Caution Wake Turbulence

If you fly at Jandakot in the morning, you will usually be using Runway 06L or R. When that's the case, the ATIS will often include "Due Perth duty runway 03, caution wake turbulence." The ILS approach for 03 at Perth starts at 3000 ft just east of Jandakot, so while a wake turbulence encounter is unlikely, it's clearly enough of a threat for ATC to always include it on the ATIS when Perth is using Runway 03. So what exactly is it, how does it affect an aeroplane, and how do you avoid it?

CASA rewrote their AIC on wake turbulence in 2017, and produced a very good description of it in AIC H30/17.

What is it?

Everyone learns in basic aerodynamics that the air pressure under a wing is greater than on top of the wing. While this has next to nothing to do with how a wing produces lift (contrary to what many textbooks will tell you), it does help in explaining wake turbulence. As the air tries to move from the area of high to low pressure, it spills around the wingtips, creating vortices. As seen from behind, these are clockwise behind the left wing and anticlockwise behind the right. (For the purpose of this discussion, we'll leave helicopters out of it, and I'll also assume you haven't always had a digital watch and you know which way clockwise is!)

In 1972 a DC-9 crashed in Forth Worth, Texas, when it was caught in the vortices of a DC-10. It caused the US FAA to create new rules for separation from heavy aircraft, but it remains a good illustration that wake turbulence can bring even a big jet down.

Characteristics of wingtip vortices

Wake turbulence starts at rotation and ends at touchdown. How strong it is depends on a few factors, including the aircraft's weight, wingspan, configuration and speed. As a rule, vortices are strongest if the aircraft is heavy, clean and slow. Logically enough, the heavier the aircraft, the stronger the vortices. There are exceptions, a notable one being the result of the crash of a business jet behind a 757 in California in 1993, which resulted in the 757 being classified as "heavy" for the purpose of wake turbulence separation if it's the leading aircraft. With flaps and other high-lift devices such as slats out, more air flows the way you want it to – backwards along the wing – and less of it flows laterally, which means vortices are stronger when the wing is clean. And you will of course remember from your aerodynamics courses that parasite drag is highest at high speed and induced drag, which is the drag produced as a result of lift production, is highest at low speed. Vortices are a manifestation of induced drag.

Vortices decay more slowly in calm air, and separation standards are based on not having wind and turbulence to disperse them. On the runway they also move sideways at a few knots (2 or 3 or 5 depending on which book you're reading), so a light crosswind will hold the into-wind vortex on the runway for longer.

To experience a severe roll in a vortex, you need to be almost directly following the aircraft generating it. If you are following an aircraft that is generating vortices and you end up in one of them, the effect is typically a small roll in one direction as you first encounter a vortex, then a much worse roll in the direction of the vortex once you are in the middle of it. If you cross a vortex at right angles, there won't be any roll, but you could expect brief turbulence.

What should you do if you encounter a vortex?

If you encounter a vortex, you can make it worse or you can make it better. If you react to the initial roll by applying opposite aileron, the main rolling motion in the vortex will be compounded by your roll input. If an aircraft's flight manual has a procedure for dealing with wake turbulence, it will probably be along the lines of:

- Wait,
- Resist the urge to react immediately,
- Don't use rudder,
- Once clear of the turbulence, recover from any unusual attitude.

On 12th November 2001, American Airlines Flight 587 took off from JFK Airport in New York, and crashed shortly after take-off, killing all 260 on board as well as 5 people on the ground. Initial speculation on the cause included terrorism, since it was only two months after the September 11 attacks. However, the NTSB determined that while the initial factor was the wake turbulence from a JAL 747 that had taken off less than two minutes earlier, the determining factor was the FO's excessive use of rudder, which led to excessive forces on the fin and caused it to separate.

How do you avoid wake turbulence?

As always, prevention is better than cure. In controlled airspace, ATC provides wake turbulence separation standards for VFR aircraft taking off, but they do not provide it for VFR aircraft in flight. What that means is they'll make sure you don't run into all the paying passengers, but they may not keep you far enough apart to account for wake turbulence. "Caution wake turbulence" from ATC generally means the spacing is less than the ATC separation minima. But in uncontrolled airspace you are on your own, so knowing the pilot actions to avoid vortices on take-off, as well as in flight and on approach, is relevant when you're competing for uncontrolled airspace with heavier aircraft, such as landing behind the Fokker 100 at Albany.

To keep it simple, let's cover the standard tips for avoiding wake turbulence when you're behind the offending aircraft. If you're departing behind a larger aircraft:

- Note its rotation point, then consider how far the vortices will move with the wind. A 10 kt headwind means the air is moving a mile every 6 minutes, which means the vortices will move about 300 metres downwind per minute.
- Plan to rotate before the larger aircraft's rotation point, or where you expect the vortices to have moved to with the wind.
- Climb above the larger aircraft's flight path.

- If you can't do that (and let's face it, your average light aircraft is not going to outclimb your average passenger jet or turboprop), wait until the vortices have dispersed. How long should you wait? More on that in a moment.

If you're landing behind a larger aircraft, stay above its flight path and land beyond its touchdown point.

If you're landing behind a larger aircraft taking off, it will come as no surprise that the standard advice is to note the rotation point, or more importantly, the point where you expect the vortices to be, and touch down well before that point.

Wake turbulence categories and separation minima

The weight categories for wake turbulence are:

- SUPER – A380 and Antonov AN225;
- HEAVY – 136,000 kg (300,000 lb) or more;
- MEDIUM – 7,000 to 136,000 kg;
- LIGHT – the rest of us.

There are very few exceptions, such as the 757. As mentioned above, it's MEDIUM when it's the following aircraft (the heaviest 757's are about 120 tonnes), but HEAVY when it's the leading aircraft.

The separation minima that ATC are required to apply are in AIC H30/17, and in AIP ENR 1.4. For take-off and landing the minima are based on time, not distance, and typical numbers for a LIGHT aircraft following a MEDIUM category aircraft are:

- Departure using full length ie. from the same point as the MEDIUM – 2 minutes,
- Arrival – 3 minutes.

Obviously they're sensible numbers when you're applying your own separation, so if you're arriving in Geraldton behind the 70-seater, allow at least 3 minutes between his landing and yours, and don't line up within 2 minutes of his take-off.

For a much more detailed description and list of hints, including for landing on crossing runways or crossing behind a departing larger aircraft, have a look at the circular: http://www.airservicesaustralia.com/aip/current/sup/a17-h30.pdf.