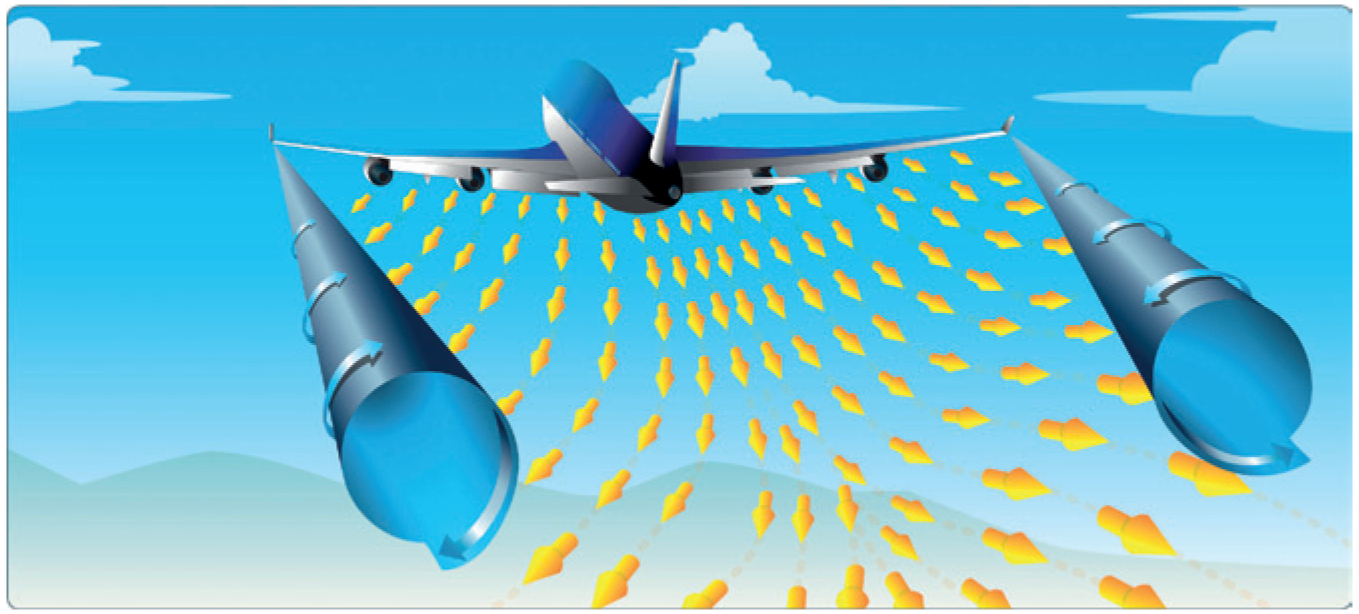
SAFETY

Someone else's wake could be your funeral

Wake turbulence: the effects and dangers by **David Acton** of National Air Traffic Services, abridged by **Steve Uzochukwu**



Above
Figure 1:
Big aircraft create lots of turbulence

WAKE turbulence and its associated hazards have been known for many years, but it was the introduction of Jumbo jets in the 1960s that highlighted the risk even to big aeroplanes operating close to these giant aircraft.

It was recognised that some form of protection should be provided, and the International Civil Aviation Organisation recommended its member states to issue guidance to pilots on the dangers involved and the separation criteria to be applied by the air traffic services.

So how does turbulence affect microlights?

With low weights and lighter wing loadings, microlights are at risk from the turbulence generated by larger aircraft. When they operate around larger types, pilots must be aware of the danger. A close association with even a Cessna 150 can have undesirable consequences.

Before discussing wake turbulence in detail, it is important to understand the different effects of jet blast and propeller slipstream (propwash). These engine-generated effects are a hazard for a comparatively limited distance directly behind the aircraft.

At full power, the exhaust wake speed from a jet engine can typically be 150mph at 61m behind the aeroplane and 50-100mph well beyond this point. This is sufficient to invert something like a Cessna 150, especially if it is broadside on.

For a propeller-driven aircraft of the size of, say, an HS 748, the propwash on full power can reach 40kt about 43m behind the engine. Scaling this effect down, it can be seen that even the propwash from a Cherokee is enough to upset a microlight close behind, so beware.

