Up and Away

Fed up with dodgy take-offs? Wish you could do something a little more realistic? David Ashby and Dave Burton take a closer look at the process

Right then, David A here. Do you find taking off a nervy affair? It's understandable if you do. After all, it's a sequence that means the model is close to the ground for a few seconds at full throttle and when things go wrong they tend to go wrong very quickly without the comfort of altitude. For this reason some model flyers view taking off as a necessary evil, something to get quickly out of the way without incident – slam the throttle open, yank back on the stick and breath a sigh of relief.

Well, I guess that's one way of doing it, but it's hardly elegant is it? Let's be honest, are we really just trying to cover up the fact that we lack confidence in handling the model on the ground, especially at speed? If that's you then it doesn't have to be that way and help is at hand. I'm going to look at the practical aspects while Dave Burton will be covering the physics and between us we'll hopefully help ease you into nicer flights. Let's get started.

UP

Needless to say and before you point the model into wind, the chance of success is improved if the model is properly prepared for the flight, the engine tuned, the fuel tank full, batteries charged, C of G sensible and the controls moving the right way. You know the drill and while there are plenty of starting and safety acronyms I could throw at you, the fact is that, every weekend, across the land, one or several models will crash owing to reversed controls, usually because the wrong model (memory) has been dialled. How you handle a take-off will, to some extent, depend on the undercarriage configuration, so let's look at the two main types.

Trikes

A tricycle undercarriage offers advantages over a tail dragger in that full power can be applied quicker from the start because the model isn't about to nose over. Generally speaking, however, the extra u/c leg means more surface drag so the model will take longer to build up speed. In turn this means you'll need to allow time before unsticking and, in some cases, a more pronounced dab of elevator to achieve flight.

Trainers equipped with a steerable nose leg can often provide steering that's far too sensitive when the model is rolling so go easy on the rudder when making tracking adjustments. Often just a slight blip or squeeze is all that's needed. Given this, adding exponential to soften the rudder and so nose leg steering sensitivity can help.

Generally, trikes tend to track better than tail draggers, although you'll still notice some torque effect.

Tail draggers

Tail draggers don't have a nose leg so the risk of tipping over and stopping (or breaking) the prop is a risk as the model starts to roll. The size of the risk varies from model to model, from very little to very high, depending on the design, C of G and undercarriage position. The runway surface and flying conditions will have a bearing, too.

Tail draggers usually require that the tail is kept down using elevator. Some guides suggest full elevator for starters which is fine although it's important to relax the control as the model gathers speed. Why? Well, full elevator will deliver a powerful response when the model reaches a certain speed and that point can be reached quicker than you think – usually within a few seconds of the model starting to roll, and especially if it's windy. So easing off on elevator will ensure the model doesn't suddenly leap into the air sooner than the pilot and laws of flight would prefer. The risk of a stall is, of course, obvious consequence for which a height safety margin won't be available.

The amount of elevator required to hold the tail will vary from model to model. Some will require little if any, others, heaps! Generally speaking, sportsters such as the Wot 4 and many of the semi-scale Extra and Edge varieties have been designed to befriend the pilot and reduce the workload. Scale or close-scale models, especially warbirds are a breed apart and often require a few design concessions to assist with the process.

Tail draggers have one more little traits up their sleeve. The absence of a nose leg means you're very likely to see and feel the effect of prop torque. Dave provides the technical explanation a little further on but rudder is usually required to assist with tracking as the model starts to roll and can be relaxed and often centred a second or two after. It's another reason too why, for a tail dragger, a gradual implementation of throttle is better than just throwing it wide open.

Lifting sharply into a steep climb suits some machines. Beware though, just because it's 3D capable doesn't mean it's immune to stalling.

THAT'S NOT ALL

There are plenty of other factors that can influence the take-off process, so here they are, in no particular order:

Crosswind – The decision to fly will depend on wind strength and direction. A 10mph breeze 15-degrees off the runway centreline won't pose a problem but a 20mph gust hitting the model at 45-degrees certainly will. Sometimes discretion is the better part and a strong crosswind will be a signal not to fly, especially if you're nervous about landing. Crosswind take-offs may require greater use of rudder to help the tracking, along with an awareness of the need to manage the effect of the conditions using ailerons as soon as the model has left the ground.

