U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Aircraft Wake Vortex Encounter Risk Mitigation

Date: DRAFT

Initiated by: AFS-400

AC No: 90-23H

Change:

This advisory circular (AC) presents basic information on wake vortex characteristics, alerts pilots to the hazards of aircraft wake vortex encounters, recommends operational procedures to avoid wake vortex encounters, and provides wake vortex encounter guidance. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

Lawrence Fields
Executive Director, Flight Standards Service

CONTENTS

Paragraph **Page**

List of Figures

1 **PURPOSE OF THIS ADVISORY CIRCULAR (AC).** This AC presents basic information on wake vortex characteristics, alerts pilots to the hazards of aircraft wake vortex encounters, recommends operational procedures to avoid wake vortex encounters, and provides wake vortex encounter guidance. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies. This AC contains information that is administrative in nature.

2 **AUDIENCE.** This AC is intended to provide guidance on wake vortex encounters to student pilots, certificated pilots, flight instructors, training providers, and pilot examiners.

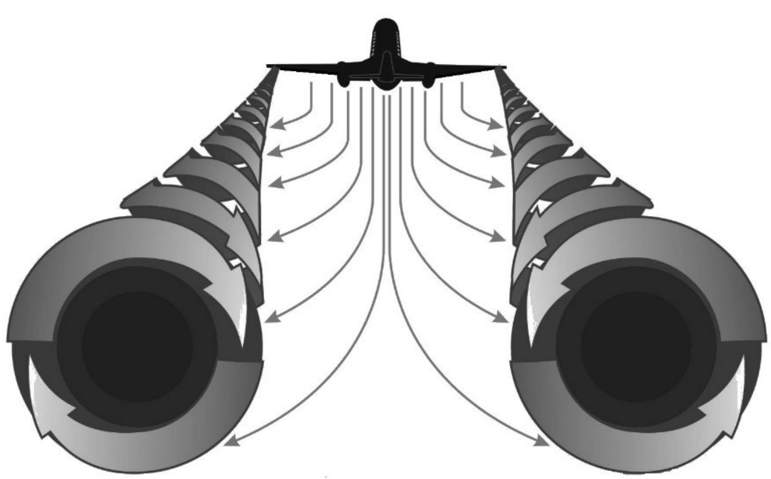
3 **WHERE YOU CAN FIND THIS AC.** You can find this AC on the Federal Aviation Administration's (FAA) website at https://www.faa.gov/regulations_policies/advisory_circulars and the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

4 **WHAT THIS AC CANCELS.** AC 90-23G, Aircraft Wake Turbulence, dated February 10, 2014, is canceled.

5 **SUMMARY OF CHANGES.** This AC has been reorganized to assist pilots in effective Risk-Based Decision Making (RBDM) as it relates to wake vortex encounters.

6 **INTRODUCTION.** Wake vortices are masses of counter-rotating air created as a byproduct of the generation of lift. Every aircraft that uses a fixed or rotary airfoil to generate lift in flight creates wake vortices of varying initial strength and persistence. Wake vortices from similar or larger-sized generating (lead) aircraft are a hazard to encountering (following) aircraft that may vary from light turbulence encounters to a loss of control in flight (LOC-I) or in-flight breakup accident. The purpose of this AC is to discuss the behavior, risk, and mitigation techniques for wake vortices. See Figure 1 below.

Figure 1. Wake Vortices



6.1 Pilot Role in Wake Vortex Encounter Mitigation. Pilots have the ultimate responsibility for the safe operation of their aircraft, including in regard to wake vortex encounter avoidance and mitigation. Pilots arriving and departing from uncontrolled airports, flying in uncontrolled airspace, or accepting a clearance for a visual approach are accepting the sole responsibility for wake vortex encounter mitigation. Pilots are advised to:

6.1.1 Learn to visualize the behavior, location, and movements of wake vortices from similar or larger-sized generating aircraft.

6.1.2 Proactively adjust their flightpath or delay operations as needed to avoid or mitigate a wake vortex encounter.

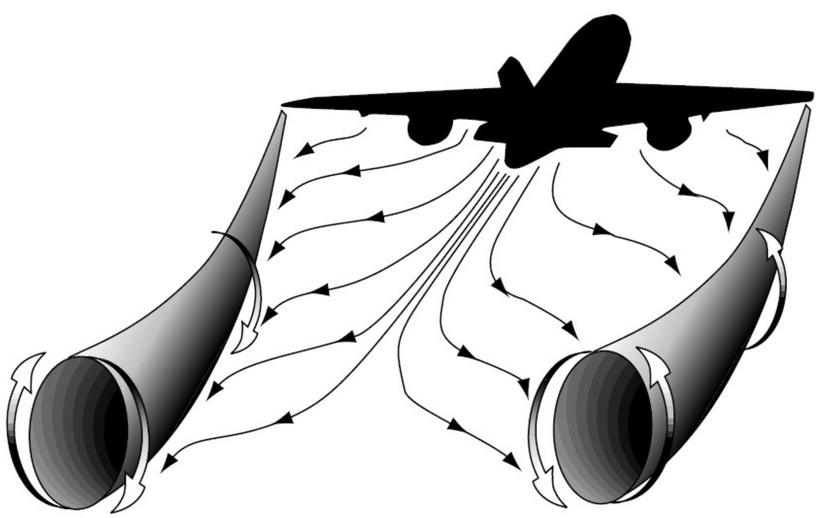
6.1.3 Be alert for possible wake vortex encounters, particularly during takeoff, approach, and landing operations.

6.1.4 Follow the wake vortex encounter avoidance and mitigation guidance contained in this AC, applicable aircraft manuals, and the Aeronautical Information Manual (AIM).

7 WAKE VORTEX CHARACTERISTICS.

7.1 Wake Vortex Generation. Lift is generated by the creation of a pressure differential above and below the airfoil (wing or rotor). Higher-pressure air below the airfoil seeks to equalize the differential by moving towards the lower-pressure air above. This movement of air rolls upwards and inwards to form two counter-rotating cylindrical vortices trailing behind the airfoil. The disturbed air surrounding the wake vortices is the wake flow field. Studies conducted during approach and landing operations have not shown a discernible difference between the wake vortices of aircraft with and without winglets. See Figure 2 below.

Figure 2. Wake Vortex Generation

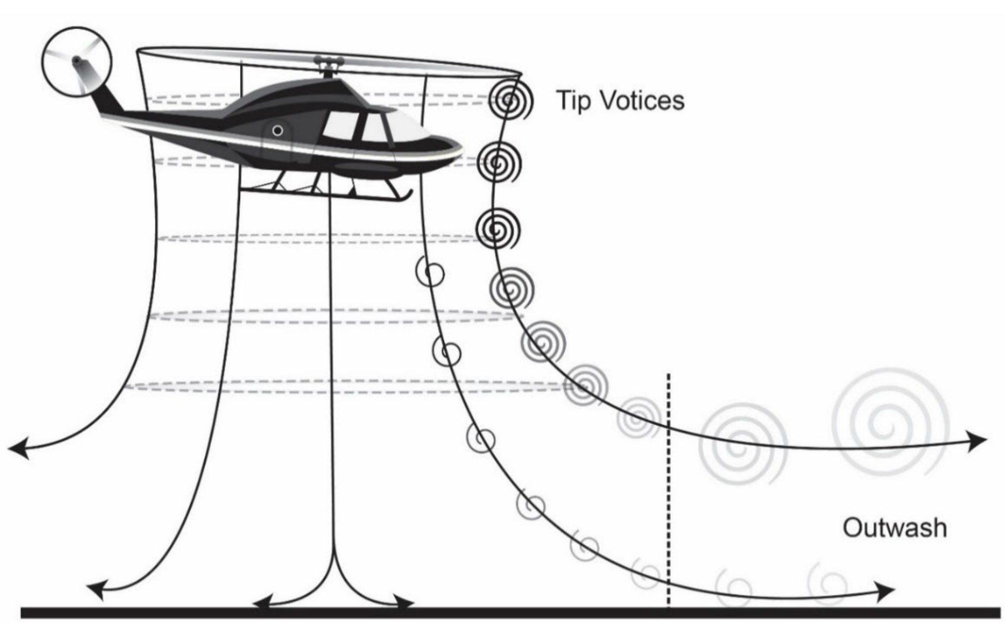


7.1.1 Airfoils generate wake vortices whenever lift is produced. In airplanes, lift and wake vortices increase in strength substantially from the rotation point (point where the airplane begins to lift off the surface) to the touchdown point (point where the aircraft returns to the surface) on landing. See Figure 3 below.

Figure 3. Touchdown and Rotation Points

7.1.2 The spinning rotor blades in helicopters and other rotorcraft generate a downward column of air called downwash. When a rotorcraft is in ground effect, the downward column of air interacts with the surface and produces outwash, a turbulent lateral movement of air. When a rotorcraft is in a hover in ground effect, outwash propagates in all lateral directions. Tip vortices from the rotor blades are pushed down helically, coalesce as they approach the surface, and are driven outwards by the outwash intensifying the turbulent airflow. Downwash and outwash may damage aircraft below and in the vicinity of rotorcraft operations. Outwash may produce adverse effects on nearby aircraft operations, including turbulence and induced roll moments. Outwash is hazardous to aircraft departing or arriving near the operation of a rotorcraft. Airborne rotorcraft producing downwash, outwash, and wake vortices have created scenarios where a similar or smaller-sized airplane, attempting to arrive or depart an adjacent runway, have suffered a LOC-I accident. See Figure 4 below.