Wake turbulence (aka wake vortex), is quite different. It is generated by the wings of an aeroplane or the rotor blades of a helicopter and is a direct consequence of producing lift. Wake vortices are present behind every aircraft from the moment the nosewheel lifts off the runway until it touches down again. They are particularly severe when generated by heavy aircraft.

Wake vortices are caused by the pressure differential over the upper and lower surfaces of an aerofoil. With high pressure above and low pressure below the wing, the air tends to flow from the lower to the upper surface in an outward direction along the trailing edge, towards the top of the aerofoil.

This results in two counter-rotating cylindrical air masses (vortices) trailing behind from the wing or advancing rotor blade (Figs 1 & 2).

Typically the two vortices are separated by about three quarters of the aircraft's wingspan, and in still air they tend to drift slowly downwards and either level off approximately 1000ft below the flight path of the aircraft, or on approaching the ground move sideways at a height approximately equal to half the aircraft's wingspan and at a speed of 5kt (Fig 3).

In a light crosswind, the vortices will drift with the prevailing wind direction, and thus one vortex will remain virtually stationary (Fig 4).

Wind shear can also cause the two vortices to descend at different rates, and close to the ground can cause one vortex to rise.

Atmospheric turbulence and high winds close to the ground hasten the decay of wake vortices, so light winds pose a higher risk. In these conditions vortices may stay in the approach and touchdown areas of airfields, or sink to the landing or take-off paths of succeeding aircraft.

Vortex strength depends on the aircraft's gross weight, wingspan, airspeed and configuration. Tests have shown that the tangential speed can be as high as 177kt immediately behind, a rate of roll beyond the control capability of many light aircraft.

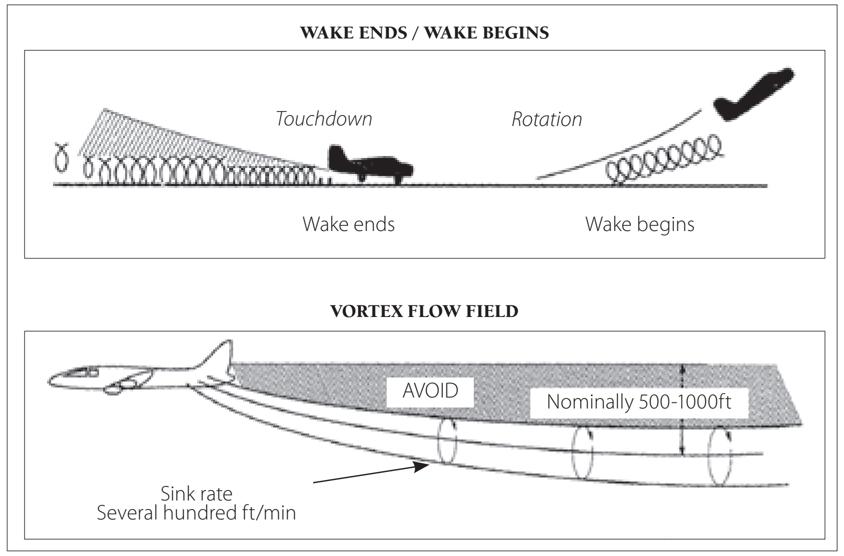
Vortex strength diminishes with time and distance, and atmospheric conditions can hasten the decay. The worst case is a large heavily laden aircraft flying relatively slowly in calm conditions.

Helicopters pose a serious hazard. Apart from the obvious dangers from the downwash created while in the hover, the rotor also generates trailing vortices in forward flight similar to the wingtip vortices created by fixed-wing aircraft. There is some evidence that these vortices are more intense than those of fixed-wing aircraft of similar weight.

The greatest chances of meeting wake turbulence are when flying in the circuit area, especially in the vicinity of a runway. Most wake turbulence incidents happen when a smaller aircraft is approaching to land behind a larger one, and some are fatal.

The obvious solution would be to separate microlight operations from larger types, but this could be too restrictive – even on an aerodrome that has allocated a specific area for microlights, there will always be an interface with other aircraft.