The runway – The quality of the strip can have a bearing on events. An uneven surface or one with long grass can increase the risk of a tail dragger nosing over, slow down a trike equipped machine or cause either to deviate from the centreline. Smooth dips can often act like ramps causing the model to leave the ground sooner than it should.

Rotating – It's important to know when to squeeze the elevator and unstick your aeroplane. In this respect it can be better to stand to one side of the model (rather than behind) as here it'll be easier to gauge the model's speed over the ground.

Flaps – Full-size aircraft often use a little flap to help provide extra lift during take-off. Models on the other hand benefit from lower equivalent wing loadings so their use is rarely required unless the pilot is seeking to create a scale-like appearance. Do be aware of their effect if deployed. They'll mainly add lift along with a little drag so shortening the take-off run yet also increasing the possibility of a model lifting off at a slower airspeed than normal and, thus, increasing the risk of a stall.

WHEN THINGS GO BAD

There are plenty of factors that can go wrong during the take-off sequence from things for which the pilot is responsible through to those over which he may have no control.

Engine out – Engines that cut at a critical moment have been responsible for the premature demise of countless airframes over the years. The best course of action to take really depends on the point at which this happens. Right at lift-off (or just after) means it's always best to keep going straight and land in the rough, some height in the bag may allow the pilot to glide round and land back on the patch but success will depend on the model so you need to know its unpowered glide characteristics very well indeed. The golden rule is to keep going straight into wind if you have any doubts - you'll get away with it flying a Wot 4 or lightly loaded 3D'er but just about everything else will treat you to the perfect demonstration of the downwind stall so never be tempted to bank round in the hope you'll make the strip, the odds are you won't.

Sick engine – You know how it is, you tuned that engine to perfection in the pits yet it coughs and splutters the moment the model takes to the air. Sick engines give you a chance so it's important to claw some height and enter the landing circuit straight away. It's best not to fly on in the hope things will get better, they rarely do.

Trim adjusts – Although it's tempting to push in some trim adjustments the moment you realise they're needed, it's safer to do so with a height safety margin. So, get the model up, come round into wind and adjust from there. Better still, get a spotter to push in the beeps for you.

C of G variance – We've all had that horrible feeling when a new model takes to the air that's clearly in need of some adjustment to its C of G. It's most likely tail heavy and you're holding in plenty of 'down' but, again, the very best course is to get some height, settle down into wind and then get a spotter to push the trim(s) while you concentrate on flying the model.

Lifting off early – Unsticking before the aeroplane is ready to fly is never a good thing. It's a reason why it's best to view the model from the side rather than from behind (so the take-off speed can be better assessed) and, if you're using elevator to hold down a tail-dragger's tail, another reason why it's best to relax said elevator as soon as possible.

It's easy to let the mind-set linger in the belief that the flight starts as soon as the model leaves the ground but many models, particularly scale, need full pilot involvement and need to be flown from the moment they start to move. That's a good thing though, it improves pilot skills, ensures mishaps rarely happen and looks better, too. Not sure how the full-size does it? Easy, just go to YouTube to see how full-size aircraft rise from the ground, visiting airshows or your local aerodrome also help.

Go on, I dare you - apply the throttle gradually, and lift off the deck just like a full-size would, I promise you'll gain instant flightline cred and add another layer of satisfaction to your flying enjoyment.

Right, I'll pass you across to Dave Burton for a look at the aerodynamic processes.

THE PHYSICS

David has focused mainly on the flying techniques that can help you to bring about a good start to your flight but let's try to get an understanding of what's causing the behaviour we see on the ground and why taking off presents the challenge it does. A nice scale-like take-off with smooth acceleration, a run on the main wheels followed by an elegant rotation and lift-off into a sensible climb angle is nice to watch and very satisfying to execute. And what's more, it's well within the grasp of all, once we understand the forces on our model and have the techniques to deal with them. David has looked the techniques so let's work on the forces.

