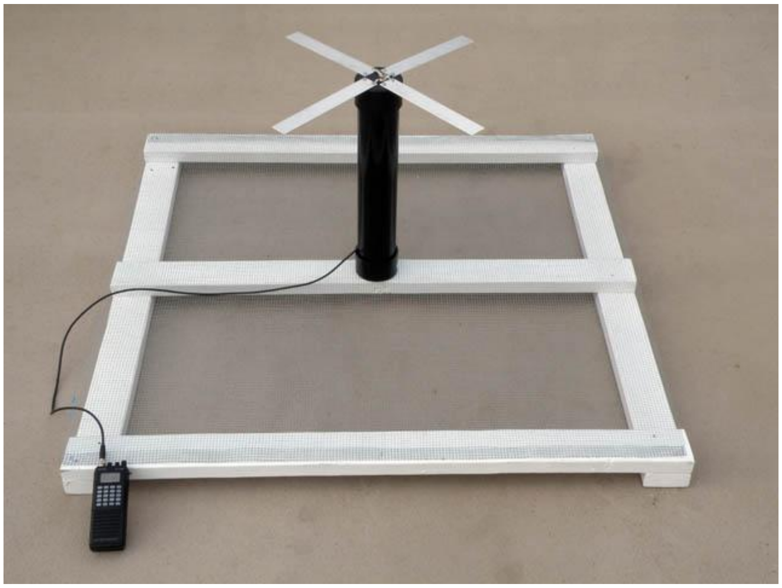
Build this UHF omni Satcom Antenna



Part 1 in this issue: UHF Satcom basics and antenna design criteria. Part 2 in a follow-up issue will focus on construction and using the "MT Omni X-wing".

Snagging military comms is one of my favorite hobbies and nothing peaks my interest more than signals traveling over 23,000 miles from space to reach my antenna. UHF Satcom is a primary mode of communication for US and allied military forces with typical radios having a transmit power around 20w. Some newer handheld transceivers are being pressed into Satcom service with only 5w of transmit power and the antenna is a key part of the system and crucial for reliable communications.

As of this writing, I know of no affordable off the shelf UHF Satcom antennas for the hobby market and checking my favorite auction sites reveal the prices of rare surplus military Satcom antennas are at an all time high. What's a Satcom hungry monitor enthusiast to do? Well, first we need to learn a few things about UHF Satcom reception and see what's required.

Let's take a look at some common antennas used for the military UHF Satcom service. The picture below shows several directional types ranging from a large crossed Yagi for fixed station use to smaller and more portable versions for manpack and hand-held use. There is also a hemispheric omni shown which is used on some vehicles and commo shelters and a vehicular" X-wing" that is of particular interest.

The large crossed Yagi to the far left has considerable gain over most models, which comes in handy when pointing low on the horizon and to better close the satellite link when other stations are using low power or smaller antennas. This particular model is a Dorne & Margolin DM C122 with a maximum gain of 14dBic. The “ic” references to a circular polarized isotropic antenna.

The two antennas to the right and down are fairly common manpack antennas from Dorne & Margolin, model DM C120 and Trivec-Avant, model AV 2040. These are specified at 6 and 7dBic gain respectively and the Trivec-Avant has an optional snap on director element set (not shown) that brings the gain up to 11dBic. Centered between these is a very compact (and covert) cross Yagi from Dorne & Margolin rated at 5dBic gain.

All antennas mentioned so far do a good job of receiving UHF Satcom when mated with a sensitive police scanner or communications receiver that covers 225-400MHz in narrow FM mode. The drawback so far is you may need to point these antennas at multiple satellites depending on your location.

The dome antenna at the right rear is omni directional and intended for vehicles and commo shelters that must remain in contact despite location or motion. The gain is not so impressive at 2dBic but it does have a radiation pattern that covers nearly horizon to horizon with fairly consistent performance.

There are usually tradeoffs in antenna design and this one gives up gain for very wide coverage. This antenna is typically used with a 200w amplifier and receive preamplifier to make up for the low gain.

Finally we get to the magnetic mount X-wing at the right front, which is a recent addition to the military antenna arsenal and primarily used for mobile “satellite on the move” or SOTM. This antenna is rated at 8dBic gain and for an omni that’s quite high.

However, looking at the X-wing with the popular antenna modeling program EZNEC we find most of this gain is pointed straight up in a wide lobe and performance drops off as look angles get below about 30 degrees off the horizon. Otherwise the X-wing works very well and I have used it on the roof of my vehicle while traveling with a hand held scanner listening to Brazilians pirating US satellites. This antenna was an inspiration for our project and we'll come back to it later in this article.

Lets cover some basic antenna requirements for UHF Satcom reception. Frequency range for downlink spans from about 243MHz to 270MHz, that's a fairly broad spectrum but manageable. Next is the polarization, which is Right Hand Circular. With some of the linear polarity designs like a basic Yagi you will loose about 3dB of your receive signal right up front due to polarization mismatch. We should strive for a Right Hand Circular antenna.