So how do you avoid mishaps? Basically all you have to do is fly above the flight path of the generating aircraft, taking advantage of microlights' superior short-field performance. If your take-off run starts at the same point on a runway as the preceding bigger aeroplane, then the better performance of the microlight will allow you to get airborne in a shorter distance and then turn away to avoid turbulence .



> “The exhaust wake speed from a jet engine can typically be 150mph at 61m behind it, and 50–100mph well beyond

If you are in any doubt, before commencing take-off, wait two minutes following a light aircraft and three minutes following larger types to give time for most of the turbulence to dissipate.

If the takeoff is from an intermediate point on the same runway, allow more time – two minutes following a light aircraft, three minutes following a Dash 8-sized small- to medium-sized turboprop aircraft, and four minutes for larger types (see table overleaf). ▷

Figure 2 (top):
Even small machines leave potential havoc in their wake

Figure 3 (below)
Where it starts and ends – a handy guide

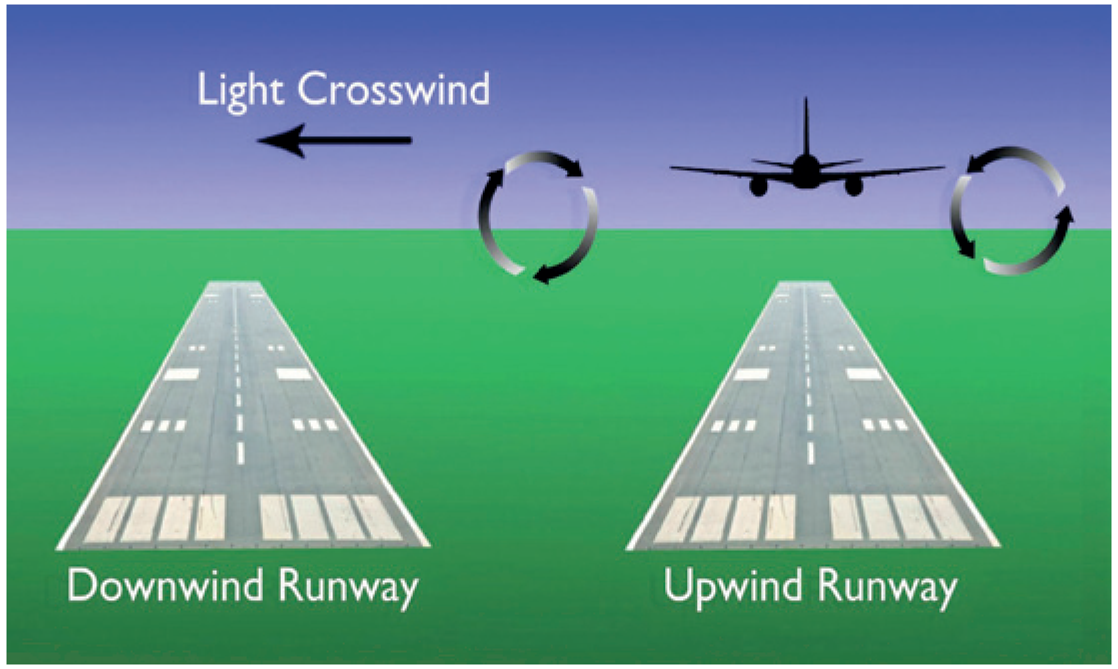


Figure 4:
And it moves sideways as well – just when you thought you were safe

▷ Remember, the bigger the aircraft the more turbulence it creates and the longer it takes to decay. So think in minutes not seconds, especially in calm conditions.

When operating from a parallel strip, always be aware of aircraft on the other runway, since in certain crosswind conditions the turbulence can drift across your intended flight path.

Departing immediately after a much heavier aircraft has landed is risky because wake turbulence will exist until the weight is off its wings and on its wheels. Also, departing from a crossing or intersecting runway can cause serious problems. Large or fast aircraft will often prefer to use the longer runway regardless of the wind direction.

