The Electronic News letter of the Chichester and District Model Aero Club

Clear Dope

May 2023

Chichester and District Model Aero Club: Committee 2023
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Social Rep: Ray Shivjee: socialrep@cadmac.co.uk

Club Evening Thursday 11th May
Fun fly in Fishbourne Playing field small models only

The BMFA are launching an attempt next month to break last year's world record for the most model aircraft airborne at a set moment in time.

This year that moment in time is 12 (Noon) on Sunday 14th May, and CADMAC is registered to take part.

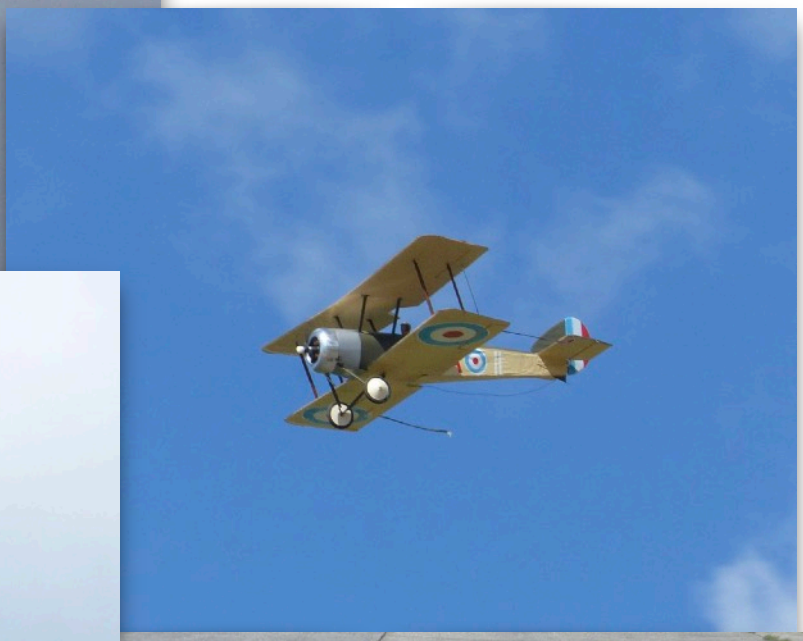
The venue will be Portshole flying site and, as for last year, **there will be a barbecue after the fly-off!**

Ray is organising the barbecue, and the cost of will be met from club funds. To that end end, for planning purposes it will be useful to have an idea of numbers attending. Accordingly, if you are able to attend **please let us know (cadmacsec@gmail.com),** and it would also be useful to know if you would require vegan food.

Needless to say, the more that we can contribute to the record attempt the better (even paper darts count!), so please do plan to come along; family members will be welcome too.

Hopefully the weather will be better that last year, and we can look forward to a great social event as well.

Some of the many photographs taken by David on the rare sunny days in April this year



This item was originally written as a response to some comments on propeller dangers in the now-defunct online magazine "Modelflight". It appeared earlier in a simpler guise in Clear Dope as far back as 2005, and has been on the Southern Area BMFA website for many years minus illustrations. It's offered again as newer members may not have seen it. So far, no feedback has arrived from any source. Too odd-ball?

The Dynamics of Flying Detached Propeller Blades

by Colin Stevens

Intimidated? You should be!

Preamble:
Tony Whiteley, in his item "The Case of the Exploding Propeller" (*Modelflight, July 2008 – Air Space*), states - "... as you know, a broken prop will (or should) always 'fly' forwards if it breaks or becomes detached." I took immediate interest in his comment, because several years ago I was unwise enough to agree to attempt an analysis of what actually happens in these circumstances, for publication in our Chichester CADMAC "Clear Dope" magazine. I did this with no particular expertise in the subject, but just trying to apply experience, logic and basic mechanics. I came to some conclusions that surprised me, but I have to admit, the text was unreadable to some members, and I was left feeling rather like a refugee from Planet Zog.

I came to a slightly different conclusion to Tony, so I thought it worthwhile revisiting the subject. I've reviewed the text, in the hope of making it clearer. I can't promise you an easy read because it's necessary to discuss some fundamental principles in mechanics. See what you think, and if you can correct my errors and/or offer any new perspectives on the topic, then please forward them to Ken Knox.

