Aerial positioning with 2.4 GHz

When radios were all 'analogue', or PPM, in the early days of 27 & 35 MHz, any glitch was passed to the model immediately so such events were pretty obvious. Over the years I think it's fair to say that they have become less so. Later developments, including PCM and other coding methods, together with microprocessors that can process the incoming signal and filter out spurious data, and transmitters that talk to only one 'bound' receiver, have made obvious glitches almost a thing of the past. Almost.

Recently there have been two or three instances of glitches on 2.4 GHz at our field. Perhaps we've got so used to being protected from interference by modern technology that we've forgotten, or tend to neglect, the basic rules that still apply.

1. Rx Aerial alignment

Aerial reception is weakest when the aerial is pointing directly at the transmitter (and vice versa) so it makes sense to make sure that where there are several aerials in the model, they are not all pointing the same way.

If there are two aerials, try to align them at 90 deg to each other, and according to the model type. If it's an aerobatic model that will be flown usually to the side rather than overhead, then position one aerial fore and aft and the other one vertical. In this way both aerials will be side-on to the Tx most of the time.

If it's a glider that's likely to spend most of it's time overhead then set one aerial fore and aft and the other horizontally across the fuselage for the same reason.

In both the above cases there may be times when one of the aerials will be end on to the transmitter but this will never occur on both at the same time

When satellite receivers provide more than two aerials (e.g. Spektrum) it makes sense to position a third at right angles to the other two and a fourth, if available, to suit the model type as above.

2. Keep the Rx aerials clear of other conductors

By clear it means not close to, or parallel with, other metallic objects including wires. What constitutes "close" is related to signal wavelength and on 2.4 GHz the wavelength is only about 5 inches. Here, 'close' is a few inches. Aerials surrounded by servos and servo leads are likely to experience problems. On the other hand, moving the aerial away by only a few inches can resolve these. Try and locate the receiver at least a few inches away from the servos and leads and, most importantly, any electric motor or ESC.

When a satellite receiver can be fitted, one way to improve reception is to use an extension lead to the main Rx. On Spektrum systems, extensions can be up to several feet in length so two of the four aerials can be located at, say, the rear of the fuselage.

3. What about the model itself ?

If a conductor such as a carbon fuselage, or even metallic-based paint, surrounds the aerial then this can cause problems.

In such cases the aerial(s) should be located in unscreened areas of the fuselage, or even in the wing. Glider manufacturers using carbon fuselages often include a non-carbon e.g. a glass or kevlar , nose area for radio equipment Alternatively some receivers, e.g. Futaba and FrSky have screened extensions to the aerials that enable them to be located entirely outside the model if necessary.

4. Positive Rx aerial location

Many receivers' aerials are quite short, and self-supporting, but any messing around inside the model can alter their position and, possibly, their effectiveness. It is good practice to positively locate these aerials by using, say, lengths of plastic tube or straws glued inside the fuselage. If the Rx has to be moved for any reason then these tubes ensure the aerials can be refitted in their original, tested, position.

If external aerials are used then such plastic tubes can be extended outside the fuselage to provide protection to the aerials.

5. Range testing

Initial testing should be done with the model held in various orientations, such as side on (both sides), nose and tail on, and with the top and bottom of the model facing the transmitter. Move the model around a bit, the angle at which there may be a reception problem could be quite narrow, depending on the installation.

At this stage it's probably worthwhile finding out if the aerial on your particular Tx has a "blind spot". Move the angle of the Tx aerial while you check the range. If the range is particularly poor at any one angle try to ensure you never present this angle to the model.

The above problems are not a case of black or white. Most models will (do) fly ok if some of the above problems are present and this is, to a large extent, due to the marvels of modern technology. Some models may still seem to fly ok if *all* the guidelines are ignored but it's probably best to spend a bit of time making sure things are as robust as you can make them rather than spend a couple of seconds finding out they aren't.

ADDENDUM

What do the above factors actually mean in the real world?