"All Gaul is divided into three parts", so said Julius Caesar in the opening line of his ripping yarn The Gallic Wars. Well, if it was good enough for him it's good enough for me, so I'm going to divide take-offs into three parts and Fig.1 shows what I'm talking about. To start with we have what we'll call the initial roll, from standstill to some velocity we'll call V1. We then go into a phase we'll call the run; this lasts up to some velocity V2. Finally, we have the part we'll call ground flying, this starts on the ground and finishes once the aircraft is at an altitude of 5 or 6ft. These three phases of take-off are separate and the dominant forces experienced by the model in each phase are very different. Let's slow a take-off right down and examine it.

Although taking off is generally easier than landing, there's an art to doing it well, and in particular doing it well when flying a scale model. If you stop and watch participants at the Nats scale flightline then the quality of the take-offs will be immediately apparent. For starters, the model's taxi in a scale fashion. If you've ever seen Mick Reeves taxiing his Spitfire then you'll have seen how he emulated the weaving s-style turns that allowed full-size pilots to see where they were going.

In keeping with their full-size equivalents, F4C models gradually gain speed before taking to the air. Flooring the throttle and yanking the model off the deck half a second later is unthinkable. Given that, why should it be any different at the club patch? Apart from 3D and freestyle aerobatic machines, this type of take-off rarely looks good. Even semi-scale sport machines usually look better when emulating approximate full-size equivalents.

PHASE ONE – THE INITIAL ROLL

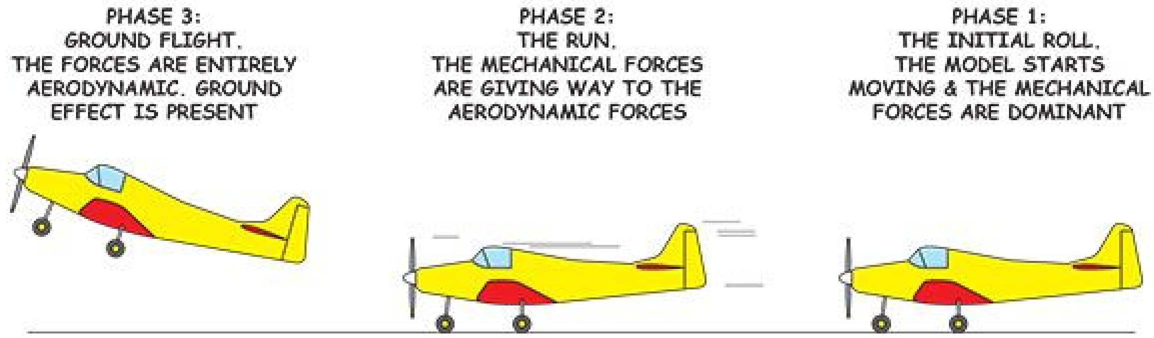
This is probably the most critical part of the whole process, get this right and you're well set for phases two and three. Make a right old pig's ear of this and it's almost impossible to achieve a good, controlled take-off, indeed there'll be little you can do in later phases to recover the situation.

Okay, you're standing at the edge of the strip, the model at your feet. You give the controls the obligatory waggle, you call "lining-up" and taxi out onto the strip. With the model facing into wind you have one last look around to check everything is clear, call "rolling" and we're ready to go. You open the throttle a bit and... nothing happens, it just sits there!

We've hit our first bit of physics. The fact is, as you know from the taxi, it takes more thrust to get a model rolling than it does to keep it rolling. The resistance to moving off we call the coefficient of static resistance, whilst the resistance to motion once we are actually moving is called the coefficient of dynamic resistance. The former is generally larger than the latter. All of this means we need to apply a bit more throttle to get things off to a start than we'll need to simply roll along at a steady speed.

This can lead us into our first error, we open the throttle, nowt happens, so we open it more. Then, suddenly, the model leaps forward and now, because the resistance has dropped, we have more acceleration than we bargained for. But to hell with it eh, let's just gun the throttle and go for it eh? Mistake. What's best is to briefly establish a short steady slow roll, get everything moving, but under your full control. You are controlling the model, not the other way round.

The trick is to give it a nudge of throttle to start moving, and then back off a tad to establish the roll, square everything up with the rudder so you're heading in the direction you want to, then open her up. This only takes a few feet, but it's a big part, and the basic foundation of a controlled take off.