Objectives:
Being concerned by the hazards involved, I thought it would be interesting to try to define the most likely flight-path of a separated blade. This requires an understanding of its flight dynamics in all aspects. For years I've taken the simplistic and somewhat unfocussed view that because of the enormous centrifugal forces involved, a separated blade must fly out tip-first from the hub.

I also expected it to jump forward under the influence of its thrust. It doesn't take much study to see that my assumptions have been completely wrong, as I hope to show.

A quick assessment soon shows that predicting the whole path of a flying blade is virtually impossible to do with any precision, since the greater part of it is determined by the aerodynamics of an unstable object, and the manner of its separation. What we can do however, is to look at the mechanisms involved and to try to establish some basic principles. It seems that an adequate understanding is just as likely to come from imagination and experience as from academics alone. Since I can make no claims to the latter, this suits me well.

To help see the wood for the trees, it's best to examine mass dynamics first and then see how aerodynamic effects operate on them. Let's give it a try.

Mass Behaviour:
Having been transfixed for years by this notion of enormous centrifugal forces transferring horrifying escape velocities to our errant blade, the penny eventually dropped, and this is very important - the centrifugal force only acts while the blade is attached, and things are quite different after separation. This is where it gets interesting.

STATEMENT: If you believe in Newton's Laws of Motion, and temporarily putting-aside aerodynamic effects, then after separation the blade must progress in a straight line at a velocity and in a direction and manner that it possessed at the instant of separation. It may not sound right, but there are no new forces acting on the blade once separated, and centrifugal force no longer applies. This about-face in my preconceptions surprised me at first, so let's try to see what goes on in more detail. I always find it helpful in these cases to strip a problem down to basics, and then build it up again.

First, let's take a hypothetical untwisted blade of zero pitch, just to diminish the aerodynamic arguments. Let's also say that it has an even mass distribution from root to tip, with its Centre of Gravity (CG) in the middle of the blade. In the case of its exit path from the prop disc, all mass dynamic effects can be assumed to be centred on this CG. If it separates instantaneously, then according to Newton it will proceed in the direction it was going at that instant. So the blade leaves at right-angles to the hub-centre/blade CG line, *i.e.,* at a tangent to the circle described by the blade CG position. Note that if the root extends hypothetically to the centre of the hub, then its exit velocity will be half the tip velocity.

What are the numbers? Let's take a prop of 11" diameter, revolving at 12,000 rpm.

Tip Velocity = RPM x Pi x prop diameter = 12,000 x Pi x 11/12 - ft/min. = 34,558 ft/min = 393 mph.

So the blade exit velocity is about 197 mph - not quite what we had envisaged perhaps, but still fast enough to cause alarm.

If we want to split hairs, we should note that a practical blade extends only from a fracture line placed most likely in the region of the hub periphery, out to the tip. This means that the radius of gyration of its CG is larger than that of the hypothetical blade, so its separation velocity is slightly greater. Looking at an 11" x 5" Graupner Grey prop and eye-balling its mass distribution, one could estimate that the velocity now becomes maybe 204 mph.

It's worth taking a look at the pull-force on the blades before separation -

Centrifugal force on the blade root = mv^2/r = blade mass x square of radial velocity/radius of gyration of the blade mass-centre.

I don't have the Graupner prop, so reverting to my 11" x 7" dia. RAM prop, I find that it weighs about 29g, so estimating the hub as contributing say 20% of the total, then the mass of each blade is approx. 12g. Again eye-balling this prop, one might guesstimate its mass to be centred at 75mm ref the hub centre. Let's see what root force we get with those numbers -

CF = (12/1000) x [12,000/60 x 2 x (75/1000) x Pi]²/(75/1000) = 1421 Newtons (I'm just not comfortable with Newtons) = 320lb-force in proper British measurements - strewth, that's the weight of a small motor-bike on each blade root. I've re-checked that and suddenly I have even more respect for props.