Figure 4. Rotorcraft Downwash and Outwash



7.1.3 When a rotorcraft hovers into the wind or accelerates from a hover, the horizontal flow of air modifies the downwash. As the rotorcraft continues to accelerate, the rotor blades move into less disturbed air and the downwash transitions to counter-rotating vortices that have similar behaviors (i.e., wake decay rate, wake drift and movement) as wake vortices created by fixed-wing aircraft. When a rotorcraft decelerates, the same forces are exerted in the reverse sequence. In terminal operations where a rotorcraft is arriving or departing, there will be a combination of wake vortices, downwash, and outwash. See Figure 5 below and Figure 6, Rotorcraft Approach to an Airport.

Figure 5. Rotorcraft Accelerating From a Hover

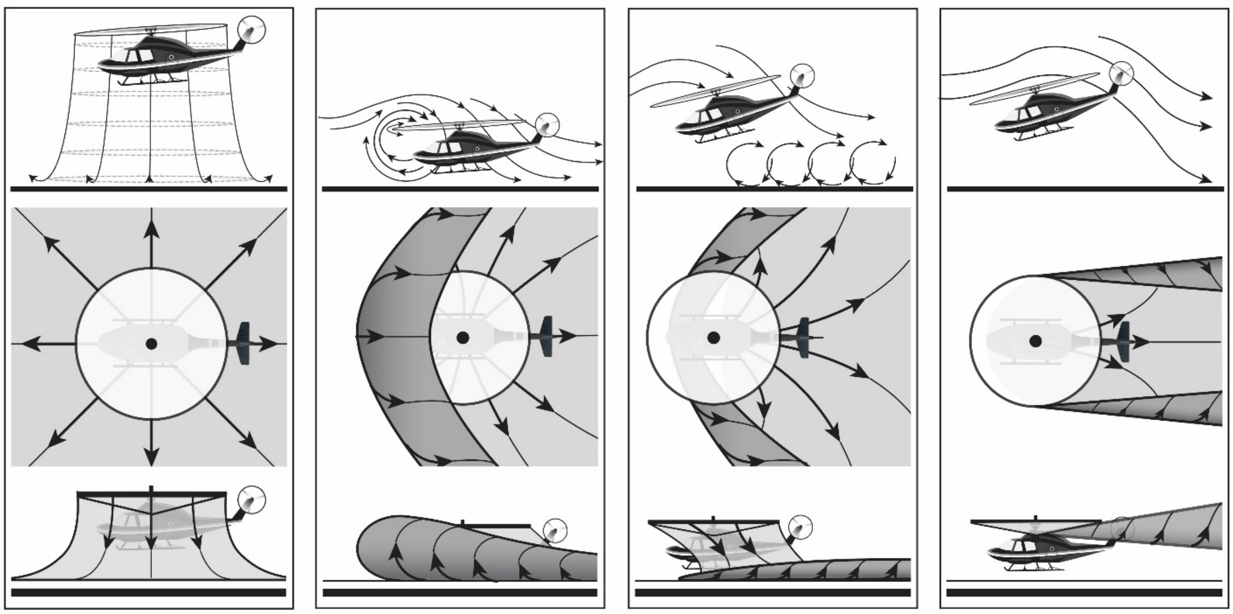
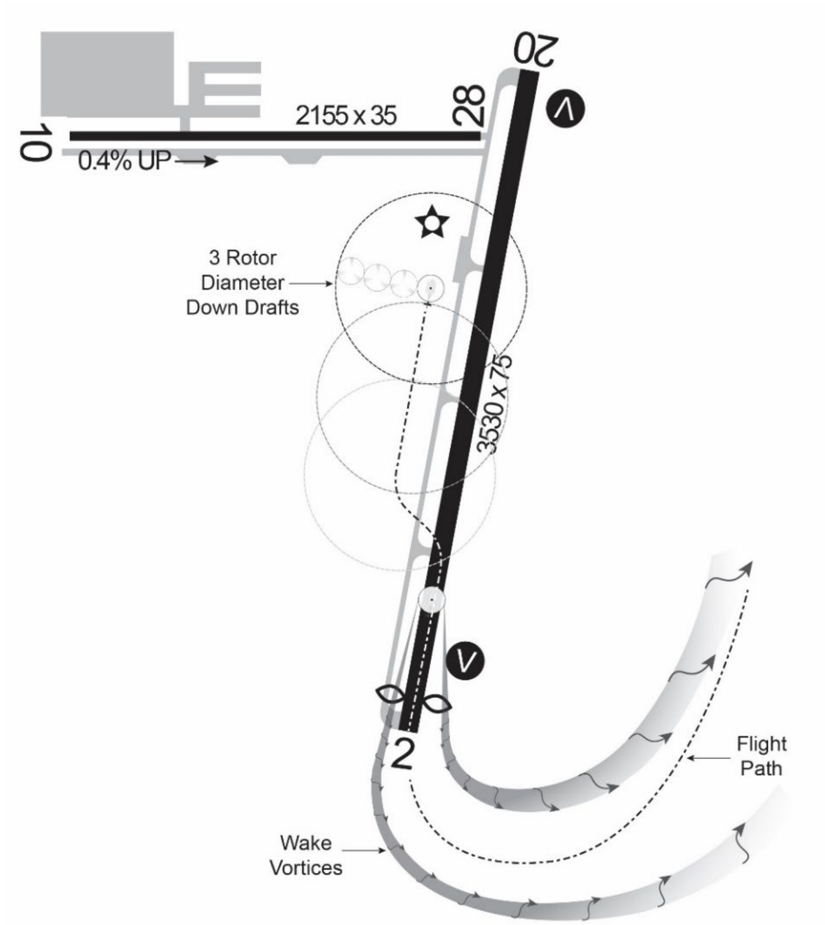


Figure 6. Rotorcraft Approach to an Airport



7.2 Wake Vortex Strength. The initial strength of wake vortices (strength of the wake vortices directly after wake generation) is influenced by the current weight, angle of attack (AOA), airfoil shape, wing loading (or disk loading), and wingspan (or rotor diameter) of the generating aircraft. Wake vortices are the strongest in the immediate vicinity behind and below the generating aircraft and dissipate over time. The wake age (time elapsed since wake generation) influences the residual strength (remaining intensity of the wake vortices at a given time after generation).

7.2.1 The greatest initial strength of a wake vortex nominally occurs when the generating aircraft is at a relatively high AOA, heavy, and in a clean configuration (e.g., landing gear and wing flaps retracted).

Note: In the terminal environment, the greatest initial strength of a wake vortex occurs when the generating aircraft is at relatively low speeds.

7.2.2 "Super" (e.g., Airbus A380) and "Heavy" (e.g., Lockheed C-5) aircraft, as defined by FAA Order JO 7360.1, Aircraft Type Designators, have been shown to produce high initial strength wake vortices that take longer to diminish due to the higher weight and longer wingspan of these aircraft when compared to aircraft of smaller categories.

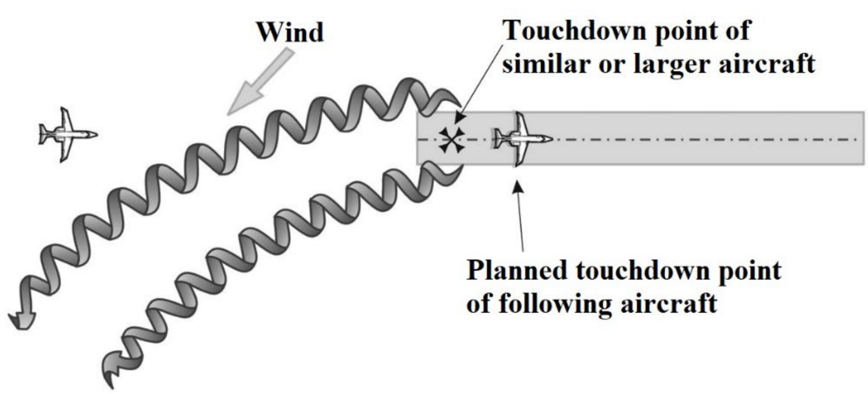
7.3 Wake Vortex Decay. The decay rate and movement of wake vortices is influenced by the initial strength of the wake vortices, distance between the pair of wake vortices and atmospheric conditions, including lateral wind speed and direction, vertical wind speed and direction, atmospheric turbulence, air density, and airmass stability. Considering a fixed wake vortex decay rate, time becomes the key variable. As more time passes since wake generation, the residual strength of a wake vortex diminishes.

7.3.1 The conditions that are the most conducive for wake vortex longevity (low wake decay rate) are light winds, low atmospheric turbulence, and a stable airmass. The wake vortex decay rate will increase with an increase in wind, turbulence, or a decrease in airmass stability.

7.3.2 The extension of landing gear, flaps, or other wing configuring devices will change the wake vortex characteristics of an airplane. The extension of flaps reduces the separation between vortices and hastens wake decay. The extension of landing gear hastens the decay of vortices by creating turbulence.

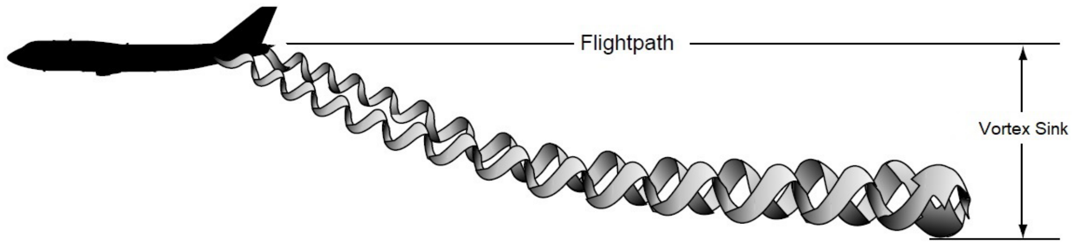
7.4 Wake Vortex Movement. Wake vortices sink behind the generating aircraft and are influenced by the surrounding airmass characteristics including vertical and horizontal winds that transport the vortices. Wake vortices tend to remain spaced apart slightly less than the wingspan (or the outboard edge of the flaps when deployed) of the generating aircraft until within ground effect where wake vortices laterally separate. See Figure 7 below.

