Working Satellite RS-12 - the Ultimate Satellite Primer

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Working Satellite RS-12—The Ultimate Satellite Primer

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I woke up this morning to work some long-haul DX and check for an opening to Southeast Asia on 20 meters. Southeast Asia? Propagation was so bad that I checked my feed-line connections to see if my antenna was actually hooked up to my receiver. Unfortunately, it was.

What can you do when propagation gets this bad?

A) Get caught up with your QSLing.
B) Study to upgrade your license.
C) Build a 20-meter QRP transceiver.
D) Discover the joys of the amateur satellites.
E) All of the above (but this article is about D).

This article is a primer for making your first satellite contact. But be careful—when you discover how much fun the satellites are, you may get hooked!

Introduction to RS-12

If you have one HF transceiver that can work split frequency (two would be better) and one HF antenna (two would be better), this article will give you all the information you need to work amateur satellite RS-12. RS-12 was built by the Russians and launched February 5, 1991. You won't need a computer tracking program or satellite data ("Keplerian elements" or "satellite orbital elements") to get started because I've prepared a table that will give you a reasonably accurate ability to locate the satellite throughout the next *year*.

Why start with RS-12? Because it's the only active amateur satellite that has both a transmitter and a receiver that operate on HF. RS-12 is a *Mode-K* satellite, which means that you transmit *to* the satellite (uplink) on 15 meters and you receive *from* the satellite (downlink) on 10 meters. This means that most amateurs who own typical HF transceivers can work RS-12 without purchasing new equipment.

A number of satellite primers recommend RS-10 as the ideal bird for beginners, but RS-10 is a *Mode-A* satellite, which means that you transmit on 2 meters and receive on 10 meters. Unfortunately, many beginners don't have a 2-meter multimode radio capable of transmitting CW/SSB. Eventually, you may wish to purchase a VHF multimode rig if you get hooked on the satellites, but not everyone has one of these radios when they get started.

There's another advantage RS-12 has over RS-10: Because RS-10 uses 2 meters on the uplink, you can't take advantage of "skip" to work DX. When RS-10 drops below the horizon, it's gone: G-O-N-E. As an HF satellite, however, RS-12 can occasionally take advantage of skip to give you propagation even after it drops below the horizon.[1] This means that you can work more distant DX with RS-12 than you can with RS-10.

We've covered most of the technical jargon you'll need to get started with RS-12 (uplink, downlink, Mode K, etc). There's one more technical term you'll need to know: *linear transponder*. That's what RS-12 carries. It takes all signals received from 21,210-21,250 kHz and retransmits them on 29,410-29,450 kHz. These frequency ranges are called *passbands*.

If you're familiar with the use of repeaters, think of RS-12 as an orbiting repeater in space, except that it repeats an entire passband instead of a discrete frequency. And it's moving fast, so you have to be *quick* to work it.

Incidentally, you may have noticed that the RS-12 uplink frequencies on 15 meters lie in the Extra-Class and Advanced-class subbands. You can only transmit on uplink frequencies where your license permits. If you're a General, Technician Plus or Novice, don't be discouraged; RS-12 also monitors 21,129 kHz—in the 15-meter Novice/Technician Plus subband (more about this later).

If you're still with me, you're ready to get started on RS-12. Let's get to work!

[1]**Notes appear on page 64.**

5 easy steps to making your first satellite contact!

Step One: Locate the Satellite

The first thing to do is find the satellite. It's in a polar orbit around the Earth, which means that it ascends from south to north, or descends from north to south, depending on where the Earth happens to be in its daily rotation on its axis. The satellite makes an orbit around the Earth in approximately 105 minutes. That works out to a ground speed of approximately 14,000 mi/h.

Knowing the satellite's location is important. It's moving fast and passes overhead in about 10 to 18 minutes, depending on the orbit. It does a better job of retransmitting your signal when it passes right over you, that is, when it's elevated more