BUILDING SPEED

Right, we're rolling and starting to accelerate; we're still in phase one. How fast we accelerate is strongly governed by the pitch of the prop. A fine pitch propeller with, say, a pitch that's less than 50% of the prop diameter, will give us nice brisk acceleration and a responsive throttle. A coarser pitch propeller will lead to more docile acceleration, but ultimately a higher speed. Indeed if the pitch is very coarse it's quite possible that at the start of the take-off run the prop blades may even be partially stalled. This will not help your throttle control in terms of establishing the straight constant speed roll because it will feel that throttle has a big lag between your inputs and the model reacting.

So, the acceleration builds, what next? Well, usually a sharp pull to the left is what's next. Why is this happening? David touched on this and here I'll give a more detailed explanation.

The fact is, there are several forces at play which all conspire to push the model to the left. The first is the torque effect. Let's meet the torque effect with one of our little experiments.

If you have a small electric motor, fix it to a mounting, pop a suitable prop on it and then connect it up to a Li-Po, ESC and receiver, as it would be in a model. Now very carefully hold the mounting firmly and gently blips the throttle on your transmitter. Can you feel the motor twitching in your hand?

Short-coupled W.W.I types can be tricky on the ground and are one example where long take-off runs are best avoided. Fortunately, their light wing loadings allow flying speed to be achieved quite quickly, just like the full-size!

The twitch will be opposite to the direction of prop rotation. If you have the prop going in the conventional clockwise direction viewed from behind, then the motor will twitch in an anti-clockwise direction. Obviously be very careful here and don't go mad on the throttle, we don't want any free flying motors around! You only have to gently blip the throttle to feel the effect. This twitch you feel is the torque reaction. When the motor is in a model this reaction is transferred, via the mounting, to the airframe and so the whole airframe feels this anti-clockwise twist. You can feel the twitch when you just gently blip the throttle, imagine how much stronger this force is when you pile on the power.

One more thing, notice that while you can feel some anticlockwise force all the time the motor is running, it's very much stronger when the motor is accelerating, when you speed up the motor the force imbalance you set up greatly magnifies the effect.

Back to our model trundling along on the strip. If you slam the throttle open so causing the motor to suddenly speed then the airframe will experience a huge torque reaction making it want to rotate anticlockwise. This will shift more weight on the left-hand wheel, which in turn means more friction on this wheel. So the plane pulls left. But, if we're a little less heavy-handed and progressively open the throttle, whilst the torque effect is still there, it's much diminished. The pull to the left will be less strong and grow more slowly. This gives us more time to correct any swing with smaller rudder inputs so that we can hold the line and keep things straight.

If your model has a tricycle undercarriage that is more or less the end of the story as far as this first phase of the take-off is concerned. But if your model is tail-dragger I'm afraid we have a number of other things to worry about.

Power can be intoxicating and freestyle pilots will use it to best effect moments after take-off.

TAIL DRAGGER WOES

Obviously models with a tail wheel usually sit on the ground in a nose-up posture. Because of this their propeller is rotating in a plane, which is slightly tilted backwards. This leads to the propeller blade on the right-hand side of the disc (again viewed from behind) being at a slightly higher angle of attack to the air than the blade on the left-hand side. So the thrust from the prop is no longer equal left and right, the right-hand side is producing more thrust. This being the case, the prop is effectively pulling the model to the left again. This phenomenon is known as the p-factor.

So, in the case of a tail dragger, we have two forces pulling the model to the left; the torque effect and the p-factor working together. We're going to have our hands full here and this is why most trainers have tricycle undercarriages, they're easier to handle on the ground because there is only the torque to deal with and no p-factor effect.

But I'm afraid that even now the cup of woe for tail-dragger pilots is not fully filled. Yes, there's even more bad news!

Safely up? Why not climb out like the big ones do?

SUPERMARKET TROLLEY SYNDROME

In this phase of the take-off the aerodynamic forces are almost non-existent. The model is not being steered by the flying surfaces; it's following its wheels. There's a major problem with rear wheel-based steering on a tail-dragger – it's basically unstable. Let's see why.