Figure 7. Wake Vortex Drift



7.4.1 Wake vortices will have the highest sink rate in the immediate vicinity behind the generating aircraft. Wake vortices from large aircraft may descend initially at a rate of several hundred feet per minute. The sink rate of the wake vortices will diminish as the wake age increases. Generally, for large generating aircraft, wake vortices will level approximately 500 to 900 feet below the flightpath of the generating aircraft. See Figure 8, Wake Vortex Sink.

Figure 8. Wake Vortex Sink

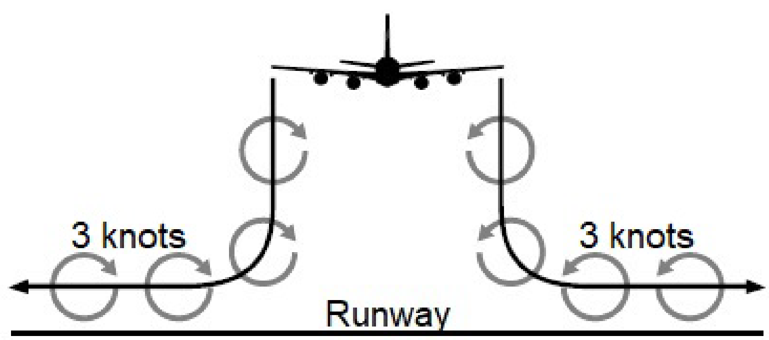


7.4.1.1 Wake vortices from "Heavy" and especially "Super" aircraft (aircraft with high initial wake vortex strength) may descend more than 1,000 feet before decaying to a less perceptible residual strength.

7.4.1.2 After initially descending, ambient thermal lifting, vertical winds, stratification, and interaction with the surface may cause wake vortices to stop descending or even rise. This rising effect is commonly referred to as wake bounce and may result in wake vortices rising into the glidepath of an approach.

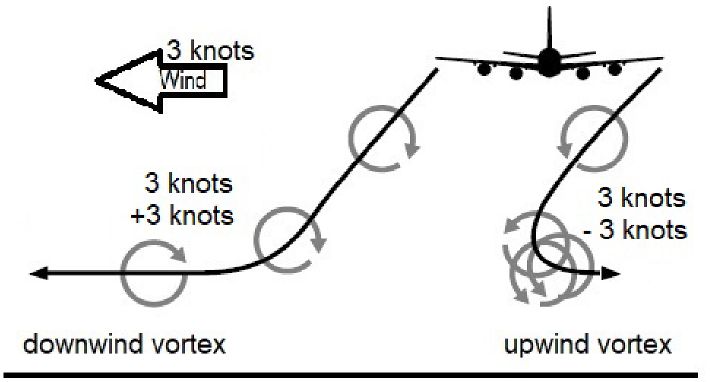
7.4.2 When wake vortices are in ground effect (less than approximately a wingspan of the generating aircraft from the surface), the wake vortices tend to diverge laterally. In a zero-crosswind scenario, the wake vortices diverge laterally at a speed of 2 to 3 knots. See Figure 9 below.

Figure 9. Wake Vortex Drift With Zero Crosswind



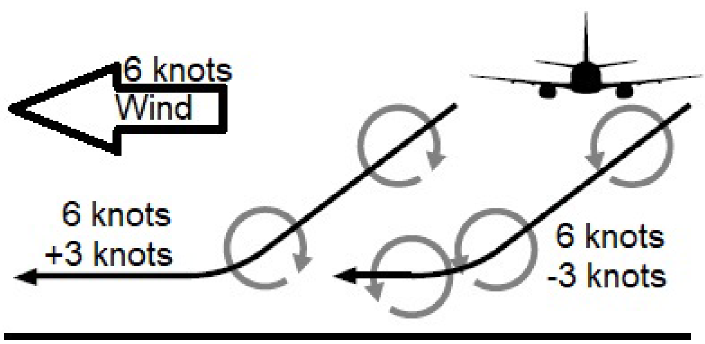
7.4.2.1 When wake vortices are in ground effect, a light crosswind of approximately 3 knots will decrease the outward lateral movement of the upwind vortex and increase the outward lateral movement of the downwind vortex. This action results in the upwind vortex remaining near the glidepath and runway longer and displacing the downwind vortex at an increased rate. The downwind vortex may influence operations on an adjacent runway. See Figure 10, Wake Vortex Drift With 3 Knots of Crosswind.

Figure 10. Wake Vortex Drift With 3 Knots of Crosswind



7.4.2.2 Stronger crosswinds of 6 knots and above may displace one or both vortices to an adjacent runway. For example, a 6-knot crosswind component added to the downwind vortex diverging laterally at 3 knots will have a groundspeed of 9 knots. In this scenario, the downwind vortex will displace laterally 1,800 feet in 2 minutes. See Figure 11 below.

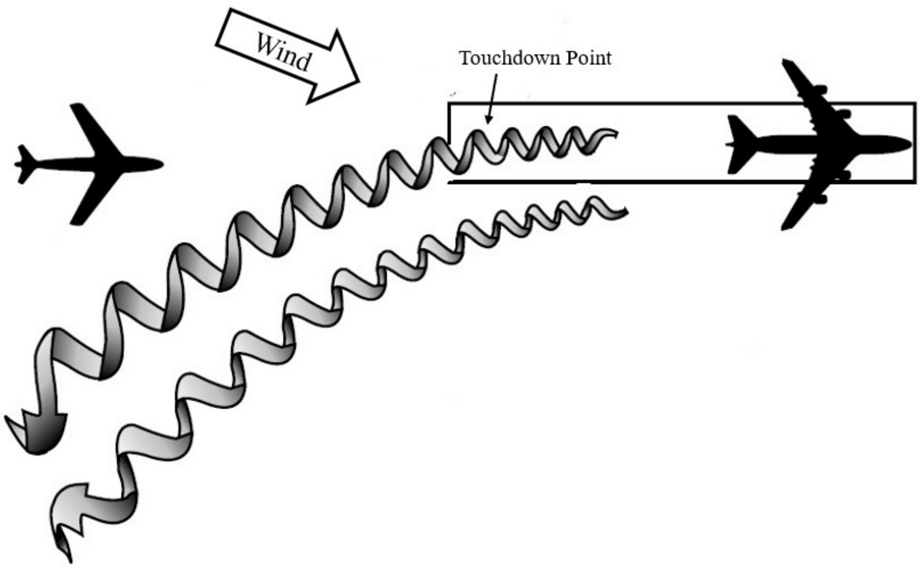
Figure 11. Wake Vortex Drift With 6 Knots of Crosswind



7.4.2.3 A tailwind condition may force the wake vortices of a generating aircraft forward from where the vortices were generated, resulting in wake vortices closer to an approach glidepath than would otherwise occur in a no-wind scenario.

7.4.2.3.1 A light quartering tailwind may cause a hazardous landing condition for encountering aircraft. The crosswind component resists the upwind vortex tendency to move outwards and keeps the upwind vortex laterally near the approach and runway centerline while the tailwind component forces the wake vortices closer to the glidepath and further down the runway. See Figure 12, Light Quartering Tailwind Wake Vortex Hazard.

Figure 12. Light Quartering Tailwind Wake Vortex Hazard



8 WAKE VORTEX ENCOUNTER RISK. Wake vortices from a generating aircraft may pose a hazard to encountering aircraft of similar and smaller size. The risk of wake vortices is the composite of the likelihood (probability) and the severity (consequences) of the encounter. No two wake vortex encounters are identical due to the variables involved that affect both the likelihood and severity of an encounter.

8.1 Factors Affecting the Likelihood of A Wake Vortex Encounter. Wake vortices are generated with differing strength and will decay and drift at differing rates. The time and therefore distance between the generating aircraft and an encountering aircraft is a major factor for the likelihood of an encounter. The likelihood of a wake vortex encounter is dependent upon the proximity of the wake vortices to the flightpath of the potential encountering aircraft and the residual strength of the wake vortices at the time of intercept. The likelihood of a wake vortex encounter may increase when the following occurs:

8.1.1 The encountering aircraft is below the generating aircraft in trail or crosses below and behind the generating aircraft. This includes a generating aircraft climbing or descending in front of and through the flightpath of the encountering aircraft, or the encountering aircraft climbing or descending behind and through the flightpath of the generating aircraft. The closer the encountering aircraft is below and behind the generating aircraft in time and distance, the less time the wake vortex has had to decay and the higher the likelihood of an encounter.

