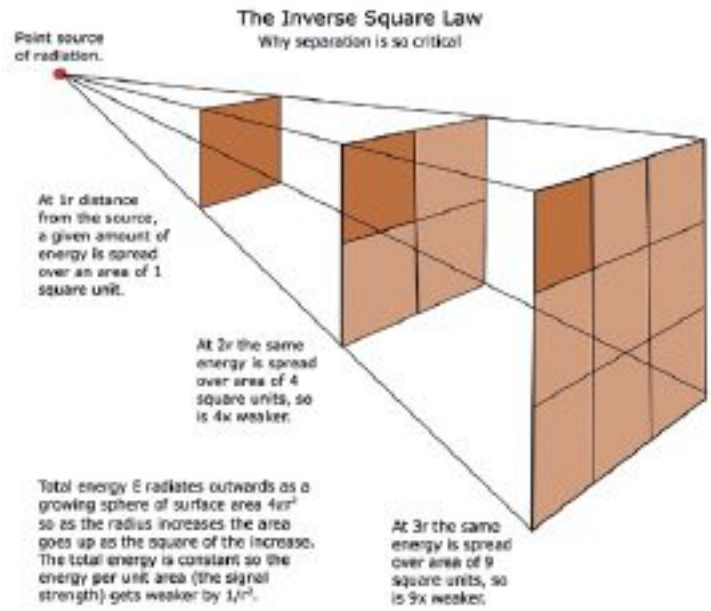
To phone or not to phone?

MOBILE PHONES ▪ **DAVE BLANDFORD**

Here Dave Blandford of Matchams Model Flyers, Bournemouth presents a discussion on the advisability of keeping mobile phones well away from model radio control equipment, and an explanation of the likely causes of glitches and crashes as related to hand-held mobile devices. Please note that it does not cover the operation of model aircraft near fixed network infrastructure such as mobile phone masts.



The Inverse Square Law.

After reading the article about mobile phones on the flightline I was minded to volunteer my own thoughts on the subject. This debate has been rumbling on for years because nobody has presented conclusive proof that a problem exists. I doubt if anyone will ever provide a concrete proof that satisfies everyone.

The problem is random and probabilistic in nature, and there are many hard-to-control variables to perturb tests. The answer is going to be along the lines of 'it will be fine if the phone is this far away', which is less than ideal but may be the best we are going to get.

There are problems in persuading folk that mobiles do cause crashes, and to get them to keep phones and flying separated:

Some flyers are not even aware that there is an issue.

Most flyers absolutely do not understand the mechanism by which interference occurs.

Some stick their heads in the sand, claiming that they are not technical, and hence not interested.

Others say that they have had no issues thus far, so all will continue to be well.

There is a strong belief that 2.4GHz is bombproof.

Occurrences are random, difficult to identify and fortunately fairly infrequent.

No one likes being parted from their phone, even briefly.

People forget they still have their phone on them – I've been there myself.

Personally, I have no doubts whatsoever that mobiles do present real issues which are not properly understood by the majority of modellers. I hope I can shed a little light in the darkness and would ask the following questions:

Has anyone really tried to quantify the problem?

Do they understand the issues and know what to look for?

What sort of evidence would be acceptable to most modellers?

THE LIMITATIONS OF TESTING

First of all it should be understood that one cannot prove absolutely that phones are totally safe in this context. One can fail to show evidence that they are dangerous, but this is not the same thing at all.

It can also be demonstrated that control problems do occur when a live phone (that is, one that is powered-on and not in flight-safe mode) is in close proximity to a transmitter, but again, this is not proof of causality. It just indicates a (very) likely link.

Secondly, it is in the very nature of interference-related investigations that the results are likely to be expressed as a probability. Suppose 100 tests are carried out, all under identical conditions (a challenge in itself) and there are no failures, does that imply there's no problem?

No, it just means that you have not seen one yet. Maybe your test is not rigorous enough, or perhaps you are not looking in the right place. How about 1000 tests? 10,000? Assuming that you do get some apparent failures, how many do you need before accepting the inevitable and agreeing that a problem does exist?