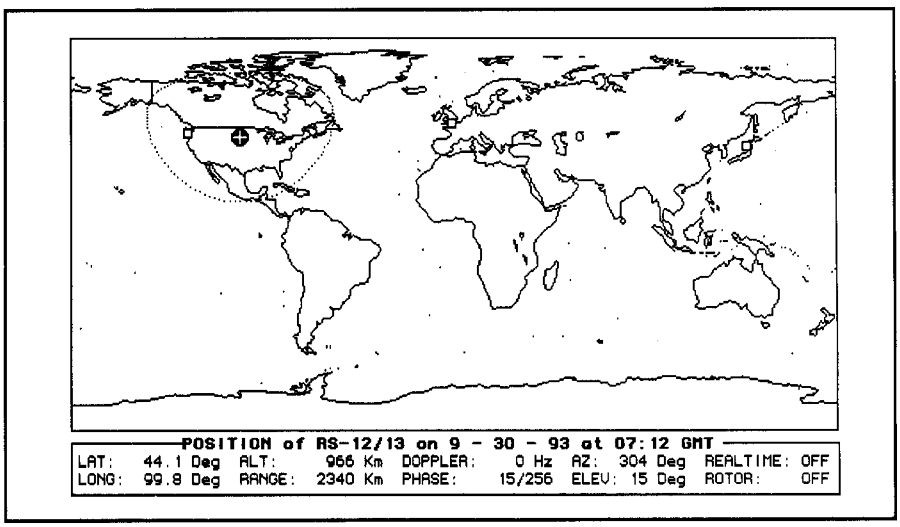

Fig 1—RS-12's huge footprint, as illustrated by *Satellite Pro*, a computer-tracking program.

than 30° above the horizon during its overflight. You have to know when to listen for RS-12 and you have to be ready for it.

RS-12's coverage area, or *footprint*, is a circle on the Earth's surface with a diameter of approximately 4500 miles (see Fig 1). That means when the satellite is orbiting over the Midwest, its coverage area engulfs the continental US, Mexico, Central America, the Caribbean and part of Canada during the course of its pass.

When the satellite rises above the horizon and you first hear the signal, *AOS* (acquisition of signal) has occurred. When the satellite dips below the horizon and you lose the signal, *LOS* (loss of signal) has occurred. You may notice something unusual about the signal: It drifts down in frequency. This is a result of the phenomenon of *Doppler shift.* (Doppler shift is the same phenomenon that causes a locomotive's whistle to drop in frequency as it zooms past you.)

The conventional way to find the satellite is to obtain a satellite-tracking program, and then input current data (Keplerian elements) on the satellite's whereabouts into the computer. There are a number of excellent tracking programs available, and the Keplerian elements can be obtained from publications such as the *AMSAT Journal*, from W1AW bulletins, on your local packet bulletin board or from sources on the Internet.

But there's an easier method. To locate the satellite, simply consult Table 1. Find the location nearest you and read the time and date of the predicted satellite pass. The table will tell you when the satellite rises above the horizon and when it falls below the horizon. The satellite passes over your station a number of times each day, but I selected the best two flights for the table. I also selected February 1, 1994 as the starting date for the table.

If you're busy on the day of a particular flight, you can still use the table to predict the satellite's location. *The satellite's path is repeated every three days, except that it passes overhead 20 minutes and 44 seconds earlier with each three-day cycle.*

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Let's go to the table. If you live in Illinois, for example, the table predicts that the satellite will rise at 0508 UTC Tuesday, February 1. That means that the satellite will also rise at 0447 UTC on Friday, February 4, and at 0426 UTC Monday, February 7, and so on. To assist you with the correction, I've prepared a table to give you a time-correction factor for six months (see Table 2).

Although it's important to use the most current satellite data available, RS-12 is in a very stable orbit. For example, I ran a satellite schedule using current AMSAT tracking data and compared the results with a schedule using year-old AMSAT data. The schedules were the same *within 1 to 3 minutes for both schedules.*

When I used the current AMSAT tracking data to create schedules for two dates that were one month apart, and I compared the results with the method of using the satellite table as corrected by the 20-minute 44-second rule, the results were ±1 minute for both methods.

The table is calculated for the geographic center of each state and all Canadian provinces. This will give good results, even for large states and provinces (and even better results for Rhode Island!). For example, on a typical satellite pass, the time for AOS for North Dakota and South

Table 1
RS-12 Locator Table
(as of February 1, 1994)