After writing the above, which is good practice, I wondered if it was possible to put numbers to it i.e. just how much is range really likely to be affected? I'd recently got an Frsky telemetry Tx and one bit of information that is transmitted back is RSSI ("Received Signal Strength Indication") that is, how strong a signal is the receiver actually getting.

I set up the system in the lab (the back garden) and had a fiddle. The results were interesting in several ways. I did three types of test :

i) Effect of different receiver aerial orientations
ii) Effect of different transmitter aerial orientations
iii) Signal blocking with batteries and servos

First of all I set up an ideal installation i.e. Tx aerial and Rx aerials both side on to the Tx and no hardware between receiver and transmitter. Tx aerial was vertical and fully side on to the Rx. Distance between Tx & Rx was about 40 feet.

The indicated RSSI signal was about 95 dB. As the manufacturer's alarm threshold for this receiver is 45 dB then the maximum range under ideal conditions would be about 300 times 40 feet, or 2 and a bit miles (such claimed ranges are not uncommon).

i) <u>Orientation of the Receiver aerial</u>

I put both Rx aerials together into a bit of plastic snake and pointed this straight at the transmitter (really the very worst case). The RSSI dropped to about 85 dB, corresponding to a maximum range of about 1350 yards. The flying site runway is about 700 yards long from the hedge to the parking area, so the range would still be about twice this distance, more than adequate for most flying I expect.

ii) <u>Orientation of the Transmitter aerial</u>

The largest drop I observed by pointing the Tx aerial straight at the Rx was, again, about 10 dB, so the range reduction would be of a similar magnitude to i). One significant point was that the reduction really only occurred at one precise alignment, even a small change in Tx aerial direction from this brought the RSSI up close to the maximum, sideways on, value.

iii) <u>Effect of receiver, servos and wires</u>

With the Tx aerial aligned for maximum signal and the Rx aerials together side by side but side-on to the Tx (i.e. best orientation) I wired up a nice juicy (electrically noisy and lots of metal gears) digital servo. This I put literally on top of the active bits (the ends) of the receiver aerials, and added the battery to the pile for extra effect. The servo was effectively right between the Tx and the Rx aerials. Results were a bit unexpected.

The maximum reduction I observed was about 6 dB but by rearranging the pile I was able to see an *improvement* at one point of 5 dB ! A reduction of 6 dB is effectively a halving of range (but still a mile and a bit).

Conclusions

So what do these results actually mean ? The worst case alignment of either the transmitter or receiver aerial, on its own, is unlikely to cause a range problem in practice. The range would still be of the order of 3/4 mile (for the glider boys that's an altitude of about 4000 feet, enough even for Terry). Having the Rx aerials at different angles in the model would make any Rx problem of this type very unlikely and the Tx alignment needs to be very precise for any significant problem to arise.

Even my crude and very limited attempt at masking of the Rx aerial by the battery and servo only produced a maximum of 6 dB reduction, quite surprising and, on its own, unlikely to be a problem.

In the worst case scenario where, say, the Rx aerials were installed parallel to each other, and they were "buried" in the servo and battery wiring, and the model flew through the critical Tx and Rx aerial alignment, then the signal reduction could be 10+10+6 dB and the range could be reduced briefly to about 200 yds.

A model that actually glitched at the field was range tested. From one direction (from the tail) with the Tx aerial pointing at the model, the power-reduced range was about 20 yds (it was fine from other directions). The worst case scenario may occur. Just aligning the Rx aerials at 90 deg and keeping them away from wiring and metal objects in the model should mean that range problems related to aerials will be unlikely, thanks to the wonders of the manufacturers of our amazing equipment.

Caveat

All the numbers I quote are for my Tx and Rx, mounted as I did in my garden at the range I mentioned, and are my best estimates of figures that I saw, on the 25th Sept 2013 etc etc. Different equipment, in different locations and at different ranges, and in different RF environments, is quite likely to produce different RSSI values but, I would hazard, similar trends.

Don't use the numbers for anything else apart from an indication that the effects observed in the garden do tie up with observations at the field and that a little care during aerial installation really is worthwhile and is likely to remove, or significantly reduce, any chance of such problems.