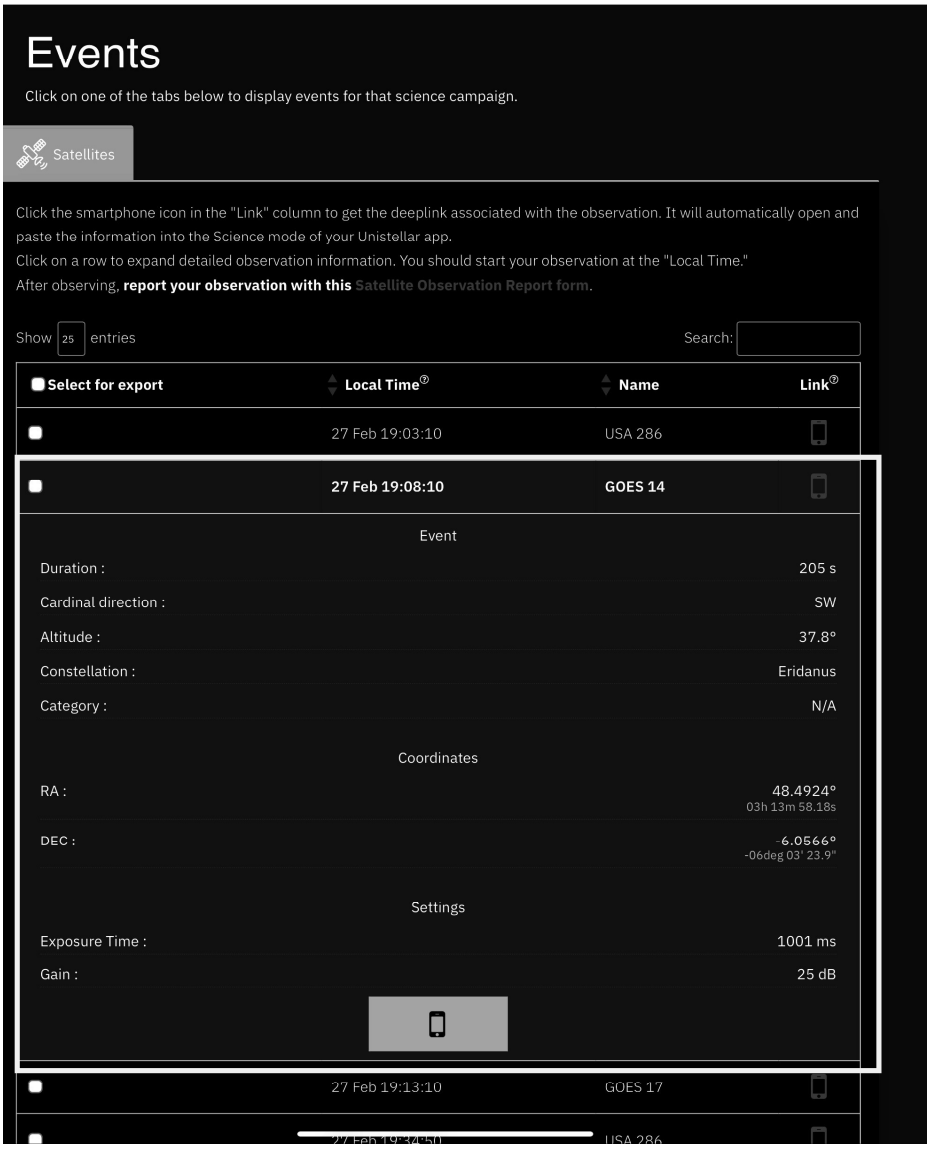

detection of radio waves, with which these satellites can interfere.

Unistellar, in collaboration with the SETI Institute, expanded the scope of its Citizen Science missions to include campaigns for artificial satellite tracking. Satellite-observing missions by Citizen Scientists began on January 17, 2023. These satellite tracking missions can help the astronomy community better understand the impact that tens of thousands of satellites will have on the night sky for both professional astronomers and backyard enthusiasts. These missions also provide objective data to help commerial and government satellite operators better mitigate negative impacts on astronomical observations.

Transceivers for Satellite Operation

Keith Baker, KB1SF/ VA3KSF
Senior Writer

[Portions of this article appeared in the March-April Edition of The Canadian Amateur.*]*

As I've said in previous feature articles in the *Journal*, while hand-held FM radios and antennas are great for "hit or miss" satellite contacts, if you are serious about satellite work, eventually, you'll want something more permanent for your home station to reliably work both the FM satellites as well as their analog cousins. The latter capability offers far more "elbow room"… and time…for extended satellite QSOs.

In this article, I'll offer a quick review of some of the more popular satellite-capable base station radios currently on the new and used market. My goal is to offer some issues to consider when shopping for a "satellite-friendly" radio so that you can get on the birds from home without also breaking the family budget!