When approaching to land, keep above the flight path of the aircraft ahead, and if this is not possible keep to one side of the approach, allowing for wind direction and thus turbulence drift.

It is advisable to keep clear of any approach path to a busy runway until the final stages of approach, as you could be overtaken by a faster larger aircraft and find yourself in the descending wake vortex (Fig 3).

When operating at an airfield with an ATC service, the controller may instruct you to adjust your flight to take into account the wake vortex separation minima that ATC is required to apply.

The minima will be similar to those recommended in this article, but may also require you to position your microlight a certain distance behind other traffic. You may feel that the instructions are a little restrictive, but remember, the controller is aware of the entire traffic situation and concerned for your safety.

NATS maintains a wake vortex database to monitor incident rates. All suspected wake vortex incidents should be reported immediately to ATC by radio and followed up after landing using form *SRG 1423 Wake Turbulence Report Form*.

The form can be submitted to the CAA as an occurrence report if that would normally be required by *CAP 382*, for example if significant handling difficulties are experienced.

Reports (except those doubling as occurrence reports) should be sent to the Wake Vortex Analysis Team at waketurbulence@nats.co.uk. ☐

- *A longer version of this article was originally printed in* Flightline, *Sept-Oct 1982, on pages 44-47.*
- *The BMAA Technical and Safety Departments would like to point out that while the thrust of this article has been about the dangers of the large and long-lasting effects of wake turbulence from GA/CAT, all aircraft of any size, including microlights, will generate wake turbulence which pilots must make allowance for.*

Weight Parameters: Maximum takeoff mass in kg

	ICAO and Flight Plan	*UK Departures*	*UK Arrivals*
Heavy (H)	≥ 136,000	≥ 136,000	≥ 136,000
Medium (M)	> 7000 & < 136,000	> 40,000 & < 136,000	N/A
Upper Medium (UM)	N/A	N/A	> 104,000 & < 136,000
Lower Medium (LM)	N/A	N/A	> 40,000 & ≤ 104,000
Small (S) (UK only)	N/A	> 17,000 & ≤ 40,000	> 17,000 & ≤ 40,000
Light (L)	≤ 7000	≤ 7000	≤ 7000

The Upper and Lower Medium are considered to form the medium category group and are not split for departure wake turbulence separation. The Airbus A380-800, while falling within the Heavy category, has additional wake turbulence separation criteria applied. In all other respects it is treated as a Heavy category aircraft.

Decision time

Geoff Weighell on dealing with partial engine failures – and he speaks from experience

WE all know what to do when the engine stops, don't we? That gets taught to every student pilot.

Different scenarios dictate different solutions. For example, immediately after takeoff, lower the nose, make sure there is enough speed to control the aircraft to a landing in an area which is pretty well straight ahead, and carry on controlling the aircraft to land with the least harm to people on the ground, your passenger and yourself.

At several thousand feet, there is much more time to go through the selection of a landing area, checks, restart attempts and radio calls. All very defined, with no options to add confusion; done it lots of times.

Partial engine failures, however, throw in an element of choice. Just having to make a decision adds workload, and there is no single answer.

What you do largely depends upon where you are and what your experience is. Do you treat it as a total engine failure, glass half empty, and carry out a forced landing as above, or do you treat it as an engine producing some power, glass half full, and attempt to fly the aircraft home?

I've done both in different circumstances. During takeoff from a mile-long runway in a three-axis microlight, at about 20ft a red warning light on the engine management system lit up the cockpit, and there was no doubt that the best thing to do was to land ahead.

I've done the same thing a couple of times in other aircraft when I've had a stutter or low power on takeoff. You're better on the ground, even if it means perhaps rolling into the hedge, than losing all power and perhaps having a bigger accident in a less suitable place.

Simple checks during the takeoff roll should warn of potential problems. Rev counter showing normal? Sound and feel of the engine normal? Airspeed building as expected? If any are not, just stop.

A more difficult choice is when the partial failure happens in the air. Once I was taking off from Swansea in a flexwing on a very warm day when at 500ft, the Rotax 912 dropped onto two cylinders.