8.1.2 The movement of the wake vortices (lateral drift and vertical sink) may create scenarios where wake vortices are maintained in a critical area such as the glidepath and/or the runway for a longer period. Wake vortices may also drift or sink into adjacent aircraft operations. Examples of drift causing a higher likelihood of encounter include:

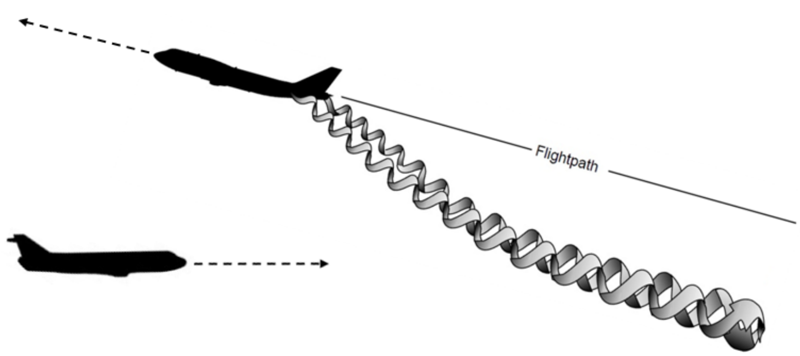
8.1.2.1 A light quartering tailwind that resists the outward movement of the upwind vortex and pushes the vortices forward in the approach and runway environment toward the touchdown zone (TDZ).

8.1.2.2 A light wind with a crosswind component of 1 to 5 knots that resists the outward movement of the upwind vortex causing the upwind vortex to remain in the final approach, runway and TDZ area longer. The crosswind accelerates the downwind vortex away from the runway and depending on conditions towards an adjacent runway, approach, or departure area.

8.1.2.3 Wake vortices that may drift and sink into the takeoff or landing flightpaths of a crossing runway or into traffic patterns of adjacent airports.

8.1.2.4 Wake vortices that may sink into en route traffic, even when legally separated by 500 feet for visual flight rules (VFR) traffic or 1,000 feet for instrument flight rules (IFR) traffic. Additional exposure may occur when a generating aircraft has transited in a climb or descent in front of the flightpath of an encountering aircraft (or the encountering aircraft climbs or descends behind the generating aircraft). See Figure 13 below.

Figure 13. Climbing Aircraft Wake Vortex Sink



8.2 Factors Affecting the Severity of a Wake Vortex Encounter. Wake vortex encounters present a spectrum of severity that ranges from light turbulence to a LOC-I, or in-flight breakup (see Figure 14, Loss of Control In Flight). The turbulence generated by wake vortices may cause injuries to occupants of an encountering aircraft and may damage aircraft components and equipment. Wake vortices from a similar or larger-sized generating aircraft may induce a roll force (or a series of counter-rotating roll forces) on an encountering aircraft that exceeds the roll control (counter roll) authority of the aircraft. Wake vortex-induced roll force(s) exerted on an encountering aircraft may result in a situation where the pilot is required to perform an upset recovery (see Figure 15, Counter Roll Control). The severity of a wake vortex encounter is affected by the residual strength of the wake vortices at the point of encounter, the characteristics of the encountering aircraft, the encounter angle (the relative angle between the flightpath of the encountering aircraft and the wake vortex), the energy state of the encountering aircraft, and the ability of the pilot to recover from a wake vortex encounter.

Figure 14. Loss of Control In Flight

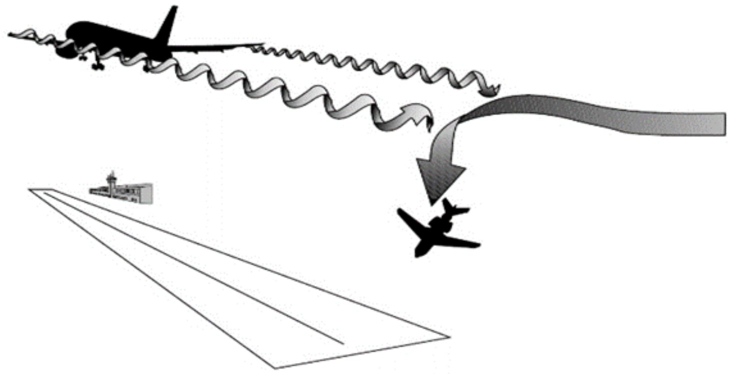
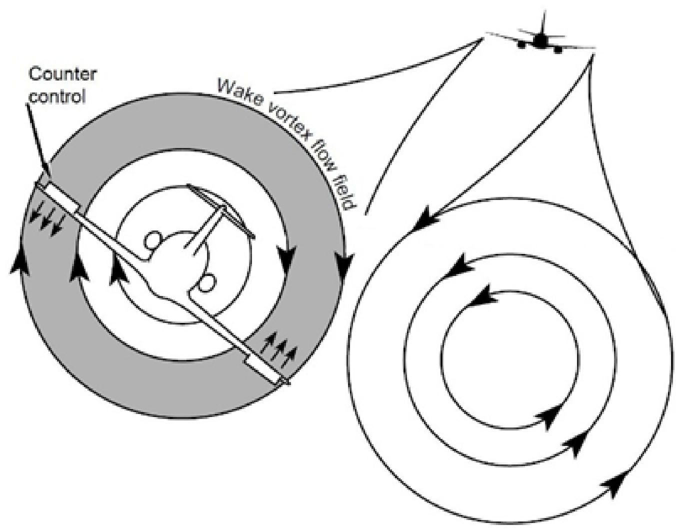


Figure 15. Counter Roll Control



8.2.1 When the wake vortices residual strength is higher, the forces imparted on the encountering aircraft is higher. The residual strength of the wake vortex at the point of intercept with the encountering aircraft is a function of the amount of wake decay deducted from the initial wake strength. The amount of wake decay depends on the wake vortex age (time elapsed since wake vortex generation), and the effect of the environment that existed during that time.

8.2.2 The capability of an aircraft to counteract the wake-induced roll depends on the counter roll control and wingspan of the encountering aircraft. It is more difficult for aircraft with short wingspans to counter the wake-induced roll. Encountering aircraft with a relatively small wingspan, even in a high-performance aircraft, will be influenced more by a wake vortex than an aircraft with a larger wingspan. In encounters where the wingspan and ailerons of the encountering aircraft extend beyond the rotation of the wake vortex, counter roll control is usually more effective, and induced roll is decreased.

8.2.3 The relative angle between the flightpath of the encountering aircraft and the wake vortex influences the severity of the encounter.

8.2.3.1 If the encountering aircraft is in line (in-trail or passing below the generating aircraft) or converging at a shallow angle with the wake vortices, turbulence and wake-induced roll is imparted on the encountering aircraft. These axial type encounters may have an interaction with the overall wake flow field (disturbed air surrounding the wake vortices) characterized by turbulence that last longer than other encounters. This turbulent interaction, known as the washboard effect or nibbling, occurs when the encountering aircraft is within the overall wake flow field but not in the core of a wake vortex. An encountering aircraft may be expelled from the wake vortex in an axial encounter due to the rotation of the wake vortex. If an encountering aircraft continues into the core of the wake vortex, the induced roll force is usually brief in comparison to the overall interaction with the wake flow field. See Figure 16 below.

Figure 16. Axial Wake Vortex Encounter

8.2.3.2 Axial encounters may cause the encountering aircraft to roll significantly in one direction and then roll in the other direction as the aircraft passes from one wake vortex to the other counter-rotating vortex. For example, an aircraft passes into the right-side wake vortex of the generating aircraft that induces a roll to the left. The pilot inputs a counter-roll force to the right. The aircraft then passes out of the right-side wake vortex as the aircraft is recovering and into the left-side wake vortex, which rolls the aircraft to the right exacerbated by the pilot control inputs. Severity may increase in this scenario as the second roll force nominally rolls the aircraft further than the first, and the pilot may overstress the aircraft with a quick control reversal. It is also possible to encounter the same wake vortex and corresponding roll direction more than once.

8.2.3.3 During a crossing encounter, where the aircraft crosses the wake flow field at a larger angle, turbulence may be experienced due to the vertical air movements of the wake vortices. Crossing encounters are brief due to the speed at which the encountering aircraft passes through the wake flow field. In a crossing encounter the encountering aircraft may experience turbulence that may be severe, but also experience less wake-induced roll when compared to an axial encounter. See Figures 17 and 18 below.

Figure 17. Air Movement Within Wake Vortices

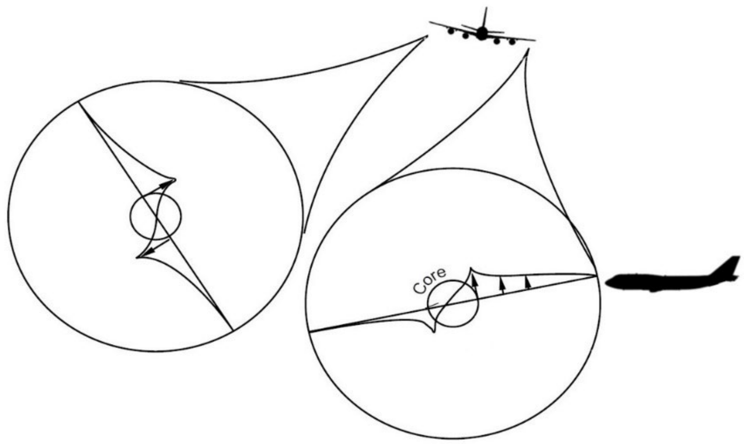
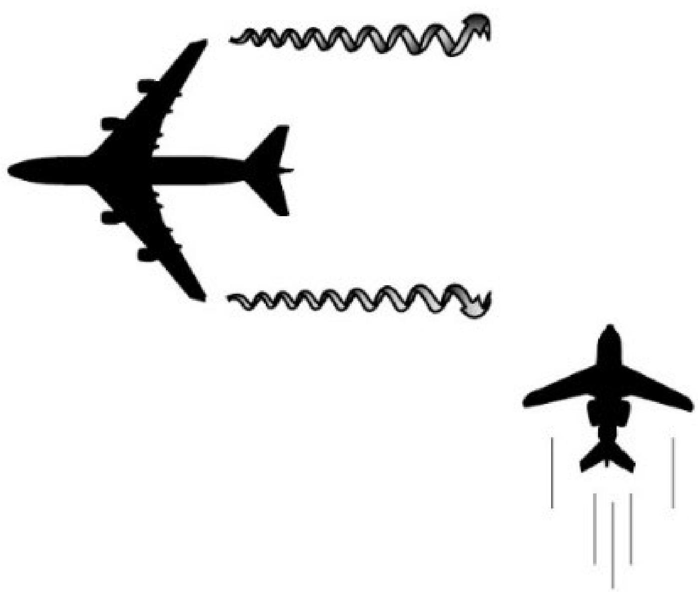


Figure 18. Crossing Wake Vortex Encounter



8.2.4 The energy state of the encountering aircraft influences the severity of the encounter. A pilot has three sources of energy available to manage or manipulate the flightpath of an aircraft. These three sources include kinetic energy (airspeed), potential energy (altitude above the ground level), and chemical energy (engine thrust). The balance of these combined energies describes the energy state of an aircraft at any given time. Refer to FAA-H-8083-3, Airplane Flying Handbook, for more information regarding aircraft energy states.

