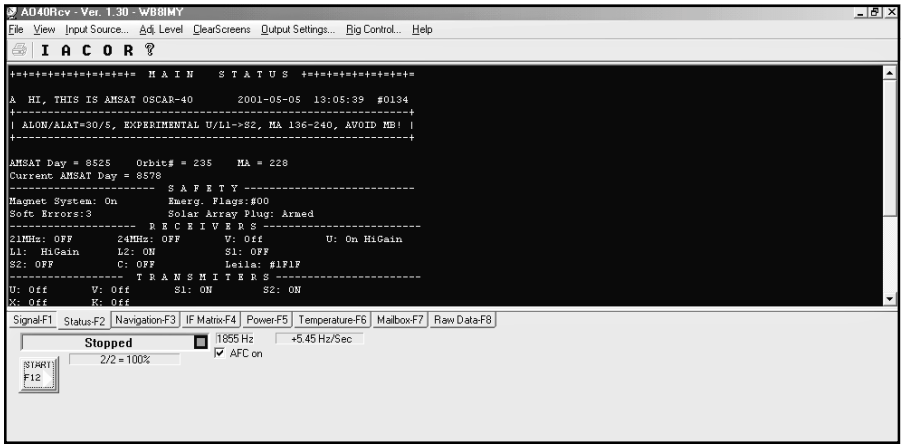


Figure 1—My OSCAR 40 station is as basic as it gets. Assembling the uplink station (B) depleted my bank account by $470. My downlink gear (A) rang in at $240 (not counting the IC-706 that I owned already), making the total cost of my OSCAR-40 station about $710.



This is *AO40RCV* as it decodes and displays the information in OSCAR 40's telemetry beacon. All you need to run the software is a PC with a sound card. You can download *AO40RCV* on the Web at www.qsl.net/ae4jy/.

Scott from *Star Trek* in one of his standard vein-popping moments. ("I dinna think she can take the strain, captain!")

Sufficiently chastised, I began prowling the flea markets, both real and virtual. On eBay (www.ebay.com) I discovered an ICOM IC-451 all-mode 70-cm transceiver on the auction block. It was a 20-year-old radio, but the seller claimed it was in mint condition. I jumped into the bidding war and finally emerged victorious at $250. The IC-451 was indeed in pristine condition, but it only pumped out about 10 W of RF.

I visited *Radios On Line* on *ARRLWeb* (www.arrl.org/RadiosOnline/) and ran into a fellow who was selling a vintage Mirage 100-W UHF RF power amp for only $120. I snapped it up in a heartbeat.

Being proud of my thrifty ways, I decided to splurge and buy the Yagi antenna brand new. I settled on an M^2 11-element beam that I picked up for just under $100. Not counting the coaxial cable, my uplink station depleted my bank account by $470. My downlink gear rang in at $240 (not counting the IC-706 that I owned already), making the total cost of my OSCAR-40 station about $710 (see Figure 1). If you're willing to do a bit of homebrewing, I bet you could shave at least $200 off that price tag, if not more.

Busted by LEILA

Is 100 W to a small Yagi antenna enough to reach a satellite that's more than 50,000 km away? If the satellite is OSCAR 40, the answer is "yes." I've been astonished at the strength of my signal on the downlink. The first time I heard my own voice coming back to me through the satellite, my hair stood on end. I still find it hard to believe that my meager antennas, bolted to a PVC **T** on a tripod in my back yard, can communicate with a spacecraft at that distance.

Once my blood pressure returned to normal after that first transmission, I realized that my signal was a bit too strong (it was nearly as loud as the Middle Beacon). I was pondering this fact and making some test transmissions when I heard what sounded like a police siren on the downlink. *LEILA* had found me!

LEILA is a German acronym for LEIstungs Limit Anzeige. Translated, it means "power (or 'performance') limit indicator." LEILA is a program in OSCAR 40's primary computer that monitors the strength of each signal sent to the satellite. Signals that are too strong can "swamp" the transponder, effectively drowning out most of the weaker transmissions. When LEILA finds an obnoxiously strong signal, it sends a siren-style warning on the corresponding downlink frequency (the one you're supposed to be listening to if you are operating full duplex). If you ignore the warning and fail to crank down your power, LEILA will notch you out! Think of it in terms of your kindergarten days when the teacher said, "If you can't play nicely, you can't play at all."

When I heard LEILA's siren call, I knew I was running way too much power. I reduced my output from 100 W to about 60 W and LEILA was happy. She (it?) resumed scanning for other offenders and didn't even write me a ticket.

Embrace the Challenge

Now I don't want to be accused of over-hyping the ease of satellite operation, even through a bird as magnificent as OSCAR 40. Let's be frank—if you are new to amateur satellites, you have an educational hill to climb. You need to become familiar with our diverse satellite "fleet," and with the fundamentals of orbital mechanics, Doppler frequency shifting, transponders and more. You're about to explore a new world, so expect a certain amount of confusion and, dare I say it, frustration.

If you're looking for an effortless, undemanding Amateur Radio experience, you've come to the wrong place. But if you're willing to step up to the challenge and begin thinking in new ways, the rewards of amateur satellite operating are considerable. I'm talking about more than bagging your satellite DXCC through OSCAR 40 (although I'm wondering who will be the first). Centuries from now, when students read of the beginnings of space travel and of mankind's migration from the Home World, the story of a ragtag band of "primitive" amateur space communicators may be lurking somewhere in the fine print. To know that I might be a minuscule participant in that history is reward enough for me. QST