Before we depart from this topic, something even more interesting emerges, and it's of vital significance. Before separation, each blade completes one revolution of its own in space per revolution of the whole prop, centred on a circular path of half the prop diameter. Each blade therefore possesses rotational energy of its own, and if one is suddenly detached that energy remains, causing the blade to revolve about its mass centre at the same RPM as the complete prop, as it follows its tangential path out of the prop disc until aerodynamic forces take effect. This came as another surprise.

I'm sorry if I've made all that hard to understand, but it's worth trying to fix these principles in mind.

Being concerned to get this right, and happier that the readership here might understand my apparent eccentricity better than my neighbours, I've just run a hurried test in the back garden. I twirled-around from one end a thin piece of wood, representing a departing blade, weighted at each end to exaggerate the effect of distributed mass, then released it and noted its behaviour. I'm happy to say that it seemed to perform as predicted above.

Summarising then, my belief is that the blade leaves the prop disc at about half the prop tip speed, and is spinning at the same RPM as the intact prop, until aerodynamic forces take effect.

Starting our engines can put us at risk

- - - and not only starting

Aerodynamic Effects:
So far we've been looking at instantaneous mass effects before aerodynamic forces have a chance to compete. Now let's make it a real blade.

Immediately after separation, we have a fast-spinning blade travelling at high linear speed away from the prop disc, now having a positive angle of attack at the tip, but a very heavy negative angle of attack at its root. Even if this blade were flat like our hypothetical blade, it would be unstable in pitch, like a wing without reflex or stabilising tailplane. Taking the simplest view of what might happen here, at separation the blade is presented leading-edge-on to the prop inrush airflow, which should tilt its axis, starting a wobble (nutation). This action should not be very energetic, since the blade angle of attack is small when in the prop inrush flow. It then revolves rapidly to present its tip to the airflow, which should add a twist on its axis, or if the nutation is severe, stalling end-on into a twisting tumble. Note here that by the time the blade has reached a 90-degree rotation, it is already out of the core of the prop inrush flow and into static air. This will magnify any disturbance. If the revolving has continued, then the trailing edge of the blade is presented next, adding more nutation, followed by the root end, adding more twist. My imagination ends about here, so I've no idea how many revolutions the blade might make before tumbling, but one thing is sure - it must cause it to diverge from its straight exit quickly into an erratic path.

Next, the separation is unlikely to be instantaneous. If the detachment travels progressively across the angled root of the blade, the blade mass will be attached asymmetrically relative to the blade CG for a very short time, and it will be moving. A strong centrifugal effect is still operating at this time, so it must impart a powerful twisting motion during the break and add to the unstable motion in free flight.

Does the pre-separation thrust play any part in throwing the blade forward? For our 11" dia. prop, the forward static thrust is likely to be in the region of 2.5 lb per blade, but its exit path will be dominated by its tangential exit speed and its momentum. I think that when in the practical situation the separation is progressive, the blade's angle of attack will be unpredictable at the instant of separation, adding to the instability described above.

Thus we have a most complex dynamic situation to understand, but none of these mechanisms point to an obvious sustained forward motion.

Is There a Safe Zone?

I believe that the combination of mass and aerodynamic effects is likely to create two somewhat conical volumes in air that can usually be considered "relatively" safer, and these are in front of, and to the rear of the model. I say "somewhat conical" because we don't know how soon the aerodynamic effects are going to throw the blade out of the plane of the prop disc, and with what energy - maybe "saucer-shaped" is a better illustration. There is a major caveat, though! The perceived safety of these volumes applies only if there is no other intervention with the flying blade, i.e. the ground, or model structure. The ground presents itself to a major proportion of the arc of the prop, so a ground-strike carries a high probability, and represents a great threat to bystanders. You could imagine that if the blade is nutating, then it could fly anywhere, so ALL BETS ARE OFF.

I have observed many blade separations over the years, and they were particularly prevalent in the late 40's/ early 50's with the introduction of early plastic props, and to me their paths seemed fairly random. On one occasion I witnessed the penetration of a blade through someone's cheek, when the victim (Mike Gaster, Fairlop, *ca* 1950), whilst stooping over his model from behind, lifted the fuselage slightly to set the dethermaliser, causing the prop-tips to touch the runway. Even from his supposedly safe position, he was hit by a jagged blade-end, which I believe gave his dentist significant extra work.