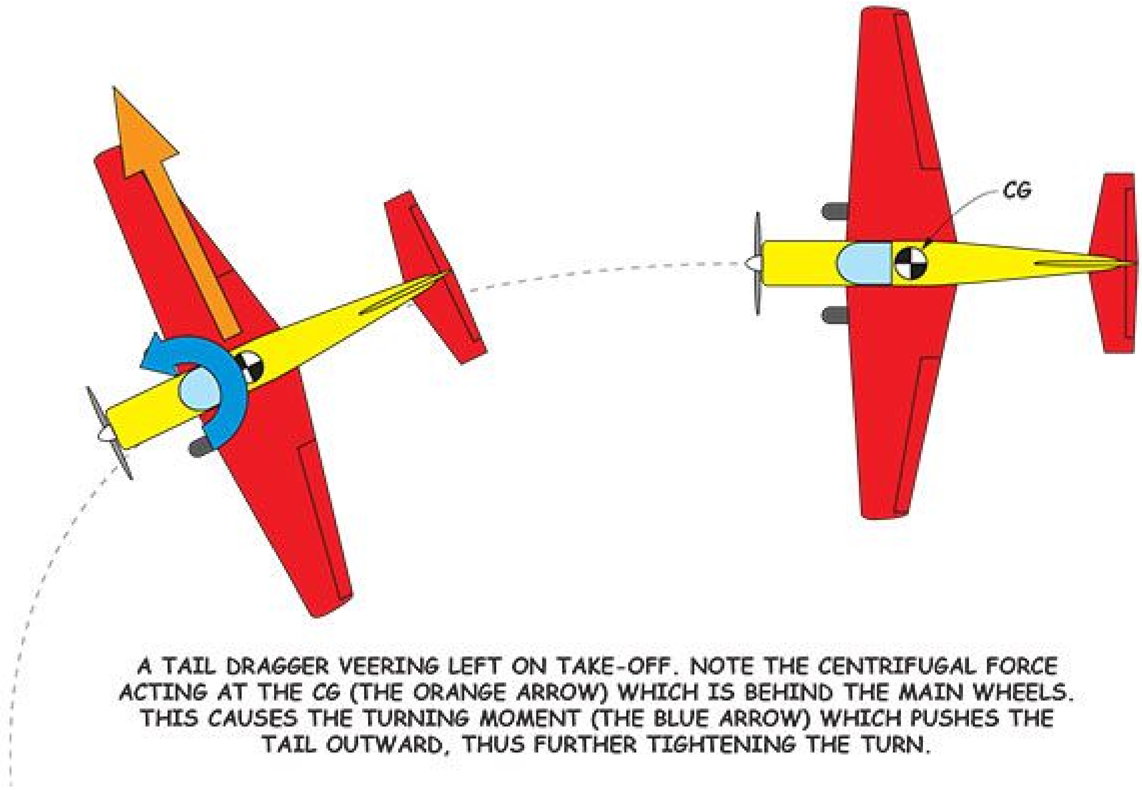
Fig.2 shows a tail-dragger rolling along the ground. Now, suppose it moves away from the desired straight and narrow path? Let's say it decides to follow a curved path to the left which, of course, we know that it will wish to do.

The dominant, weight-bearing wheels are obviously the mains. To sit on all three wheels on the ground, and not tip onto its nose, the model's centre of gravity must be behind the mains. This centre of gravity is also shown.

What happens as the model just starts to swing left? It's now following a curved path, so there will be centrifugal force. Where will this force act? It will act at the centre of gravity. What will it do? It will try to push the centre of gravity outward, away from the centre of rotation. Because the centre of gravity is behind the main wheels the effect of this will be to pivot about the main wheels and push the tail out. If the tail moves out then the nose is moving into the turn. Result? The model turns even tighter to the left. If the turn tightens so the centrifugal force increases, the tail will be forced even further out and the turn will tighten again. This is self-reinforcing. The turn will get tighter and tighter in a spiral as the tail swings further and further round and the model does a passable impersonation of the famous Ozzlum Bird. This, then, is a ground loop.

Notice that tricycle undercarriage models don't have this problem. In these the centre of gravity must be in front of the main wheels and so when the model swings off a straight course the centrifugal force actually pushes the nose out of the turn and so the system is self-correcting. Another reason why trikes are easier to handle at take-off.