The terrain in front was very, very uninviting, and we were gently descending at the reduced power. I had enough height to turn and land downwind on the runway with quite a strong tailwind.

This is where a partial engine failure adds choice, and I decided to put my hang gliding skills, limited though they were, to the test.

Instead of crashing ahead or landing downwind, I then started to bounce around in the very strong thermals, and actually managed to gain some height and drift downwind at the same time.

More by luck than skill, I was able to make a glide approach to land into wind.

On another occasion, again flying a flexwing, I ▷

Above
Ulster Flying Club instructor Ken Crompton showed consummate skill as always, putting down the Thruster safely after engine failure

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▷ experienced a reduction in power when about two miles from the airfield. I was able to maintain level flight, but couldn't climb.

Should I land or try to get back to the airfield? There were good landing fields below, but there were also good landing fields all the way back to the airfield.

I chose to fly back to the airfield, but on a route that always had a good landing field in a position where, if there was a further power loss or total failure, I could make a safe dead-stick landing. I made it home.

So, two instances of making a choice to stay in the air. Both times I had the option to make a decision, and both times I landed safely on an airfield.

However, the choice is that of the pilot, and there will be times when a partial failure is best treated as a total failure.

I have experienced this as well. Flying with a passenger in a flexwing, there was a significant loss of power when he dropped an article of clothing and it wrapped around the propeller drive shaft.

He had been briefed to keep his hands together and not to touch anything, but he had been fiddling in his pockets and dislodged said article.

Anyway, there was power, but not enough to be relied upon, so I treated it as a total engine failure: selected a field, made my gliding approach and when it was clear that I would land in the chosen spot, turned off the engine and landed. Always treat a sick engine as dead; never rely upon it to help with the landing approach.

These were all instances in microlights, but I have also had two suspect events in helicopters.

During a training flight in an R22, an EGT gauge started flickering as we reached the downwind leg during a circuit detail. The instructor, who had told me that engine failures in helicopters were as rare as hens' teeth, took control and flew directly to a safe landing area. It turned out that during servicing a magneto had not been properly fitted.

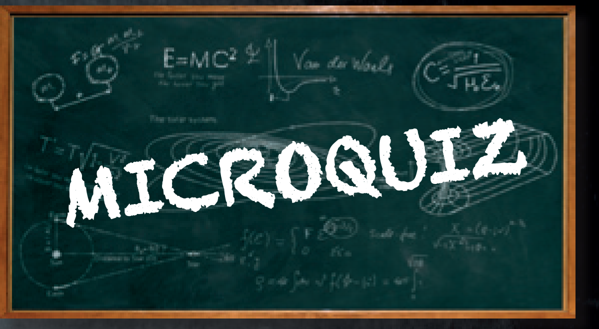
During my GST, the oil pressure gauge started to show some very fluctuating readings, so we treated the aircraft as suffering from an engine problem and again decided to land to investigate. It was a faulty pressure sender.

To summarise, as a pilot one has to make a decision with a partial loss of power or suspected engine problem. What influences the decision will be stage of flight, height available, terrain and your experience.

My choice at Swansea was influenced by the very inhospitable terrain ahead which I judged could result in an accident that might hurt.

My second event choice was influenced by the availability of good landing areas all the way home.

My land-ahead choice and those in the helicopters were made because they were the sensible option. □



1 A MATZ can sometimes have a "stub" or "panhandle" which has the following vertical definitions:
- a Surface to 3000ft
- b 1000ft to 3000ft (QFE)
- c 1000ft to 3000ft (QNH)

2 Which right is conferred on contracting states by Article 16 of the ICAO Convention?
- a The right to force an aircraft from another contracting state, that is crossing its sovereign territory, to land and search it
- b The right to search, without unreasonable delay, an aircraft from another contracting state landing on or departing from its sovereign territory
- c The right to detain the pilot

3 Nearly all weather occurs in the…
- a Troposphere
- b Stratosphere
- c Thermosphere

4 Lenticularis clouds can indicate…
- a Strong thermal activity
- b Calm winds aloft
- c Mountain wave or standing wave is present

