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Aviation Safety Information Leaflet (ASIL)
AIRCRAFT WAKE TURBULENCE

Federal Public Service
Mobility and Transport

.be

1. INTRODUCTION

1.1 This ASIL (Aviation Safety Information Leaflet) provides basic information on wake vortex behavior, alerts pilots to the hazards of aircraft wake turbulence, and recommends operational procedures for pilots to avoid or deal with wake turbulence encounters.

2. WHAT IS WAKE TURBULENCE

2.1 All aircraft generate wake vortices, also known as wake turbulence. When an aircraft is flying, there is an increase in pressure below the wing and a decrease in pressure on the top of the aerofoil. Therefore, at the tip of the wing, there is a differential pressure that concentrates the roll up of the airflow aft of the wing tip. Limited smaller vortex swirls exist also for the same reason at the tips of the flaps. Behind the aircraft all these small vortices mix together and roll up into two main vortices turning in opposite directions, clockwise behind the left wing (seen from behind) and anti-clockwise behind the right wing (see Figure 1).

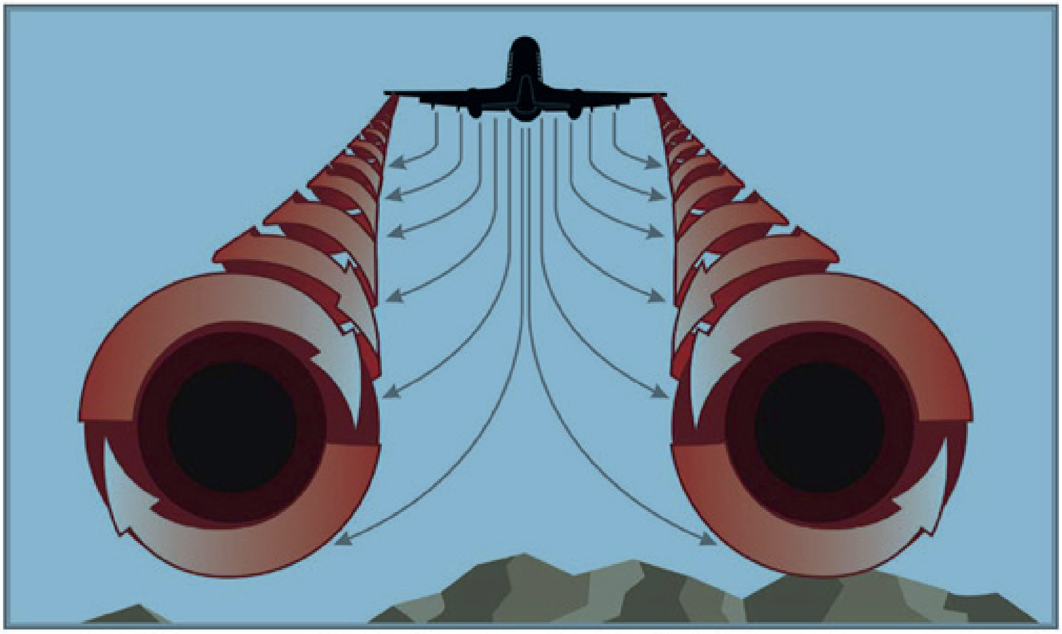

Figure 1: Development of wingtip vortices

2.2 What makes wake vortices particularly dangerous is that they can persist some distance behind, and below, the aircraft generating them. En route, an aircraft's wake can extend for more than 25 nm, and descend very slowly downwards and outwards – levelling off around 1000 ft below the generating aircraft.

2.3 The vortices are generated the whole time an aircraft is airborne. While generally only a few meters in diameter, they can be very intense, depending on the aircraft's weight, wingspan, configuration and attitude. Size really matters, though there are exceptions: some aircraft, such as a Boeing 757, have a reputation for producing particular intense vortices.

3. SPECIFIC EXAMPLE: APPROACH PATHS OF BRUSSELS AIRPORT

3.1 Brussels Airport is frequented by aircraft of the MEDIUM and the HEAVY (i.e. aircraft of type A330/A340, B777, MD11 and B747) wake turbulence category. Moreover, since recently also the Airbus A380 visits the airport, which has the wake turbulence category SUPER.