There is bound to be the odd glitch, even if it is totally unrelated to what you are testing for. And just how rigorous does your test need to be? For me, if a phone in my hip pocket causes a problem just one single time, there's a link. I have had three such events myself and have been witness to several more where a phone was implicated. Case proven.

At this point another question arises: is the cause of the suspected problem understood well enough so as to be able to design a test that will indeed catch any failures? My experience is that the average modeller's understanding of how phones can affect RC gear is poor at best, and usually totally wrong. So, a digression here.

INTERFERENCE IN THE GOOD OLD DAYS

Back in the days of 27/35MHz there was much potential for radio interference on the spot frequency you were operating on. 27MHz was a nightmare, with industrial, military and medical equipment, communications gear and cheap foreign toys all operating in the model band, and on both frequencies you were prone to being shot down by a fellow modeller powering-up on your spot. All this caused the signal your receiver was detecting to be corrupted, so the encoded data could not be resolved.

Imagine you are at a crowded, noisy party. Someone across the room is talking to you. They are speaking perfect sense but you can't make out what they are saying amid all the hubbub.

Their voice is being swamped and distorted by the other sounds and although you can hear perfectly, you can't hear them. This equates to radio interference. The radio signal is being corrupted. You, as a receiver, can't make out the

signal. In a nutshell:
Tx – good
Radio link – bad
Rx – good.

HERE AND NOW

Fast forward to the present day with 2.4GHz gear and the issue is vastly different. The technology of spread-spectrum does just what it says on the box – the signal is spread over the whole available band, along with all the other signals.

Via the binding process your receiver is given the secret masonic handshake that allows it to hear your transmitter only, ignoring all the others. This provides a very robust RF link which mobile phones do not affect; indeed, they use the same technology.

HOW MOBILE PHONES AFFECT ELECTRONICS

So, how do mobile phones interfere with modern gear? The short answer is that they can emit strong bursts of RF energy (electromagnetic pulses or EMPs), typically as they are woken up by an incoming call or text.

If the phone is close enough to your transmitter this EMP can crash the software that the controller is running, corrupt registers holding flight data, wipe memory and generally give your kit a really bad day.

Continuing the party analogy, the noise level is now much reduced and you can hear your friend perfectly well. The trouble is that now he is being worked over by a couple of heavies and is not able to put two coherent words together; maybe he's been laid out altogether so he is unable to say anything. This is electronic interference.

The electronics in the transmitter have been compromised. So now the problem has moved away from the radio link. It's now a transmitter issue. The radio link may be fine, the receiver is good and working in a clean environment. It has no problem deciphering the signal from the transmitter.

However, if that signal contains some wrong data (reversed servos, incorrect model memory etc.), so be it. You will have an exciting few seconds before meeting terra firma. So:
Tx – bad
Radio link – good (maybe)
Rx – good.

The reason there's a 'maybe' above is because if the RF section of the transmitter has been compromised, rather than the control section, there may be no signal being transmitted at all.

Just to add a final twist, if you have put a phone in your plane to video the flight from onboard, everything in the last paragraph now applies to your receiver instead of your transmitter. It's still electronic interference, but this time with the receiver rather than the transmitter. In the analogy, the room is quiet, your friend is speaking clearly but now you are the one getting worked over, so can't catch what is said. If you do put a mobile in a model, put it in flight-safe mode. Here:
Tx – good
Radio link – good
Rx – bad.

It is hard to say whether the fail-safe would kick in either case – if the transmitter has locked-up completely, yes it would. If there is a trim change or servo reversal, no it wouldn't. If the receiver has locked up then no is the likely answer.

Most modellers do not seem to understand this essential difference between radio and electronic interference, clinging on to their legacy knowledge from 27/35MHz days. This still happens even after fully explaining the situation.

My club, Matchams Model Flyers, near Bournemouth, has put in place a ban on mobiles on the flightline and following the inevitable discussion, one member was heard to say, 'Anyway, I never use my phone at the field, I put it safely away in my pocket.' Duh…

Right, moving on. The cause of the crash (or glitch if you are lucky) is the phone in your pocket saturating the transmitter electronics so the control circuitry is compromised, NOT interference to the RF link. Accept this or take up painting or golf. Don't be a flat-earther.