Over the years, several amateur radio manufacturers have offered base station radios specifically equipped to work the satellites. This equipment usually offers all-mode VHF/UHF capability to transmit and receive in "full duplex" mode. This means the radio can transmit signals on one band while simultaneously receiving them on another. While not necessary, this feature makes it far easier to know if your signal is getting into (and through) the satellite without causing harmful interference to conversations already ongoing through the transponder. This feature also helps you more easily tune your radio to compensate for Doppler shift as the satellite whizzes overhead.

So, Where Do I Start?

A good place to start your search for a satellite-capable, full-duplex radio is with an Internet list that's been painstakingly compiled by our friends at AMSAT Sweden (in English!) at: https://www.amsat.se/2021/01/11/transceivers-for-amateur-radio-satellites/. As you can see from his list, even though

there is only one brand new, full-duplex radio on the market today, many older (but still perfectly functional) satellite-capable radios can still be found on the used market. With this list in hand, some time spent scouring the various amateur radio bulletin boards that offer listings for used equipment (such as www.qrz.com, www.qth.com, or www.eham.net in the USA or www.kwarc.org in Canada) may pay off in a somewhat older, but still perfectly functioning satellite radio at a fraction of the cost of a new one.

Separate or "All In One"?

Indeed, while a single, all-in-one, full-duplex base station radio is nice to have, for many years, I have successfully operated on satellites using two separate radios. One was an all-mode VHF radio (a Kenwood TS-711A), and the other was an all-mode UHF radio (its 70 cm companion, the Kenwood TS-8llA). And while I had to manually tune each of them to keep up with "Dr. Doppler," this setup still provided me with many hours of solid satellite radio time.

And, even today, if a full duplex, all-in-one transceiver (even a used one) is beyond your means, you can still adapt a number of the all-mode, VHF/UHF-capable base or mobile radios now on the new (or used) market for satellite work. For example, many satellite operators have very successfully adapted a pair of (now discontinued) all-mode Yaesu FT-817s and/or FT-818s (so-called QRP) radios (or their more powerful cousins, FT-857s) for both FM and analog satellite work… one radio for the VHF/UHF uplink and one radio for the VHF/UHF downlink.



Figure 1— The Yaesu FT-847 is a 1990s-era, all-mode, HF/VHF/UHF base station radio that was specifically optimized for full duplex satellite work. While now long since out of production, used ones can sometimes still be found for sale. (Courtesy: www.rigpix.com.)

Unfortunately, and as I've said, fewer and fewer newly manufactured, all-in-one amateur radios these days have the capability to operate in full duplex mode on VHF and UHF. However, one is still being offered on the new radio market… and (hopefully) more will follow. That current radio is ICOM's IC-9700.

ICOM's IC-9700

ICOM has been filling the "high-end" VHF/UHF and 1.2 GHz niche market with an outstanding radio in their IC-9700. It has all the capabilities and features a satellite enthusiast could want. Specifically built with the VHF/UHF weak signal and satellite operator in mind, the IC-9700 has an RF direct sampling receiver for 2 m and 70 cm, with a single, down conversion receiver for 23 cm with an IF Sampled receiver between 311–371 MHz. This design provides an extremely quiet receiver with the power of ICOM's latest DSP technology and a robust PA providing 100 W on 2 m, 75 W on 70 cm, and 10 W on 23 cm. The IC-9700 can also directly allow digital inputs to automatically track Doppler shifts from satellite tracking software.

Yaesu's FT-847

However, if you're on a budget (and as you can see from AMSAT Sweden's list), several radios are available on the used (I call it the "experienced") radio market that, if you can find one, will offer you many hours of enjoyment working the satellites.

One of those radios is Yaesu's FT-847. It was first introduced in the mid-1990s and changed base operation forever. When you purchased an FT-847, you got three radios in one -- an all-mode HF, VHF/UHF radio and a satellite radio in a single box. The radio produced 100 W output on HF and 6 m, plus 50 W on the 2 m and 430 MHz bands. Additional features included cross-band (so-called "full duplex") operation, normal/reverse tracking, CTCSS/DCS encoding and decoding, 0.1 Hz tuning steps, DSP Notch, DSP noise reduction, and DSP filtering. The FT-847 was also 1200/9600 bps Packet ready and came with an MH-31B8 hand-held microphone.

For about 20 years now, I've owned a late model FT-847 that I bought used from another radio amateur who had taken very good care of it. Needless to say, it remains an essential part of my portable



Figure 2— The Yaesu FT-736 was a very popular satellite radio in the late 1980s and early 1990s. Many '736's can still be found on the used market. (Courtesy: Yaesu USA.)



Figure 3—The ICOM IC-910H was another all mode VHF/UHF base station that was specifically optimized for full-duplex satellite work. While this radio has been dropped from the ICOM lineup in favor of newer satellite-capable models, it can still be found on the used market. (Courtesy: www.rigpix.com.)

When Kenwood designed and built the TS-2000 (way back at the turn of the century!), it was clearly thinking ahead and offering a radio that still provides many of the features we satellite ops look for in a satellite-capable radio.

