TENNA TIP #3

GPS Antennas for Composite Aircraft

by Bob Archer of Sportcraft Antennas

Because there seems to be at present more interest in GPS than any other aircraft system I think we should talk about it first. The theory of how GPS operates is very similar to Loran in that it uses the time difference between three or four transmitted pulse strings from three or four sources to determine Hyperbolic equal time difference lines and calculates position from this data. Of course space based transmitters transmit the GPS signals and Loran transmitters are land based. And the frequencies of operation are very different, the Loran systems operating at 100 Kilohertz and GPS at 1.575 Gigahertz, with a secondary frequency at 1.227 Ghz. A wavelength at 100 Khz. is 9836 ft. and at 1.575 Ghz. is about 7.5 inches. These wavelengths give an indication of the size of the required antennas; a large antenna for Loran, a small one for GPS. About 3 3/4 inches for a dipole. There is a galaxy of 24 GPS satellites now in earth orbit at an altitude of about 10,600 miles which gives them an orbit period of about 12 hours. They are updated as to time and position every orbit to maintain their accuracy.

Most satellite systems, including GPS, use circular polarization for their RF systems which means that the electric field rotates at the rate of the frequency being used. You might think of it as 360 degrees of polarization rotation in one wavelength of travel. Circular polarization is used because linear polarization when passing through the heavyside layer of the upper atmosphere rotates the polarization depending on the angle of passage and it is possible for the signal to completely cancel out. When using circular polarization on both transmitter and receiver antennas these effects are minimized and maximum signal may be utilized. Of course both ends must use the same rotation, either RH or LH circular polarization, or the signals could cancel out. There are several different types of receiving antennas that can be used by GPS receivers and I'll try to touch on each of them. All GPS receiving antennas should have a radiation pattern that optimally would look like a flattened hemisphere so that there is somewhat more gain at the low elevation angles because that is where the satellites are the farthest away. The first and most common at this time is the patch antenna. It is small and flat and can be installed easily on the outside of metal or graphite aircraft skins and inside of non-conductive composite aircraft with some minimum type of mounting bracket. Also there is what is called a turnstile antenna which consists of four small pieces of flat metal in a square pattern and each piece fed with 0,90,180 and 270 degrees of sequentially phased signal that provide the circular polarization. This type antenna is usually somewhat short on gain because of being loaded with dielectric material to make it small and having a quadrature hybrid of some type to provide the phased signals which will absorb some signal. A lot of these have built in amplifiers and they are then called "active" antennas.

Another type is the normal mode helix antenna. Garmin used these on their early models and still do on their handhelds and are about .75 inch in diameter and three inches long. A regular helix antenna radiates most energy off the end but a normal mode helix is smaller in diameter and radiates more energy off the sides. With the correct ratio of length to diameter the radiation pattern can be optimized. I have one of the Garmin handhelds and I wanted to put an antenna between the headliner and the fabric over the cabin of my Bellanca so I built a foam conical form two inches high by two inches in diameter and wound on extra long dipole type elements that wind down from the apex to the base in a spiral manner. Works very well. Then there are Archimedean spirals, log conical spirals and bifilar and quadrifilar helices and numerous turnstile types. All of which are circularly polarized with various positive and negative attributes.

The installation of all these types of antennas in a non-conductive composite aircraft, or even fabric, is simple in that none of them require ground planes and they are so small and light that they do not require much room or structure to support them. All that is required is that they be mounted in the top part of the aircraft looking up in such a manner that they can see most of the sky through the non-conductive skin when installed. In metal or conductive aircraft of course they must be installed on outside of the conductive skin of the aircraft or installed inside a fiber-glass fairing of some type. On tandem type aircraft with canopies the top of the roll over structure is a great location. We will just leave the details to the builders.

To test the reception of signal through glass or other types of skins just fire up the old hand held GPS out side the airplane and then take it inside and check the signal strength difference. There should be very little to no difference for glass or fabric but graphite will cut the signal off. In my meanderings I have come across some primers for glass that are very lossy.

This is probably more information than anyone ever wanted to know but maybe it will help someone. I am always open to questions if there are any out there.

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