3.2 A large number of GA pilots flying uncontrolled VFR in Class G airspace are flying extremely close to the lower limit of the Brussels TMA1 (Class C). The TMA1 starts at 1500ft QNH, while many Brussels approach procedures have a horizontal (level) part defined at 2000ft QNH. In the worst case this means that such a wake turbulence category SUPER as mentioned above could be flying just 500ft above a small GA airplane (see Figure 2).

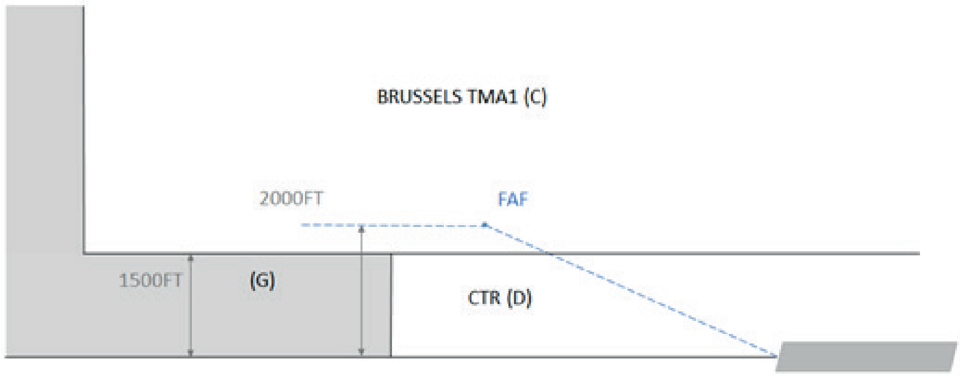

Figure 2: Situation airspace below Brussels TMA1 1

3.3 Therefore do not make full use of the upper limit of Class G airspace. Or at least try to avoid crossing the approach paths at the upper limit of class G airspace within 15 NM distance from the threshold of the active runway(s) and try to stay upwind. The danger posed by wake turbulence is always present in these areas. Even if you cannot see an airliner, wake turbulence can remain up to several minutes after the plane has passed.

3.4 When you plan to fly close to the border of a CTR, it is considered a good practice to listen out the ATIS (on the radio or prior by phone) to inform you on the active runway(s) for landings.

4. WAKE TURBULENCE ENCOUNTERS ENROUTE

4.1 How does it feel to encounter a wake vortex

4.1.1 In most cases the effect of the vortex is mainly felt in roll. Consider the case of an aircraft entering laterally in a vortex, which is the most frequent situation. Assuming the lead aircraft is crossing the track of the following aircraft from left to right, the following aircraft will enter the right vortex of the leading aircraft on the following aircraft's left side. Seen from behind, this vortex is rotating anticlockwise. When the left wing of the follower first enters the vortex, there is on this wing a local angle of attack increase and therefore the lift becomes higher than on the right wing. The initial roll motion is therefore to the right. Then, when the aircraft is in the middle of the vortex, it will be subjected to the full strength of the vortex and roll in the same direction as the vortex, to the left (see Figure 3). This is the main rolling motion that creates the strongest roll acceleration.