8.2.4.1 An encountering aircraft in the takeoff or approach-to-landing flight phase is at a lower energy state (kinetic energy/airspeed and potential energy/altitude) and may have a higher severity encounter with wake vortices than the same aircraft with a higher energy state. The time allotted for a pilot to recover from a wake vortex encounter is compressed when the aircraft is close to the ground.

8.2.4.2 An encountering aircraft that is above design maneuvering speed (V_A), operating maneuvering speed (V_O), or turbulent air penetration speed (V_B) (high kinetic energy relative to the "envelope" of the Vg diagram) is more susceptible to a pilot action that may overstress the aircraft during recovery, especially with sudden control reversals.

8.2.5 The training, knowledge, decision making, awareness, and skill of the pilot may influence the severity of the wake vortex encounter.

9 WAKE VORTEX ENCOUNTER MITIGATIONS. Wake vortices are generally a hazard invisible to the human eye but may be detected visually during times of high humidity or when wake vortices interact with smoke or clouds. Pilots must learn to envision the location and movements of the vortices generated by other aircraft and to adjust their flightpath accordingly to mitigate the likelihood and/or severity of a wake vortex encounter. The best risk mitigation for wake vortex encounters is avoidance. Wake mitigations including the following:

9.1 Departures.

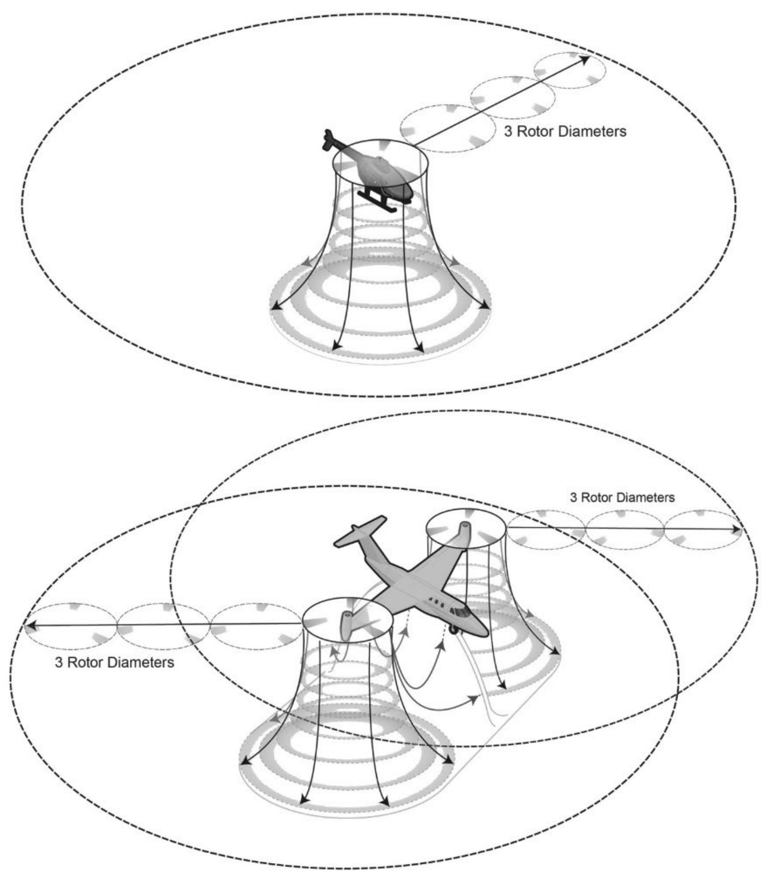
9.1.1 Pilots are advised to be alert for any departure situation that may lead to a wake vortex encounter. Pilots are expected to adjust aircraft operations and flightpath as necessary to preclude serious wake vortex encounters. Space your departure (including expected departure flightpath) to give ample time and distance for wake vortex decay, especially if your flightpath will cross at or below the flightpath of a similar or larger-sized aircraft or rotorcraft. For reference, aircraft taking off from the same runway or a parallel runway separated by less than 2,500 feet are to be separated by air traffic control (ATC) in accordance with FAA Order JO 7110.65, Air Traffic Control. ATC will not clear a small aircraft to line up and wait behind a "Heavy" or "Super" aircraft. For a small aircraft, prior to the issuance of a takeoff clearance, ATC requires an interval of at least 2 minutes to have elapsed since the takeoff of a Boeing 757-size aircraft and 3 minutes since the takeoff of an Airbus A380-size aircraft.

9.1.1.1 At controlled airports, a pilot may request additional time for wake turbulence separation. A pilot is advised to make this request before taxiing onto the runway.

9.1.2 At uncontrolled airports (including at a part-time controlled airport when the control tower is not in operation), pilots are solely responsible for wake vortex encounter avoidance and mitigation.

9.1.3 The effect of rotorcraft wake vortices, downwash, and outwash may be stronger than expected compared to airplanes of a similar size. Pilots of fixed-wing aircraft are advised to treat rotorcraft of a similar size as a larger aircraft for wake avoidance. Pilots of fixed-wing aircraft are advised to avoid the area within three times the rotor diameter (of the nearest rotor in the case of a multirotor aircraft) of a rotorcraft in a hover or slow hover taxi. Wake vortices from an arriving or departing rotorcraft may be present in different locations than the expected location of wake vortices from fixed-wing aircraft. See Figure 19 below.

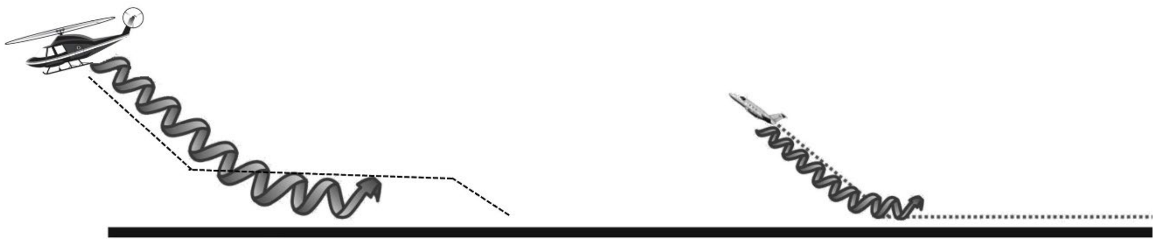
Figure 19. Avoiding Rotorcraft Downwash and Outwash



9.1.4 Do not follow or cross behind and below the flightpath of a similar or larger-sized aircraft without adequate time to allow for wake vortex decay and drift. Avoid flying below the flightpath of a preceding aircraft by delaying operations to allow for wake decay and drift. Avoid the flightpath of a preceding aircraft by altering your flightpath above and/or laterally upwind of the flightpath of the generating aircraft.

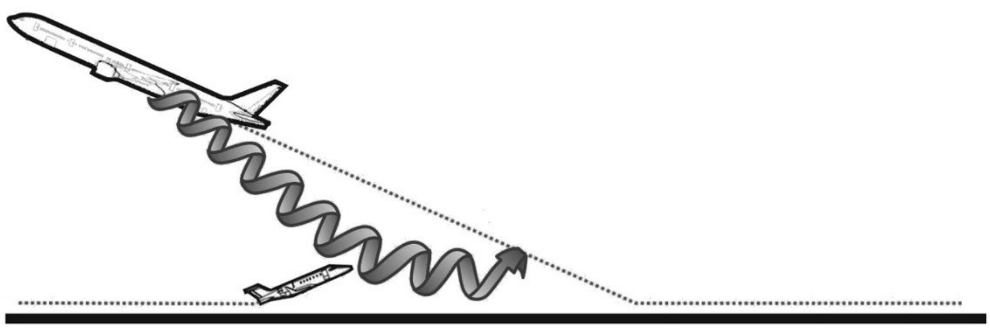
9.1.4.1 When departing after a similar or larger-sized aircraft has taken off on the same runway, or on a closely spaced parallel runway (where conditions exist for the wake to drift into your flightpath) delay operations to allow for wake decay and drift. Take note of the takeoff rotation point of the preceding aircraft as well as the departure flightpath. Rotate prior to the rotation point of the preceding aircraft. Continue climbing above the flightpath of the preceding aircraft and/or altering your flightpath upwind until above or clear of the flightpath of the preceding aircraft. Avoid a flightpath that will cross below and behind the departure flightpath of the preceding aircraft. See Figure 20 below.