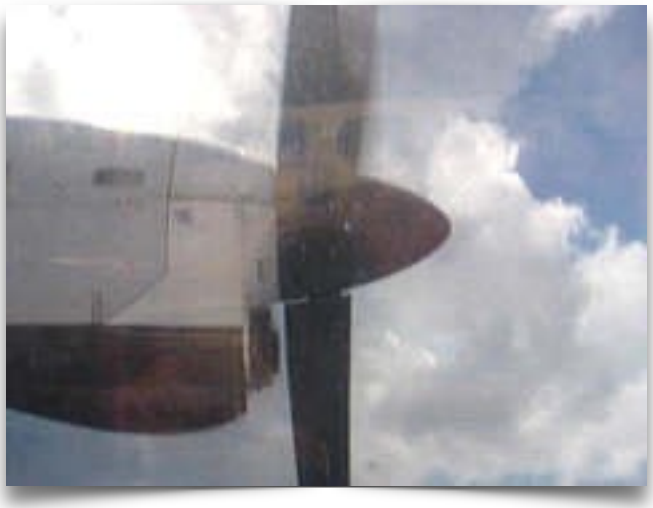
At every outing there is the need to run an engine at full power whilst adjusting it. When I do this, I always prefer to do it over grass, and to avoid hard surfaces. I'm just as wary of other people's models as my own in this situation, and prefer to walk away. Perhaps we should take special note of 4-stroke engines here. I would definitely prefer to take-up station behind those - they frighten me with their tendency to throw the whole prop - nuts, washers and spinner included which, being devoid of the arguments above, do usually fly in a forward direction - that is until the ground intervenes. I would say that these events are more common than blade separations in recent times.

So is it really safer to stand behind the prop? Will a blade always eventually fly forwards? Apart from some shielding offered by the airframe, there doesn't seem much to suggest that it's much safer when seen from these perspectives. Perhaps better minds than mine can decide. Whatever the shaky theory, the final proof probably lies in statistics. The behind-prop position has gained fairly universal acceptance, so it would be very unwise to dismiss it out of hand since it might mirror such statistical evidence. I'm sure we've all formed our own views.

We have to accept that there is NO SAFE PLACE to be when dealing with props running at high speed, apart from at distance. Having examined what is likely to happen to a separated blade, it is up to the reader to take responsibility for his own safety and that of others, so any observations made here are personal to the writer.

I can't develop these arguments any further, and I leave that to those with more knowledge. So, in conclusion To those of you who have stuck with me to the end, I say - thank you for your tenacity and I hope that you have found something to interest you here.

- To those who have found it over-complicated and have skipped straight to the end, I would say - get on and enjoy your flying. None of us really need a dissertation on the short life history of a flying prop blade to know that it's going to hurt if it hits you.



Nice view you have there, Hoskins. I take it that you've not seen that article on flying prop blades?

AirACES©2023
Arun & Chichester Air Enthusiasts Society
www.airaces.org.uk
We are on Facebook Like us on Facebook for news and events.

Arun & Chichester (Air) Enthusiasts Society presents:

"Like Father Like Son – The story of a WW2 Spitfire ace & the son who followed in his footsteps".

A talk by Air Marshal Graeme 'Black' Robertson CBE BA FRAeS FRSA RAF (retd) on Monday 22nd May 2023.

7pm for 7.30pm start at the Chichester Park Hotel, Chichester. PO19 7QL.