Searching the Internet reveals many home brew directional UHF Satcom antennas like Axial Mode Helices, Crossed Yagis and a few omni types like the Quadrifiler Helix and Eggbeater. Building most of these require sharp mechanical skills, scaling dimensions from amateur frequency ranges, finding odd impedance coax for matching or using expensive test equipment to tune various parts of the antenna. I want to keep this project simple for our readers so many of these designs were ruled out. Another hurdle is where to point some of these antennas once they are built and an omni directional like the X-wing is sounding better as we progress.

I find conflicting information on where the US military UHF satellites live but there seems to be four major orbital locations to cover the entire globe. Two closely spaced slots sit over the equator roughly inline with the center of the US at 100° W and 105° W, one centered over the Atlantic Ocean around 22.5° W, one over the Indian Ocean at 72° E and three over the Pacific Ocean at 177° W, 172° W and 172° E. Other countries have fleets of UHF satellites and there are many other orbital locations in use besides what is listed here. For additional information on satellite locations and frequency information you might check this excellent site: www.uhf-satcom.com.

Now, with the 100° W and 105° W orbital slots being roughly in line with the center of the US, the maximum elevation needed anywhere within the continental US (CONUS) would be about 60 degrees off the horizon when viewed from the southern most central point in the US near Brownsville, TX. Most other locations in the US will point at lower elevations, especially when looking at orbital slots over the Atlantic or Pacific Oceans.

This brings us back to the X-wing antenna, which works very well for satellites overhead but starts to loose performance as you get very low on horizon. Lets see if we can make our own version with some improvements tailored for the US, Europe and other regions that share a similar Longitude.

The commercially made X-wing is basically a set of two cross dipoles fed 90 degrees out of phase to create the desired circular polarity. The dipole elements sit approximately 1/4 wavelength above a reflector (vehicle roof, hood, etc.) to achieve the desired pattern, as verified with the popular antenna modeling program EZNEC.

At 1/4 wave above a reflector the dipole impedance is not far from 50-ohms and the wide elements are partially responsible for the broad bandwidth, or the full 225 to 400MHz band for this commercially made antenna. A 50-ohm, 90-degree hybrid divider provides the necessary phase shift between dipoles to create circular polarity and non critical lengths of 50-ohm cables would be used to feed the dipoles

Using EZNEC we find that moving the dipole elements up near 1/2 wavelength produces a null straight up but brings the main lobe down to about 40 degrees off the horizon. This lobe is wide enough to cover a more suitable 20 to 60 degrees off the horizon for use in the Continental US and other regions that share a similar Longitude. We'll use this dipole height for our project antenna.

We also need to house and feed the dipoles properly to create Right Hand Circular Polarity and to match our 50 ohm feedline to the receiver. A commercially made 90-degree hybrid is out of the question for this project and a simple coax Tee with critical lengths of coax will be used to feed the dipoles and create circular polarization. At near 1/2 wavelength above a reflector the dipoles are closer to 75 ohms and would require an odd impedance phasing harness so here is our first compromise. We'll use 75-ohm RG-6 TV coax for the phasing harness.

For the dipole support I chose 3" ABS pipe and caps to allow ample room inside for the phasing harness and connectors. The elements are made from 1 1/2" wide by 1/16" thick aluminum stock, which is readily available at many home improvement centers. These wide elements will provide ample bandwidth.

The antenna needs to sit above an adequate reflector around 48" square (or round) and I used 1/4" mesh galvanized "hardware cloth" stapled to a wooden 2 X 4 frame with an extra center member to affix the ABS pipe support.

So far my prototype antenna is pulling in signals equal to and up to 2dB better (measured on spectrum analyzer) than the commercial X-wing antenna depending on satellite location. That's not bad for a few hours work and less than 1/100 the cost of a commercial version.

I'll cover the detailed assembly instructions and user options in next months issue and here is a parts list so you can start gathering items to build your own MT Omni X-wing antenna. Stay tuned!

Qty	**Description**	**Notes**
1	Aluminium flat stock 1 1/2" X 1/16" X 48"	1/8" thick can be used.
1	3" ABS pipe, 24" long	Available in 10ft lengths for around $5.
2	3" ABS pipe cap	Make sure they have a flat top face.
2	Chassis mount female F connector	See note 1 below
1	Type F all female "Tee" adapter	L-Com BA132 or equivalent.
4	Type F male connector for RG-6	Radio Shack 278-223

1	Adapter, type F male to Type N female	SO-239 or BNC to F adapter as option.
1	RG-6 coax, foam type dielectric, 24”	See note 2 below
1	Hardware cloth or chicken wire 48” X 48”	
3	Wooden 2 X 4, 8ft long	
6	8-32 X 1/2” Phillips screws, stainless steel	
6	8-32 hex nuts, stainless steel	
2	Ring lug, 3/8” hole, #12-14 wire	Radio Shack 64-3040
2	Ring lug, #8 hole, #12-14 wire	Radio Shack 64-3117
1	#14 bare copper wire, 6” long	

Note 1
Look for one with a threaded barrel at least 1/2” long. Radio Shack part # 278-0212 is short but will work with a few extra assembly steps.

Note 2
If cable specifications are available choose a velocity factor of 80% +/- 2%. I used Carol brand coax from Home Depot.