State/Province	*AOS*	*LOS*	*AOS*	*LOS*
Alabama	0506	0524	1609	1626
Alaska	0846	0903	1031	1048
Arizona	0652	0709	1753	1811
Arkansas	0507	0524	1608	1625
California	0652	0710	1752	1809
Colorado	0654	0711	1752	1809
Connecticut	0324	0341	1421	1438
Delaware	0323	0340	1422	1438
Florida	0506	0522	1610	1627
Georgia	0507	0524	1609	1626
Hawaii	0833	0849	2127	2144
Idaho	0655	0712	1750	1807
Illinois	0508	0526	1606	1624
Indiana	0509	0526	1607	1624
Iowa	0509	0527	1606	1623
Kansas	0508	0525	1607	1624
Kentucky	0508	0525	1607	1625
Louisiana	0506	0523	1609	1626
Maine	0325	0343	1420	1437
Maryland	0323	0340	1607	1624
Massachusetts	0324	0342	1421	1438
Michigan	0510	0527	1605	1623
Minnesota	0510	0528	1605	1622
Mississippi	0506	0524	1609	1626
Missouri	0508	0525	1607	1624
Montana	0656	0713	1750	1807
Nebraska	0509	0526	1606	1623
Nevada	0653	0711	1752	1809
New Hampshire	0325	0342	1420	1438
New Jersey	0324	0341	1421	1438
New Mexico	0507	0524	1753	1810
New York	0325	0342	1421	1437
North Carolina	0508	0525	1608	1625
North Dakota	0511	0528	1604	1621
Ohio	0509	0526	1607	1624
Oklahoma	0507	0524	1608	1625
Oregon	0654	0712	1750	1807
Pennsylvania	0324	0341	1607	1623
Rhode Island	0324	0341	1421	1438
South Carolina	0524	1609	1609	1626
South Dakota	0510	0527	1605	1622
Tennessee	0507	0525	1608	1625
Texas	0506	0523	1609	1626
Utah	0653	0711	1752	1809
Vermont	0325	0342	1420	1438
Virginia	0323	0340	1608	1624
Washington	0655	0713	1749	1807
West Virginia	0509	0526	1607	1624
Wisconsin	0510	0527	1605	1623
Wyoming	0655	0712	1751	1808
Alberta	0657	0715	1747	1805
British Columbia	0657	0715	1747	1804
Labrador	0328	0345	1418	1435
Manitoba	0512	0530	1602	1620
New Brunswick	0325	0343	1420	1437
Newfoundland	0327	0345	1418	1435
Nova Scotia	0325	0343	1420	1438
Ontario	0512	0529	1603	1621
Quebec	0327	0344	1418	1435
Saskatchewan	0658	0715	1602	1619

Table 2
Correction Table

This table gives you a time-correction factor for six months.
Example: On 3 March 1994, subtract 3 hours and 27 minutes from the AOS and LOS times provided in the locator table (Table 1).

Date	*Factor*	*Date*	*Factor*	*Date*	*Factor*
1 Feb 94	0:00	5 Apr 94	7:15	7 Jun 94	14:30
4 Feb 94	0:20	8 Apr 94	7:36	10 Jun 94	14:51
7 Feb 94	0:41	11 Apr 94	7:56	13 Jun 94	15:12
10 Feb 94	1:02	14 Apr 94	8:17	16 Jun 94	15:33
13 Feb 94	1:22	17 Apr 94	8:38	19 Jun 94	15:53
16 Feb 94	1:43	20 Apr 94	8:59	22 Jun 94	16:14
19 Feb 94	2:04	23 Apr 94	9:19	25 Jun 94	16:35
22 Feb 94	2:25	26 Apr 94	9:40	28 Jun 94	16:55
25 Feb 94	2:45	29 Apr 94	10:01	1 Jul 94	17:16
28 Feb 94	3:06	2 May 94	10:22	4 Jul 94	17:37
3 Mar 94	3:27	5 May 94	10:42	7 Jul 94	17:58
6 Mar 94	3:48	8 May 94	11:03	10 Jul 94	18:18
9 Mar 94	4:08	11 May 94	11:24	13 Jul 94	18:39
12 Mar 94	4:29	14 May 94	11:44	16 Jul 94	19:00
15 Mar 94	4:50	17 May 94	12:05	19 Jul 94	19:21
18 Mar 94	5:11	20 May 94	12:26	22 Jul 94	19:41
21 Mar 94	5:31	23 May 94	12:47	25 Jul 94	20:02
24 Mar 94	5:52	26 May 94	13:07	28 Jul 94	20:23
27 Mar 94	6:13	29 May 94	13:28	31 Jul 94	20:44
30 Mar 94	6:33	1 Jun 94	13:49	3 Aug 94	21:04
2 Apr 94	6:54	4 Jun 94	14:10	6 Aug 94	21:25

Dakota is only one minute apart—and those are *big* states. Remember, we're predicting the path of a 4500-mile satellite footprint moving at 14,000 mi/h.