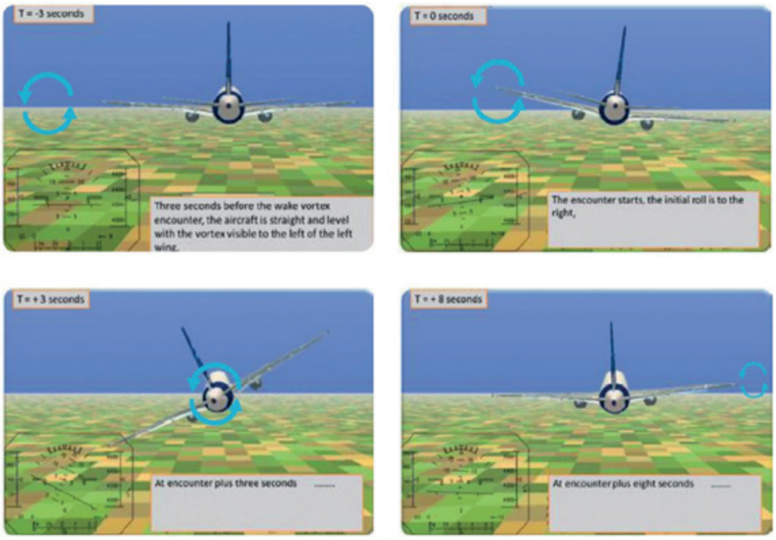

Figure 3: Aircraft behavior in a wake vortex encounter

4.1.2 The typical signature of a severe encounter is an initial small roll in one direction followed by a much more significant roll in the other direction. When in cruise, the roll motion may be associated with significant load factor variations.

4.2 Effect on the trajectory of the follower

4.2.1 To experience a severe roll encounter, it is necessary for the follower to have a trajectory with a small closing angle with the vortex. However, if this angle is too small, the aircraft will be smoothly ejected from the vortex (due to the initial roll in the example above). When perpendicular, there will be no rotation, and any encounter will be a very brief but sharp turbulence effect. To experience a severe encounter, the most critical angle between the trajectory of the follower and the vortex is around 10 degrees.

4.3 Duration of an encounter

4.3.1 A severe encounter, as described above, where the trajectories of both aircraft have around 10 degrees, typically lasts around 4 to 6 seconds. It is not possible to remain for a long time in a severe vortex as the rotating airflow on the wing and on the fin, will eject the aircraft from the vortex. Recent Airbus flight tests showed that a large sideslip angle is established. Therefore, a vortex should not be the cause of long duration turbulence during normal flight.

5. WAKE TURBULENCE ENCOUNTER ENROUTE – PILOT ACTIONS

5.1 When an encounter occurs, the pilot's actions can lessen or aggravate the situation.

5.2 Considering the way a vortex acts on an aircraft, if the pilot reacts at the first roll motion the natural correction is to roll to the left. When in the core of the vortex, the main roll motion to the left will then be amplified by this initial piloting action. The result will be a final bank angle greater than if the pilot had not moved the controls.

5.3 In addition, in-flight incidents have demonstrated that the pilot inputs may exacerbate the unusual attitude situation with rapid roll control reversals carried out in an "out of phase" manner.

5.4 A pilot's best response to a wake turbulence encounter is to follow the recommended procedure from the aircraft manufacturer. Refer to the specific Aircraft Flight Manual for further guidance.

5.5 In the absence of specific aircraft manufacturer procedures, pilots should exercise caution with pilot control inputs, especially avoiding abrupt reversal of aileron and rudder control inputs. If altitude and conditions permit, it may be better to allow the aircraft to transition through the wake and then recover from any resultant unusual attitude, rather than aggressively trying to control the aircraft during the wake encounter.

5.6 As a rule of thumb:

When encountering serious wake turbulence enroute:

- **INITALLY JUST WAIT**
- **RESIST THE URGE TO IMMEDIATELY MOVE THE CONTROLS**
- **DO NOT USE THE RUDDER TO COUNTERACT THE EFFECTS**

Only once clear of turbulence : start recovery control inputs.

5.7 If the autopilot is engaged and remains engaged, it may be better to allow the autopilot to recover from the wake vortex encounter rather than disconnecting the autopilot and using manual control inputs. However, be prepared to assume manual control of the aircraft if the autopilot disengages.

5.8 Rapid and gross side-to-side deflection of the rudder in response to a wake turbulence encounter can give rise to very large forces on the fin that may exceed structural limits. It is important to be aware that use of the rudder does not reduce the severity of the encounter nor does it improve the ease of recovery.

5.9 The regulation imposes that the pilot in command has to keep his/her safety belt fastened during the whole flight. In addition to that it is a good practice to ensure that each passenger on board also has his/her safety belt properly secured when flying at altitudes below 2000 ft AGL and not only during take-off and landing.

Questions? Suggestions?
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