Figure 20. Departure Flightpath



9.1.4.2 When departing after a similar or larger-sized aircraft has taken off from the opposite end of the same or closely spaced runway (where conditions exist for wake to drift into your flightpath) delay operations to allow for wake decay and drift. See Figure 21 below.

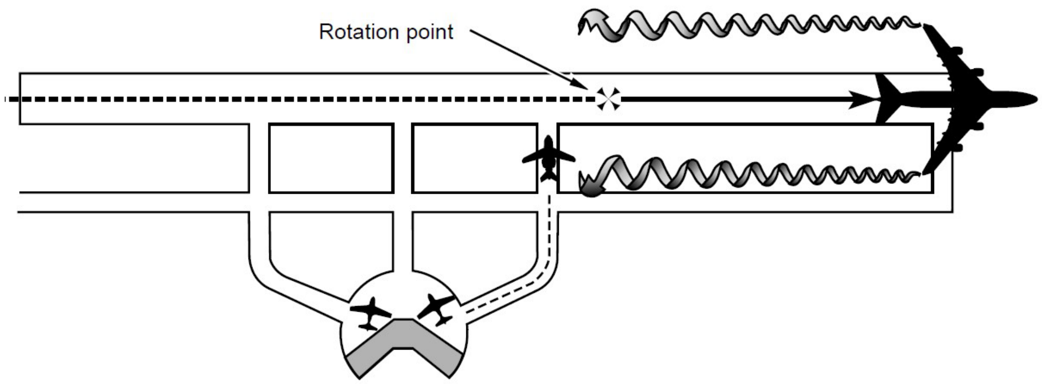
Figure 21. Opposite Direction Departure



9.1.4.3 When departing after a similar or larger-sized aircraft has arrived on the same or closely spaced parallel runway (where conditions exist for wake to drift into your flightpath), rotate after the point of touchdown of the preceding aircraft. Avoid a flightpath that will cross below and behind the descent path of the preceding aircraft.

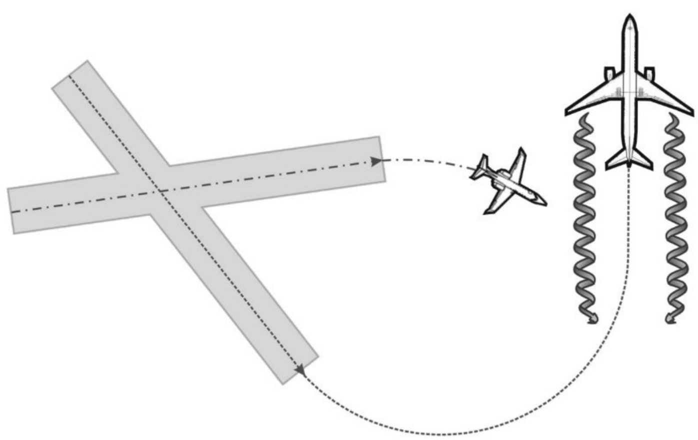
9.1.4.4 When departing from an intersection from the same runway, or a staggered threshold (offset parallel runway) from a closely spaced parallel runway (where conditions exist for wake to drift into your flightpath) after a similar or larger-sized aircraft has taken off, take note of the takeoff rotation point of the preceding aircraft as well as the departure flightpath. Rotate prior to the rotation point of the preceding aircraft. Continue climbing above the flightpath of the preceding aircraft and/or altering course upwind until above or clear of the flightpath of the preceding aircraft. Avoid a flightpath that will cross below and behind the departure flightpath of the preceding aircraft. See Figure 22 below.

Figure 22. Intersection Departure



9.1.4.5 When departing after a similar or larger-sized aircraft has taken off from a crossing runway, take note of the takeoff rotation point of the preceding aircraft, the departure flightpath, and envision the drift of the wake vortices. Avoid a flightpath that will cross below and behind the flightpath of the preceding aircraft. Rotate and climb above the flightpath of the preceding aircraft and/or alter course upwind until above or clear of the flightpath of the preceding aircraft. See Figure 23 below.

Figure 23. Crossing Departures

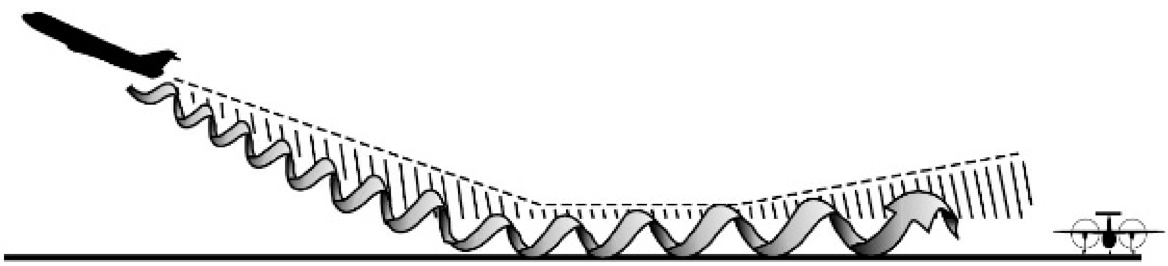


9.1.4.6 When departing after a similar or larger-sized aircraft has arrived on a crossing runway, take note of the point of touchdown of the preceding aircraft, the approach path, and envision the drift of the wake vortices. Avoid a flightpath that will cross below and behind the preceding aircraft. Rotate and climb above the flightpath of the preceding aircraft and/or alter course upwind until above or clear of the flightpath of the preceding aircraft.

9.1.4.7 Converging runways have a variety of layouts and hazards. Avoid a flightpath that will cross below and behind a similar or larger-sized aircraft.

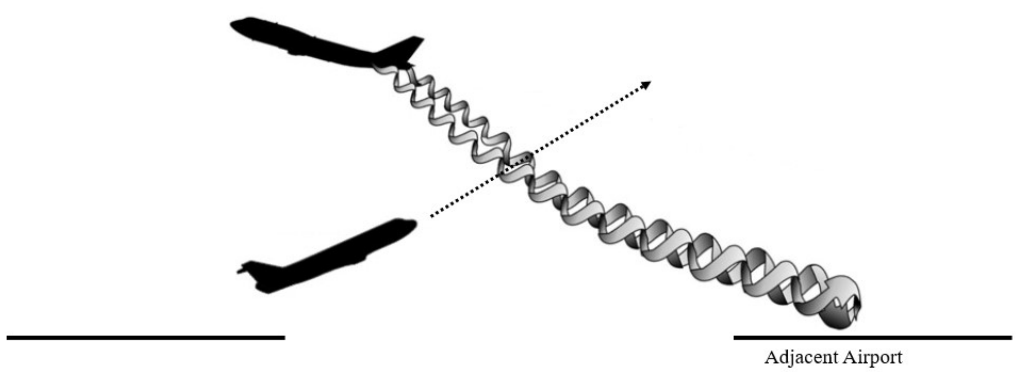
9.1.4.8 When departing after a similar or larger-sized aircraft performs a missed approach, low approach, go-around, balked landing, or touch and go, the wake vortex hazard may exist along the runway and in your flightpath. Pilots are advised to ensure that an interval of at least 2 minutes has elapsed before your takeoff (and up to 4 minutes when operating behind "Super" aircraft). See Figure 24 below.

Figure 24. Missed Approach Wake Vortices



9.1.4.9 When departing from an airport adjacent to another airport with a similar or larger-sized aircraft operations, take care to avoid wake vortices from preceding arriving and departing aircraft from both airports. See Figure 25 below.

Figure 25. Departures From Adjacent Airports



9.2 Arrivals.

9.2.1 Pilots are advised to be alert for any arrival situation that may lead to a wake vortex encounter. Pilots are expected to adjust aircraft operations and flightpath as necessary to preclude serious wake vortex encounters. Space your arrival (including expected approach path) to give ample time and distance for wake vortex decay.

9.2.2 The effect of rotorcraft wake vortices, downwash, and outwash may be stronger than expected compared to airplanes of a similar size. Pilots of fixed-wing aircraft are advised to treat similar-sized rotorcraft as larger aircraft for wake avoidance. Pilots of fixed-wing aircraft are advised to avoid the area within three times the rotor diameter (of the nearest rotor in the case of a multirotor aircraft) of a rotorcraft in a hover or slow hover taxi. Wake vortices from an arriving or departing rotorcraft may be present in different locations than the expected location of wake vortices from fixed-wing aircraft.

9.2.3 Acceptance of ATC instructions to follow another aircraft, or to maintain visual separation from another aircraft, is an acknowledgment that the pilot will maneuver the aircraft as necessary to avoid the other aircraft and to maintain adequate wake turbulence separation and avoidance.

9.2.4 During visual approaches or at uncontrolled airports (including at a part-time controlled airport when the control tower is not in operation) or during charted visual flight procedures (CVFP), pilots are solely responsible for wake turbulence separation and avoidance. In a radar environment with ATC, pilots may query ATC for updates on separation and groundspeed with respect to a preceding aircraft.

9.2.5 When on approach to landing, take note of runway threshold locations, relative glidepaths, and touchdown points of similar and larger-sized aircraft. Wake vortices will likely descend, drift with the wind, and may cross your flightpath.

9.2.5.1 For runways with electronic or visual guidance, stay at or above the glidepath, as appropriate. Otherwise, consider remaining at or above a nominal 3-degree glidepath using the "3 to 1" glidepath guidance. For every nautical mile (NM) away from the runway, the pilot is advised to be an additional 300 feet above the touchdown zone elevation (TDZE) (e.g., 1,500 feet above TDZE at 5 NM). Exceptions exist where a 3-degree glidepath (318 feet per NM) is too low, including operations near mountainous terrain.