The first time I started tracking satellites, I was amazed at how accurate the overflights are. With reasonably current satellite data, you can set your watch by this bird.

Although the locator-table technique is useful, the table will eventually lose its accuracy, perhaps after a year. The table isn't designed to replace sophisticated satellite tracking. It's to help you make your first satellite contacts so that you can be introduced to satellite communications.

Step Two: Listen for the Satellite

We're ready to get to work. Let's listen for the satellite. Check the table for the location nearest you and read the time when the satellite will be overhead. If you can't make that date, use the three-day rule to locate the satellite at a future date.

Now you're ready to listen for the satellite's telemetry beacon. The beacon is a CW signal transmitted at approximately 20 WPM that gives information about the satellite's status. The RS-12 beacon frequency is 29,408 kHz (±2 kHz).

The signal won't be right on 29,408 kHz, so you'll have to tune around 29,408.5-29,409.5 kHz. The beacon will be faint at first, but it will quickly strengthen into a respectable CW signal. Table 3 summarizes the RS-12 uplink and downlink frequencies.

Congratulations, you've located your first amateur satellite!

Table 3
RS-12 Uplink/Downlink Frequencies (kHz)

Uplink Passband	21,210-21,250
Downlink Passband	29,410-29,450
Telemetry Beacon	29,408 (±2 kHz)
Novice/Tech Uplink	21,129
Novice/Tech Downlink	29,454

Step Three: Listen to the Downlink

Having found the beacon, you're ready to listen for stations using the satellite. Set your receiver to the SSB mode and tune through the downlink passband (29,410-29,450 kHz). You'll hear CW and SSB signals, but no FM signals. (Technically, the satellite can retransmit FM signals, but FM isn't used because it drains too much of the satellite's output power and conventional FM isn't allowed on the uplink frequencies anyway.)

The signals in the passband are subject to Doppler shift. Spend a few minutes listening to the signals. During the course of a typical satellite run, the signals will drift about 2 kHz.

Here's an example of a typical satellite conversation:

"CQ satellite, CQ satellite. Whiskey Alfa Three Uniform Lima Hotel, WA3ULH Temporary Amateur Extra, over."

"WA3ULH Temporary AE, WA3ULH Temporary AE, this is Kilo November Four Mike November, KN4MN, over."

"KN4MN, thanks for your call. You're 5-3, 5 by 3 in North Carolina. My name is Rob, Romeo Oscar Bravo, over."

"Okay, Rob, you're also 5 by 3 in North Carolina. My name is Ernest. Ernest is my name, over."

"Fine business, Ernest. QSL and thanks for the contact. 73."

"Thanks Rob. The frequency's all yours. 73."

The transmissions are short, almost in a contest-like mode. The satellite run is brief and people generally want to establish a number of contacts during each overflight. In addition, the Doppler shift causes signals to drift, so short transmissions minimize the drift between each exchange. Some people ragchew on RS-12, but as a rule, even ragchewers make short transmissions.

Notice that the station responding to the CQ (KN4MN) called the first station (WA3ULH) twice before transmitting his own call sign. This technique gives the other station a chance to find you because you're likely to be off-frequency with the Doppler shift.

Now switch to 15 meters on the uplink passband (21,210-21,250 kHz.) You may hear stations transmitting *to* the satellite. Notice that there's no Doppler shift. These are conventional CW and SSB signals. You may hear a station shift its frequency around, but this isn't Doppler shift. The shift you hear is caused as stations try to stabilize their signals on 10 meters by keeping one hand on their transmitter dials on 15 meters.

Step Four: Hear Your Own Signal (Optional)

You're ready to move on to the next step: transmitting a series of "Vs" on 15 meters and listening to your own signal on 10 meters. You'll need two HF rigs to do this and if you only have one transceiver, you can skip this section and go to Step Five.

If you have two transceivers, make the following preparations prior to the satellite run: Set your transmitter to 21,230 kHz. Tune up your radio and antenna and get ready to transmit in CW. Turn off the CW sidetone on your transmitter and turn down the audio gain. Set your second transceiver to 29,408 kHz (the beacon frequency), put the radio in the CW mode and tune up your antenna. At the appropriate time, listen for the beacon. After you hear the beacon, wait 2-4 minutes for the satellite to rise well above the horizon.

Now tune the second transceiver to 29,430 kHz. Make sure that the frequency is clear, and key a series of Vs on 21,230 kHz with your first transceiver as you tune your second transceiver around 29,430 kHz (±2 kHz) until you hear your own signal. Identify your station before and after the test.