Note that the RF section of the transmitter is presumably just as prone to EMP saturation as the control side is, so the radio link itself could still be upset. The ironic thing here is that firstly the phone that shoots you down will probably be your own, and secondly the person innocently responsible is likely to be a friend or family member.

DISTANCE IS EVERYTHING

The most important variable involved in whether your phone locks-up your transmitter is the separation-distance between them, but there are other factors. For instance, if your phone is far from a cell mast so reception is poor, it is likely to increase its power output. Another factor is how well screened your transmitter case is. Screening tries to put your transmitter electronics in a Faraday cage, whereby unwanted radiation is kept out.

This means that cheaper gear will necessarily be more prone to EMPs than top-end stuff, all other factors being equal, since cheaper gear will have little if any screening. Then there are physical variables like battery voltage, temperature etc. which could affect how sensitive to interference your equipment is.

But back to distance. Radio signal strength obeys the inverse-square law - if the distance from the source is halved the signal is four times stronger; three times closer, nine times stronger.

Suppose the phone is moved from your pocket, where it is 10" away from the main pcb in your transmitter, to touching the transmitter case, where it is 1" away. It is now 10 times closer and the signal at the pcb becomes 100 times stronger. Read that again. 10 times closer, 100 times stronger.

This is why you can test for ever with the phone a meter or so away (a fairly safe distance in my opinion) and never see a glitch. Place it touching the transmitter and let's see... a meter is 40" and 40 squared is 1600. So the signal strength that the pcb encounters is now 1600 times as strong.

If you are now thinking that the RF signal your receiver sees when 500m away must be tiny compared to what it saw when you were taxing out to take off, you are right. Move 500 times further away and the signal strength falls by a factor of 500 squared.

That's a quarter of a million times weaker. There is an automatic gain control in all receivers to adjust for this, but that's another story… Food for thought.

WHAT THE PROFESSIONALS SAY, AND THE CHANGES I MADE AS A RESULT

Finally, consider this. I have worked in electronics for most of my life and in my last job helped put sophisticated medical equipment though EMC testing at an EMC test house in order to ensure regulatory compliance.

Electromagnetic compatibility testing checks that the equipment under test does not radiate interference that might affect other equipment. It also bombards the test unit with RF energy over a wide range of powers and frequencies to ensure it does not lock-up or malfunction. This latter is exactly what a phone does, in an uncontrolled way.

Whilst there I took the opportunity to discuss my RC experiences with the professionals. They all immediately said the same thing; no surprise there, keep the phone well away from the transmitter.

Before I realized all this I used to fly with my phone in my front trouser pocket, switched on and in normal mode. This put it 10" away from transmitter. Never gave it a thought. I have had three separate issues on two models; firstly a severe change in aileron trim with a 2.4GHz JR computer radio.

Next, a week later, total loss of control of the same model and radio resulting in a major crash. Lastly, months later, total loss of control of a small electric plane controlled by a 30-year old 35MHz AM Sanwa non-computer system. Neither system had ever shown any problems before.

Now I always leave the phone in the car when flying and the issues have never resurfaced. None of this is proof but logic suggests a very strong probability. Recently a friend was talking about his experiences of glitches on 2.4GHz. He always flew with his phone in his hip pocket. I persuaded him to leave his phone in the car, and all his glitches have since gone away.

Just for the record a mobile phone can screw up any piece of electronics; it doesn't have to be a radio. It's not radio interference, it's electronic interference. The phone just has to be close enough. Remember that receivers have memory too (failsafe settings, bind data etc.), and they run software. So do ESCs and some servos. To those who put phones in models in order to video flights I would say, be aware. Any electronics can be compromised if the signal is strong enough.

Keep your phone away from all your radio gear at all times, not just when flying. If you put your transmitter down in your car next to your phone while you have a coffee you may still get data corruption.

Another point to consider here is, does the transmitter have to be powered-on for data to be corrupted? On this one I have no idea, but suspect the answer is no.