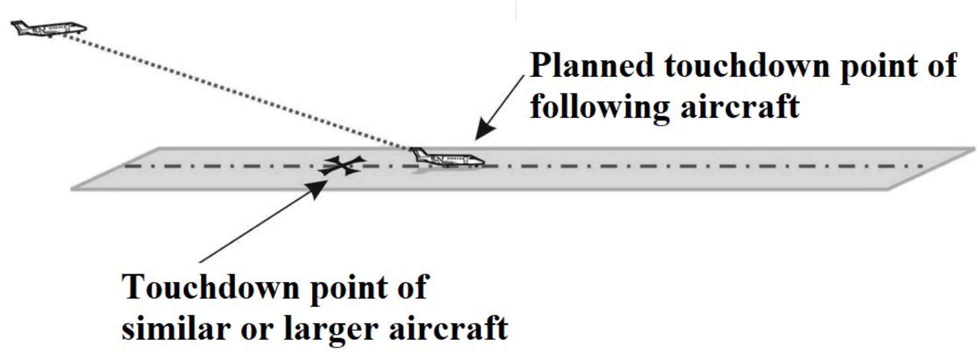
9.2.5.2 If a pilot has visual contact with the runway and a preceding similar or larger-sized aircraft, the pilot is advised to maintain a line of sight to an aim point that is beyond the expected touchdown point of the preceding aircraft, no less than 1,000 feet from the threshold of the arrival runway. Note the touchdown point of the preceding aircraft (e.g., a puff of smoke from tire contact of the preceding aircraft) and adjust the aim point as necessary. Maintain the line of sight to the aim point and stay above the flightpath of the preceding aircraft to touchdown. Ensure you have adequate runway remaining for a safe arrival and then touchdown beyond the touchdown point of the preceding aircraft.

9.2.6 If the extension of your touchdown point due to wake vortex encounter mitigation does not allow sufficient distance to safely stop the aircraft prior to the end of the useable runway or would cause an unstabilized approach, delay the approach to landing to allow ample time and distance for wake decay and drift before landing at an appropriate touchdown point.

9.2.7 Do not follow or cross below the flightpath of a similar or larger-sized aircraft without adequate time and distance to allow for wake vortex decay and drift. Avoid flying below the flightpath of a preceding aircraft by delaying operations to allow for wake decay and drift as well as altering your flightpath above and/or altering your flightpath laterally upwind. If there is any doubt as to the safety of the arrival, make the decision early to perform a missed approach, go-around, or a balked landing.

9.2.7.1 When arriving after a similar or larger-sized aircraft has landed on the same runway, or a closely spaced parallel runway (where conditions exist for wake to drift into your flightpath), delay operations to allow for wake decay and drift. Approach the runway at or above the flightpath of the preceding aircraft and touchdown after the touchdown point of the preceding aircraft. See Figure 26 below.

Figure 26. Landing After a Larger Aircraft

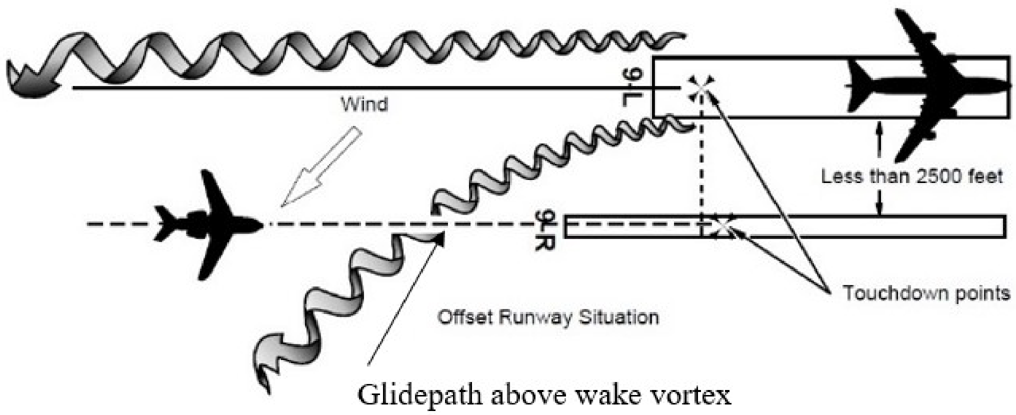


9.2.7.2 When arriving behind a similar or larger-sized aircraft landing on a closely spaced parallel runway closer than 2,500 feet (where conditions exist for wake to drift into your flightpath) with a staggered threshold (also referred to as offset parallel runways), consider the implications of where the wake vortices may be found and avoid that area. Approach the runway at or above the flightpath of the preceding aircraft and touchdown after the touchdown point of the preceding aircraft.

9.2.7.2.1 Aircraft abeam each other on approaches to nonstaggered parallel runways with the same glidepath angle will be at approximately the same altitude. Conversely, on approaches to staggered parallel runways (one TDZ is more distant) with the same glidepath angle, when aircraft are abeam each other, the aircraft on approach to the more distant TDZ will be relatively higher. When following a similar or larger-sized aircraft to a staggered parallel runway (where conditions exist for wake to drift into your flightpath) to the closer TDZ, adjust your flightpath or delay operations accordingly. See Figure 27, Parallel Runways with Threshold Stagger.

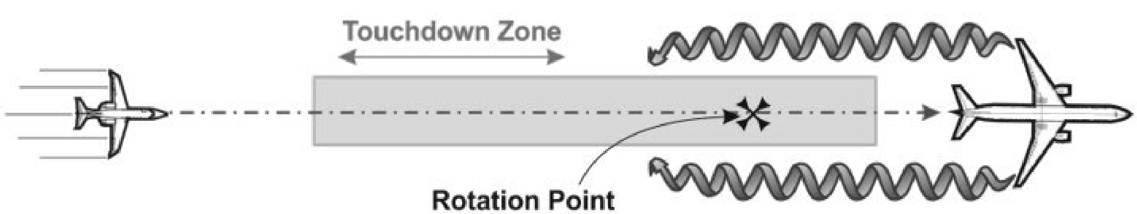
9.2.7.2.2 In certain scenarios when parallel approach courses authorized for simultaneous dependent operations, parallel offset approaches, or simultaneous offset instrument approaches (SOIA) are in use, aircraft on both approaches are advised to remain on the electronic glidepath, as applicable, for wake vortex encounter mitigation. Reference the instrument approach chart notes for details.

Figure 27. Parallel Runways with Threshold Stagger



9.2.7.3 When arriving after a similar or larger-sized aircraft has departed on the same or closely spaced parallel runway (where conditions exist for wake to drift into your flightpath), touchdown prior to the rotation point of the larger aircraft. See Figure 28 below.

Figure 28. Landing After a Departing Aircraft



9.2.7.4 When arriving after a similar or larger-sized aircraft has departed from a crossing runway, take note of the takeoff rotation point of the preceding aircraft, the possible wake vortex drift, as well as the departure flightpath. Avoid a flightpath that will cross below and behind the flightpath of the preceding aircraft. If the preceding aircraft rotates prior to the intersection, execute a missed approach or go-around unless a landing is ensured well before the intersection. See Figure 29, Landing After a Crossing Runway Departure (Rotation Point Before Intersection) and Figure 30, Landing After a Crossing Runway Departure (Rotation Point After Intersection).

Figure 29. Landing After a Crossing Runway Departure (Rotation Point Before Intersection)