5 Wind shear may be best described as…
- a A slow increase of the wind speed above 3000ft
- b A flow of air down the side of a mountain
- c A horizontal or vertical change of wind speed and direction

6 Which of the following arcs does not have the centre of the earth as the its centre?
- a A great circle
- b Small circle
- c Equator

7 An aircraft that decelerates while maintaining level flight will experience…
- a An increase in induced drag
- b A decrease in induced drag
- c No change in induced drag

8 Carbon monoxide poisoning can be caused in flight by…
- a A fuel leak
- b Cracks in the heat exchanger
- c An engine fire

9 When an aircraft rolls wings level after a prolonged turn, the pilot may experience a feeling of…
- a Descending
- b Turning in the opposite direction
- c Decelerating

10 The sudden lifting of a windsock on a summer days at an inland aerodrome may be caused by:
- a A sea breeze
- b Thermal activity
- c An onshore breeze

MF's quizmaster Lawrence Bell is the developer of QuizAero, the online ground school for microlight student pilots, quizaero.co.uk.
Answers on p30

Don't just kick the tyres

Inspect them properly, says **Roger Pattrick**

DO you just glance at the tyres during your preflight, or do you check them properly?

While not the most glamorous part of any aircraft, they certainly deserve your attention during the preflight inspection, as a problem with the tyres can affect your takeoff and landing performance.

Most importantly, check the pressures regularly. These affect the rolling resistance of the aircraft, and also have an important bearing on its suspension.

If they look a bit flat, try pushing the aircraft, then pump them to the correct pressure and try again. It can be quite surprising how much of a difference that makes. Also remember that this is with an empty aircraft, so just imagine the difference once fuelled up and with pilot and passenger. Low tyre pressures make for a much longer takeoff roll.

The tyres are part of the aircraft suspension, and are one of the specific points checked during drop testing as part of the certification process. The tyre must not bottom during this test, for if it does then the loads in the undercarriage increase significantly, which can result in undercarriage failure.

Get the pressure wrong, and the suspension could behave quite differently from what the designer intended. The correct pressures should be in the aircraft operator's manual.

Checking the tyre pressure also gives you an opportunity to examine the tyre's overall condition.

Check that the wheel valve is not snagged within the wheel. If it is, that needs to be corrected, otherwise there is a chance that the valve will either leak or get completely pulled out next time you land, or apply the brakes in anger.

Also, if the valve has been pulled, it's possible that the tyre may have slipped on the rim, which is a sign of low pressure.

A good idea is to add a creep mark to show any tyre slippage. This is simply a dab of white paint overlapping both tyre and wheel; when the two parts become misaligned, the tyre has slipped.

Look at the sidewalls and tread. Any cracking of the tyre wall means it needs replacing. Cracking can be caused by running the wrong pressures, or simply the age of the tyre.

Tyre tread specifically is not always important, other than indicating how much wear there is on the tyre, but do look for cuts or abrasions. Also check the whole tyre for any bulges of the sidewall, and for overall symmetry. These issues are not always obvious if wheel spats are fitted, so take these off periodically


If the sidewalls are cracked, the tyre needs replacing

to permit a proper look. It will also give you the opportunity to check the whole wheel arrangement and give it a good clean.

When replacing the tyres, use the same grade of tyre to ensure that the suspension is not adversely affected. Changing to a different make and size can have a significant effect on the weight and balance of the aircraft: a thin multi-rib tyre can be up to 2kg lighter than a heavily treaded one, making a 6kg difference for the whole aircraft, the equivalent of more than eight litres of fuel.

Finally, wheel balance. On aircraft this does not normally get checked, but it's worth bearing in mind. An out-of-balance wheel can cause vibration, which can be particularly noticeable just after takeoff. A slight vibration may also be caused by a wheel spinning in flight. If you suspect this, try applying the brakes while in the air, this will give you a pointer.

Also, an out-of-balance wheel will tend to settle in the same orientation after every takeoff, meaning that the same part of the circumference touches down first on every landing. In time, this can lead to a bald patch on the tyre. □

" A thin multi-rib tyre can be up to 2kg lighter than a heavily treaded one – adding up to the equivalent of more than eight litres of fuel