If your tail dragger model has a very short tail then this instability is even more noticeable. One of my favourite models was a Pitts Special – it's sadly no longer with me but was great to fly although every take-off was an adventure! Being a tail dragger with quite a steep tail-down posture on the ground and very short tail moment, it was a real challenge to keep straight and more than one take-off was abandoned as I struggled against its insane desire to squirrel around on the ground.



A TAIL DRAGGER VEERING LEFT ON TAKE-OFF. NOTE THE CENTRIFUGAL FORCE ACTING AT THE CG (THE ORANGE ARROW) WHICH IS BEHIND THE MAIN WHEELS. THIS CAUSES THE TURNING MOMENT (THE BLUE ARROW) WHICH PUSHES THE TAIL OUTWARD, THUS FURTHER TIGHTENING THE TURN.

PHASE 2 – THE RUN

The point of exit from phase one is marked by a change in the dominant forces on the model. We move from the realm of vehicle mechanics, where ground contact forces through the wheels are dominant, into a region where the aerodynamic forces are king. The wheels are losing their influence and the fin is becoming the governing factor in determining direction.

If we exit phase one with the model straight then 80% of the job is done. The problem is that if we come out of phase one off-angle it'll be very difficult to straighten up. Further use of the rudder in this phase will only yaw the model; it won't necessarily change its direction of motion. But even if we have maintained a good straight take-off line, our battle isn't completely won, another factor comes into play at this point: the wind. If the wind is significantly off the axis of your take-off line then the model will try to weathercock into it as the aerodynamic forces grow. Aeroplanes do not naturally want to fly facing out of wind, in many cases they can only be made to do so by a conscious effort. It's back to that rudder again, but bear in mind it isn't necessarily a simple matter of just continuing with our left rudder correction from phase one. Depending on the side the wind is coming from we may need to switch over to right rudder correction at some point!

As phase two progresses, lift increases, the wheel contact with the ground gets lighter and, in effect, we're flying in two dimensions. It's during this phase that the tail dragger should be allowed to raise its tail and take up a more or less horizontal posture. The nasty p-factor effect will go away and, as we're probably by now at close to take-off throttle, the torque effect lessens as well.

Warbirds tend to concentrate the mind a little more. The effect of this Corsair's big prop will need to be managed during the take-off run.

PHASE 3 - GROUND FLYING

Soon the wheels leave the ground and we are flying. The most important thing now is to let the model continue to gain speed and not allow it to climb at too steep an angle. Remember our airspeed is still very low and the model is close to the stall so it's best not to provoke the situation.

We also need to remember that, this close to the ground, the wings don't function as cleanly as they will in mid-air – the so-called ground effect is at work. One area where this can be a problem is when we become airborne with some rudder deflection still in place. This will probably lead to one wing being a little low. Try to resist the temptation to pick it up with the ailerons. Flying slowly, this close to the ground, down going ailerons can easily trigger a tip stall on the low wing, the consequences of which will not be good. Instead, a little opposite rudder to square things up is much the preferred option.

Keep your climb-out angle swallow. It looks better and it gives the model the best opportunity to gain speed and sufficient altitude for that first turn. Don't be in too much of hurry to make that turn either, give her a chance to leave the ground well behind.

Sports models are usually pretty forgiving so making a sudden rise is less risky than with scale types where a tip stall is an ever-present danger.

DO WE HAVE A PLAN B?

What if it all goes wrong? Well first of all, if you lose control of it in phase one then the best advice is always to abort. Onlookers will certainly think far more of a pilot who is sensible enough to know when to start again rather than battling on with only partial control.

No matter how good the take off, sometimes things happen that might be outside our control. For example we might have an engine go dead-stick in phase three. The guiding principle here is the same for us as it would be for a full-size pilot – never turn back. Instead put the nose down and glide to a long landing straight ahead. Do that and everything is in your favour - you're into wind, you'll hold what limited speed you have, you should be able to time a flair and so effect a controlled landing. If you try to turn, without adequate speed and / or height, then it all works against you. You'll lose height or speed in the turn, you're now low, slow and going down wind, a combination that will almost certainly end in tears.

FINALLY

Well there we are, the science of the take-off! I hope you'll feel that you now understand a little better why your model does some of the strange things it does during the first moments it spends on the runway. Now, go back and re-read the practical tips and, with practice, I'm sure your take-offs will reach the elegant standards to which we all aspire.

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