Once you've heard your own signal, you're ready to make your first satellite contact!

Step Five: Making Your First Contact

Here are two ways to make your first contact, depending on whether you have one or two transceivers.

If you have two transceivers and two antennas, make the following preparations prior to the satellite run: Set your transmitter to 21,230 kHz. Tune up your radio and antenna, and get ready to transmit in SSB. Turn down the audio gain, set your second transceiver to 29,430 kHz, set the radio to SSB mode and tune up your antenna. On schedule, listen for stations in the downlink passband (29,410-29,450 kHz).

If you have one transceiver, make the following preparations prior to the satellite run: Set your VFO A to 21,230. Tune up your radio and antenna and get ready to transmit in SSB. Set your VFO B to 29,430, set the radio to SSB mode, and set your radio to split operation with VFO B set to receive and VFO A set to transmit. On schedule, listen for stations in the downlink passband (29,410-29,450 kHz).

If you have Novice, Technician-Plus or General-class privileges, transmit CW on 21,129 kHz and receive on 29,454 kHz. These are the uplink/downlink frequencies for the RS-12 CW Robot. When the Robot isn't on the air—which is most of the time—the satellite relays any signals it hears on 21,129 kHz. Always listen to the 29,454 kHz downlink before you transmit. If the Robot is on and someone is using it, wait until they're finished.

Listen for someone calling "CQ satellite." Synchronize your transmitter to the received frequency and make a call using the format above. Here's an example of how to synchronize your transmitter and receiver (frequencies in kHz):

Received Signal	*Transmit Frequency*
29,445	21,245
29,430	21,230
29,425	21,225

Notice that the last two digits are the same. The way to work the satellite is to get everything set up prior to the run and only worry about synchronizing the last two digits during the run.

During your first contacts, don't worry too much about Doppler shift. Experienced satellite operators will tune around to find you. Just keep your transmissions brief. After you gain experience, try to stabilize your transmissions (if you have two HF transceivers) by fine tuning your *transmit* frequency on 15 meters. This is the custom with satellite operation and it helps to pre-

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vent stations from drifting into other conversations.

After you've successfully worked someone via SSB, you may want to try working CW on the satellite. That's my preferred mode, and CW is popular on RS-12, especially on the lower segment of the passband at 29,410-29,420 kHz. After a few successful satellite sessions, you may try putting out your own "CQ."

Don't be surprised if you begin working DX on the satellite. During my first month on RS-12, I worked stations in Panama, Venezuela, Canada and Colombia. I found the Colombian station by monitoring the uplink passband on 15 meters several minutes before the AOS at my station. The satellite was over his station in Colombia and I heard HK1LAQ calling CQ on 15 meters before I could hear him on 10 meters. As soon as I had AOS, I was ready to pounce.

Next Steps

Are you hooked? If so, I recommend the following steps:

Join AMSAT.[2] This is a great way to support future satellite launches. AMSAT membership is inexpensive and you'll receive a regular newsletter with interesting articles. The newsletter provides the Keplerian elements you'll need to do your own satellite tracking.

Second, obtain a satellite-tracking program. These are available through AMSAT and other sources (see the *Lab Notes* column on satellite-tracking software in December 1993 *QST*). Input your Keplerian elements and discover the fun of satellite tracking. Most programs have a variety of interesting maps that show satellite passes in real time. My seven-year-old son, Howard, loves these maps and we enjoy simulating satellite flights together.

Pick up a satellite book, such as the *Satellite Experimenter's Handbook*, available from your dealer or from ARRL HQ (see the Publications Catalog in this issue). The book provides a wealth of information on working other satellites. You can learn a lot in Chapter 13 of the *ARRL Operating Manual*, including a description of how to work the satellite through the use of the RS-12 Robot.

And don't despair; as the solar cycle continues to decline, you can go back to my pop quiz above, and try answers "A," "B" and "C"!

Special thanks to Randy Stegemeyer, W7HR, for his assistance and for his permission to use map illustrations and data analysis generated by Satellite Pro™. *Thanks to Roger Burt, N4ZC, who gave me my first satellite contact and taught me some of the tricks of the satellite trade.*

Notes:

[1]See July/August 1993 *AMSAT Journal* for a thorough discussion

[2]AMSAT-NA, 850 Sligo Ave, Silver Spring, MD 20910; tel 301-589-6062

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