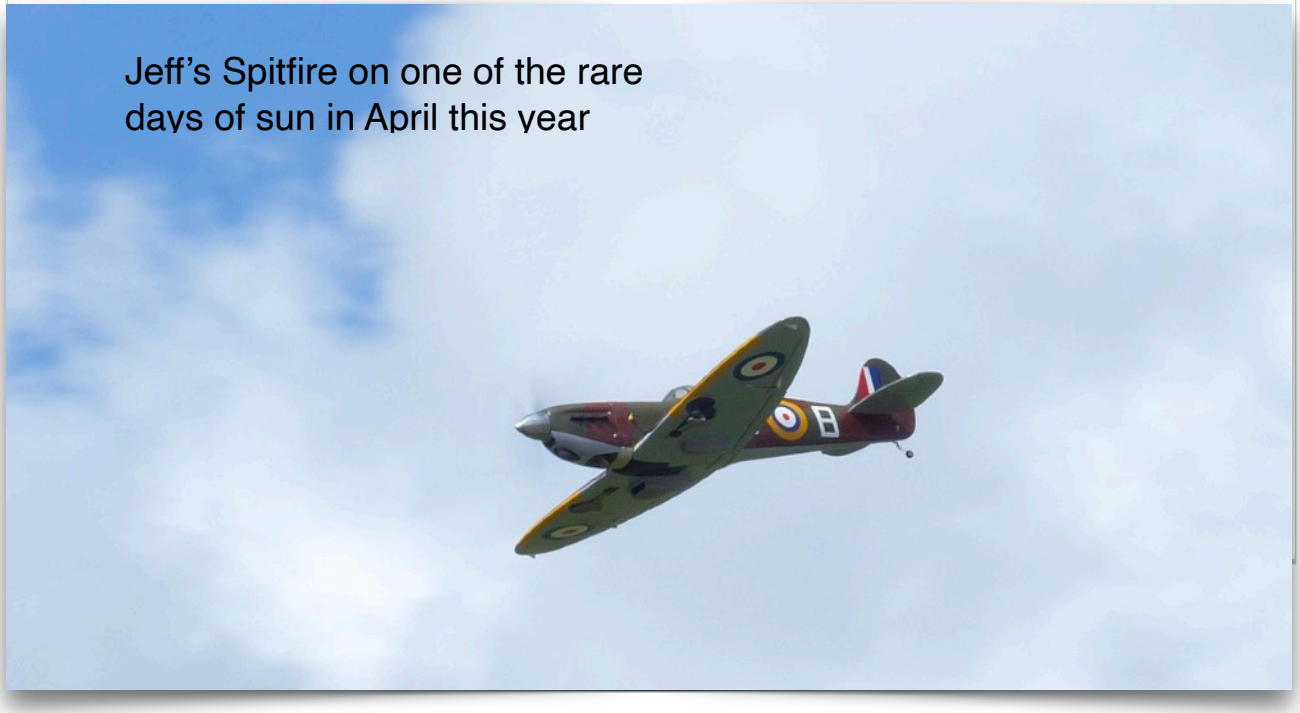
Join Air ACES for an evening in the company of Graeme 'Black' Robertson, an illustrious and famous ex RAF pilot, who flew front line fast jets.

'Black's' father was a decorated Spitfire ace, whose brief wartime career was ended by injury, and 'Black' himself was a Cold War flier who retired in 1998.

Illustrated with stories of their shared experiences he will reflect, not just on parallels a generation apart, but also on the changing face of the RAF.

Entrance for Air ACES members is £5, non-members £7.

Tickets on sale at the door, on the evening.