Yaesu FT-736

Another satellite-capable radio you might look for on the used market is the Yaesu FT-736. As the older brother to the '847 (minus its HF capability), it (along with the ICOM 970H and Kenwood 790A) was a very popular all-mode, VHF/UHF satellite radio used by many satellite ops throughout the 1990s.

ICOM's IC-9100

Like Yaesu and Kenwood, ICOM has been a strong supporter of the amateur satellite community over the years. When ICOM



Figure 4—The ICOM IC-9700 is their latest offering for satellite operators. It offers a wealth of features for both the serious satellite and "weak signal" VHF-UHF operators. (Courtesy: ICOM America.)

satellite station even today. Fortunately, '847s can still be found for sale on the used market. However, because it was such a groundbreaking satellite radio to begin with, it's managed to hold its value through the years.

Kenwood's Venerable TS-2000

Another radio that can still be found on the used market is Kenwood's TS-2000. This radio still offers even the beginning satellite user a superb value in a "do everything" rig. This HF/VHF/UHF all-mode radio sports a 100 W transmitter for HF through 2 m (50 W on 70 cm), dual channel receive, digital signal processing (DSP), a 16-bit processor, built-in TCXO for superb frequency stability, as well as a built-in auto antenna tuner for 160 through 6 m. For satellite work, the TS-2000 uses 10 dedicated memory channels to synchronize the transceiver between normal or reverse tracking of uplinks (transmitting) and downlink (receiving) frequencies.

My TS-2000 still forms the basis of my primary amateur radio satellite station!

discontinued the sale of their very popular IC-910H VHF/UHF all-mode base radio, they replaced it with a more robust, all-in-one-box satellite radio in their IC-9100.

The '9100 delivers a solid 100 W on all bands and all modes HF through 2 m and 75 W on UHF. It simultaneously receives on two different bands and operates as if two different receivers are in one radio, which is ideal for satellite work. The radio also sports 32-bit DSP and offers ICOM's increasingly popular D-Star digital communications capability. In the satellite



Figure 5— The Kenwood TS-2000 is another all mode HF/VHF/UHF base station radio that is well suited for full duplex satellite work. But, like so many others of its kind, it, too, has long since gone out of production. However, they can still be found on the used market. (Courtesy: Kenwood USA.)



Figure 6— ICOM's IC-9100, will work all satellite modes, HF through UHF with many additional "satellite friendly" features. It sports a 32-bit processor and (available) D-Star capability to boot. (Courtesy: ICOM America.)

mode, the '9100 synchronizes uplink and downlink frequencies via 20 satellite memory channels that allow for storing operating modes, tone settings, and other satellite-unique parameters.

Buyer Beware!

Fortunately, as I've noted, these older radios occasionally appear for sale on the more popular, online ham-radio-related trading Web sites (or at swap meets or hamfests). However, when buying any used electronic equipment sight unseen, a good rule of thumb to remember is "buyer beware." If the price of a particular piece of used radio equipment sounds too good to be true, it probably is!

Disclaimer

Now, none of this discussion is intended to provide a personal (or "official") endorsement by me (or AMSAT) for any particular manufacturer's radio. Like those seemingly endless arguments about which automobile brand is "best," each of us has our preferences for a specific manufacturer's radio equipment.

The bottom line is that you must still do your homework to learn which features each satellite-capable radio offers and how they all compare with what you can reasonably afford. That activity has always been an essential part of our amateur radio hobby, and shopping for radio equipment to work our satellites is no exception.

New England Sci-Tech Updates AMSAT TLE Bulletins

Kaden Golda, KW1CDR, Thian Golda, KO1MAN, RJ Fitzgerald, N1BGA, Oliver Johnson, KC1TCM

AMSAT provides amateur radio satellite tracking data—two-line element sets (TLEs)—to amateur radio satellite operators through a daily bulletin and on the AMSAT Live OSCAR Satellite Status Page (amsat.org) to aid hams in pointing their antennas for optimal satellite communication. That TLE data requires manual updating, a very annoying process that can take a lot of time every month with no days off.

New England Sci-Tech is changing that process. Sci-Tech's goal is to reduce AMSAT's volunteer labor requirements and make updates more current by creating a daily bulletin to replace the previous weekly updates.

New England Sci-Tech is a non-profit STEM education center and maker space dedicated to project-based, hands-on learning for youth and families across the New England community. Its mission is to promote the development of a STEM-literate and skilled citizenry ready to meet the needs of the 21st century and beyond.

The Sci-Tech project team (Figure 1) set out to automate the retrieval of two-line element sets (TLEs) from space-track.org and then create a system to organize that data and post it to the daily bulletin. All of this was an effort to support list maintenance.

The team's first step was to generate a table of IDs to match the data pulled from Space-Track.org to AMSAT satellite names. The table was created by modifying an existing AMSAT product called "nasabare.txt," a text file with the name of every AMSAT spacecraft and its US Space Force satellite catalog number. The result was a table that replaced an error-prone manual process. This new table enables further data modification and serves as the foundation for the rest of the project.