I have shown to my own complete satisfaction that a phone 12" away from a transmitter is too close for reliable operation. A yard or so away would probably be fine; were it in contact with the transmitter disaster would be certain, sooner or later.

This may be why there is no hard evidence - modern electronics are designed to be resilient to such interference, but there are limits, and to experience the problem one needs to push the limits.

FOR THE DOUBTERS

If you are still a doubter, bear in mind that airlines, hospitals, filling-station forecourts and probably other locations all require mobiles to be off at certain times. In other instances a minimum separation must be maintained from, say, people with pacemakers. These places and situations all have one thing in common: safety-critical electronics systems, or money-critical in the case of forecourts. Flight-safe mode exists because the phone manufacturers know that there are potential issues, and the simplest solution is to kill the phone's ability to generate EMPs when this is deemed appropriate.

IN CONCLUSION

1. Mobile phones in close proximity (under three feet) to any critical electronics is a bad idea. Even if it is nearly always ok, one day it won't be. Closer is much, much worse. Separation-distance is everything. The probability of an EMP-related event goes up hugely as the separation is reduced. Increasing it by a few inches might be the difference between crashing or not.
2. To understand how phones upset RC control systems requires a paradigm-shift in your thinking. The problem is not one of interference with the radio link, as was the case with 27/35MHz. It is a radically different effect that cripples or corrupts the whole transmitter electronics due to the EMP that the phone emits.
3. Any electronics can be affected, including your receiver, should you put a phone in your aircraft. If you do this, ensure it is in flight-safe mode.
4. Just because no one has published hard evidence of a link between phones and crashes does not imply that there isn't one. Remember, absence of evidence is not evidence of absence. I suspect that some people will never be convinced because the nature of the issue is random and probabilistic, and also heavily dependent on the proximity of the phone. It needs to be really close. There are a host of other factors which making testing and diagnosis difficult. Just accept that there is a problem.
5. Data corruption can also occur away from the flight line. Keep all phones away from all radio gear at all times, whether on the flightline, in the car, in a transmitter pound, in the workshop or in the pockets of coats casually dumped near your gear. Am I paranoid? No, just aware, and cautious. I have an electronics background, I have been bitten three times and I have had the benefit of professional EMC advice. The result is I won't have phones anywhere near my gear unless switched off. Beware of other people sidling up to you whilst you are flying. Have they got a phone on them? Switched on? Not in flight-safe mode? It could be as close to your transmitter as it would be in your own pocket, and that is too close.
6. Don't risk it; turn your phone off or put it in flight-safe mode. Better still leave it in the car, away from your models and transmitter. I keep the phone in the front of the car and the gear in the back. Six foot away would appear to be far enough.
7. Beware of grabbing your phone to video a friend's new model, then casually dropping it back in your pocket. So easy to do. This happened a short while ago at my own flying field, and the member concerned then went on to fly. And suffered loss of control and a crash.
8. If you do persist in flying with a live phone on your person, bear in mind that operating in areas of poor mobile reception will likely increase the output power of your phone. This will increase the separation distance at which glitches can be caused. Also, the more calls/texts you receive, the greater the frequency of possible mishaps, since glitches often occur just as a call is received. These factors might just turn a glitch into a full-blown crash.

I hope these words go some way towards getting modellers to better understand the nature of the problem. Our sport is under threat from many sources for largely non-existent reasons. Let's not give the anti-RC lobby real ammunition by shooting ourselves down.

Phones do cause glitches and crashes if they are close enough to the controlling electronics, and anything can get corrupted or altered. All that has to occur is for a 0 to become a 1 somewhere and you are now using a different model memory or flight mode, or your elevator is reversed, or perhaps the main processor has locked-up.

Believe it! You wouldn't fly in a field where you might get knocked over by a large over-friendly dog, yet flying with a phone in your pocket is the equivalent as far as your transmitter is concerned.

Don't play Russian roulette with your phone! I heartily endorse the BMFA policy of no phones on the flightline or within 10 feet of programmable transmitters. I would, however, extend it to include any transmitter, or receiver – indeed, all RC equipment.

Fly safely.

David Blandford.