CAA Registration information,

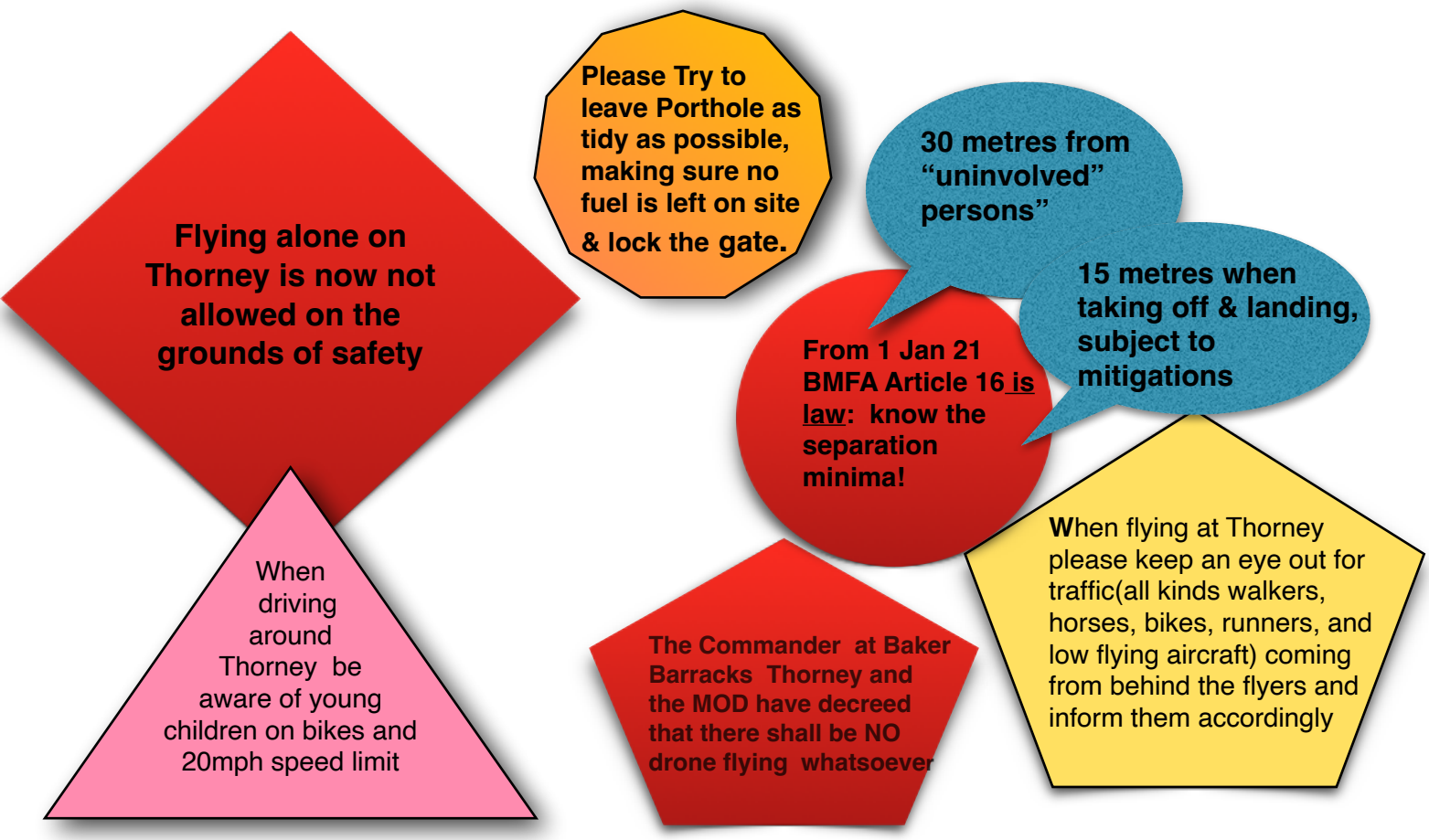
In the early days, a number of members paid for this through the CAA rather than the now more popular route, the BMFA.
I phoned the BMFA this morning to ask if it was possible to switch, and to my surprise they said yes, everyone can pay the £10 through the BMFA.
The possible advantages are:
1. Country Members won't have to deal with the CAA, only the BMFA.
2. Full Members who up to now pay the CAA themselves can switch membership types and become Senior Member (CAA), so the club pays it all.

Regards.
Jeff

The following dates are booked for Fishbourne Field Flying evenings

Thursday 11th May
Thursday 8th June
Thursday 13th July
Thursday 10th August
Thursday 14th September

Date	Day	Location	Event
14th May 2023	Sunday	Portshole	Most models in the air record attempt and BBQ Launch time 12 Noon prompt
18 May 2023	Thursday	Portshole	FunFly Competition
24 May 2023	Wednesday	Portshole	Electric Glider Competition
17 June 2023	Saturday	Thorney	Scale Day
15 July 2023	Saturday	Thorney	Pre-2000 Models Day (Replacement for Chris Foss Models Day in 2022)
26 July 2023	Wednesday	Portshole	FunFly & BBQ
05 August 2023	Saturday	Thorney	Gliding Competition



The club Facebook page is now in its fifth year. It has over one hundred members. It contains many contemporary site reports, and has a wealth of photos in its archives.
Administered by Nick Gates. David Hayward & Ken Knox
Here is the link:-
https://www.facebook.com/groups/Chichesteraeromodellers/