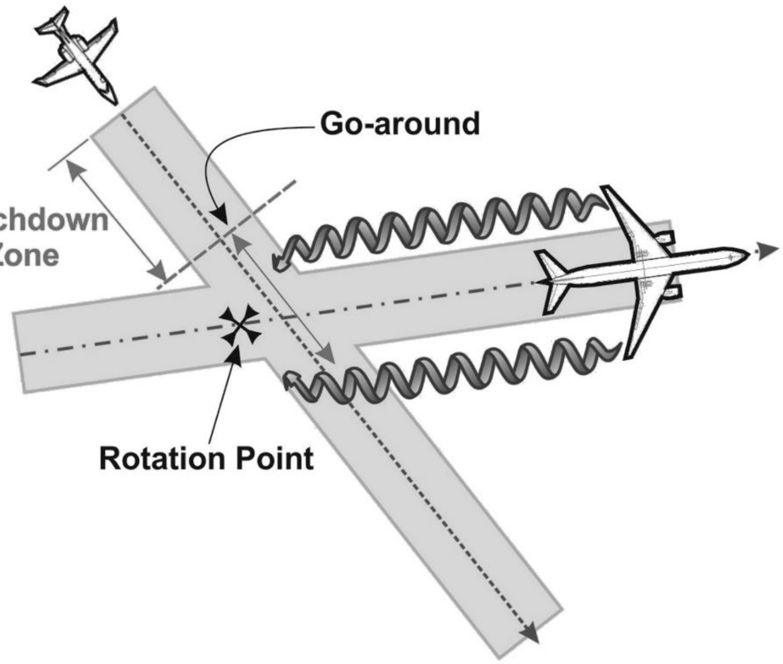
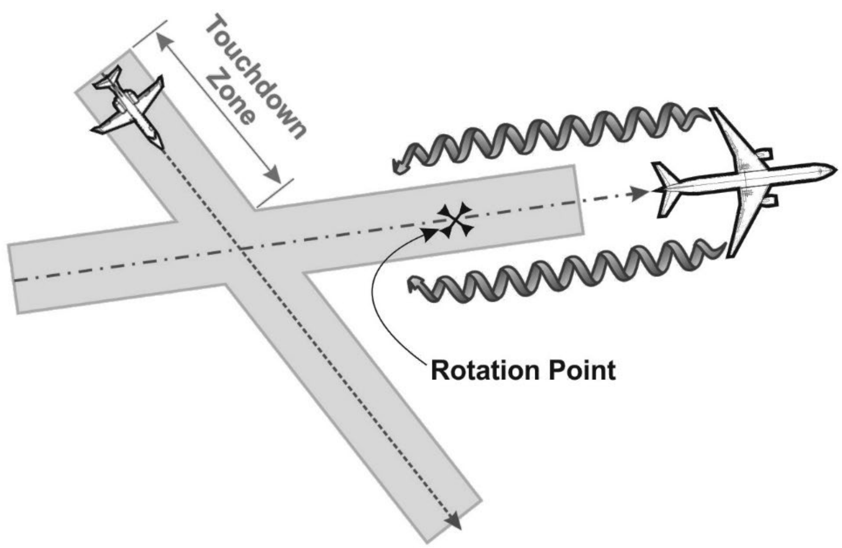
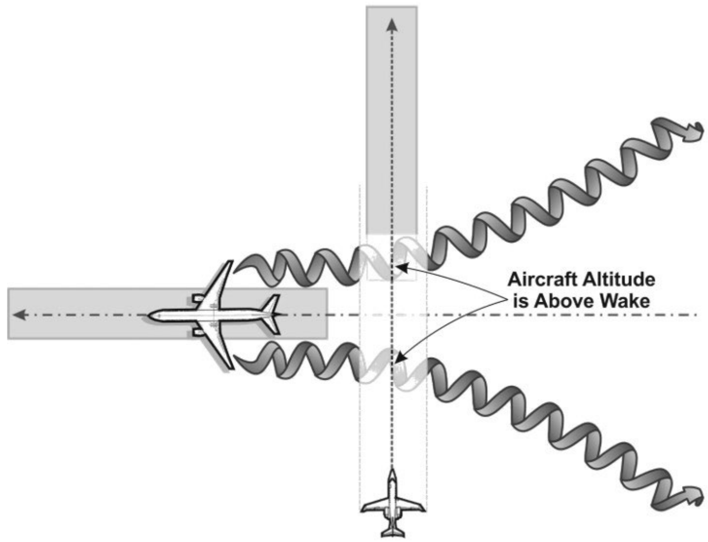


Figure 30. Landing After a Crossing Runway Departure (Rotation Point After Intersection)



9.2.7.5 When arriving after a similar or larger-sized aircraft has landed on a crossing runway, take note of the point of touchdown of the preceding aircraft, the possible wake vortex drift, as well as the approach path. Avoid a flightpath that will cross below and behind the preceding aircraft. See Figure 31, Landing After an Arriving Aircraft on a Converging Runway.

Figure 31. Landing After an Arriving Aircraft on a Converging Runway



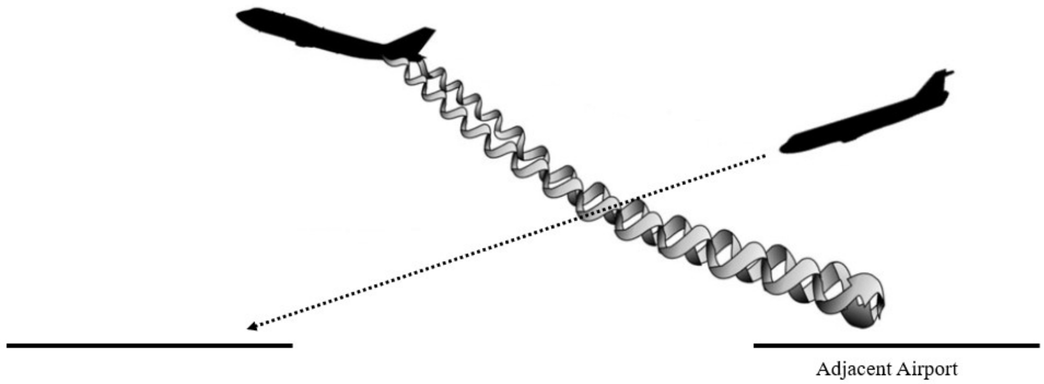
9.2.7.6 Converging runways have a variety of layouts and hazards. Avoid a flightpath that will cross below and behind a similar or larger-sized aircraft.

9.2.7.7 When arriving after a similar or larger-sized aircraft has taken off from the opposite end of the same or closely spaced runway (where conditions exist for wake to drift into your flightpath) delay operations to allow for wake decay and drift away from the approach area and the flightpath of your possible missed approach.

9.2.7.8 When arriving after a similar or larger-sized aircraft performs a missed approach, low approach, go-around, or a balked landing, the wake vortex hazard may exist along the runway and in your flightpath. Pilots are advised to ensure that an interval of at least 2 minutes has elapsed before your landing (and up to 4 minutes when operating behind "Super" aircraft).

9.2.7.9 When arriving at an airport adjacent to another airport with similar or larger-sized aircraft operations, take care to avoid wake vortices from arriving and departing aircraft. See Figure 32, Arrival at an Adjacent Airport.

Figure 32. Arrival at an Adjacent Airport



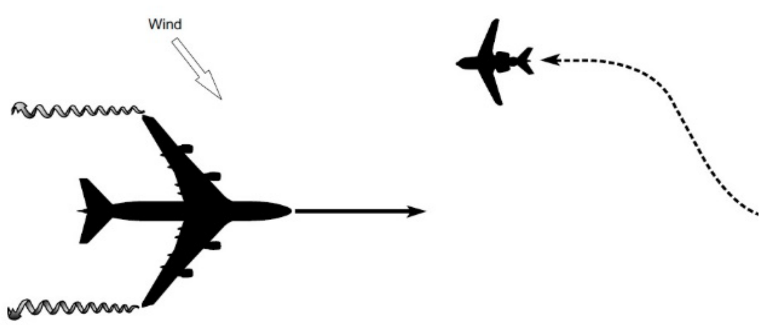
9.3 En Route.

9.3.1 En route VFR with 500-foot separation from IFRs traffic, pilots are advised to avoid flight below and behind the flightpath of a similar or larger-sized aircraft. If a preceding aircraft is observed above on the same track (meeting or overtaking), adjust your position laterally, preferably upwind.

9.3.2 Pilots are advised to be alert for wake vortices when operating in the vicinity of aircraft climbing or descending through their altitude or approximately 5 to 25 miles after passing 1,000 feet below opposite-direction traffic or behind same-direction traffic.

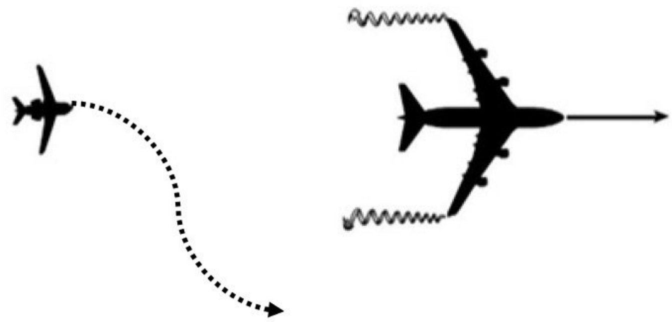
9.3.3 If the hazard of wake vortex encounter is suspected, especially in the case of a generating aircraft defined as a "Heavy" or "Super," request a lateral offset upwind of the expected wake vortices. Lateral offsets upwind as small as the wingspan of the preceding aircraft may move the trailing aircraft out of the immediate vicinity of a wake vortex. See Figure 33 below.

Figure 33. Opposing Flightpaths



9.3.4 Strategic Lateral Offset Procedure (SLOP) may be utilized where allowed by International Civil Aviation Organization (ICAO) Doc 4444, Procedures for Air Navigation Service (PANS), and national Aeronautical Information Publications (AIP) (i.e., oceanic airspace) to offset from an airway, preferably upwind. SLOP does not apply to domestic U.S. airspace. In domestic U.S. airspace, pilots need an amended clearance (as applicable) to fly a lateral offset. See Figure 34 below.

Figure 34. In-Trail Flightpath



9.3.5 Condensation trails (contrails) and wake vortices propagate, descend, and decay in the atmosphere differently. The ice particles that form in the exhaust of aircraft flying at high altitude are only to be used as a gross indication of the flightpath of a preceding aircraft, not the specific wake vortex location.

9.4 Wake Vortex Encounter Mitigations for Generating Aircraft.

9.4.1 Large aircraft operators are advised to make every attempt to fly their aircraft predictably, which includes when in the terminal environment, flying on the glidepath (not above it) and flying as closely as possible to the approach centerline or the extended runway centerline. These procedures establish a baseline from which pilots of in-trail aircraft may make effective flightpath adjustments to mitigate wake vortex encounters. At airports without visual and/or electronic glidepath indications, pilots are advised to use the "300 feet to 1 mile" guidance for glidepath.

9.4.2 Larger aircraft operators are advised to remain as close to as feasible the centerline of an airway so that the following aircraft may offset upwind to avoid wake vortices.

9.4.3 Pilots of "Heavy" or "Super" aircraft are advised to use the appropriately designated weight identifying term in radio communication.

9.5 Wake Vortex Encounter Mitigations Utilized by ATC.

9.5.1 <u>Wake Vortex Encounter Mitigation Roles and Responsibilities</u>. Pilots have the ultimate responsibility for the safe operation of their aircraft. Pilots arriving and departing from uncontrolled airports, or accepting a clearance for a visual approach, operating using VFR outside of controlled airspace are accepting the responsibility for wake vortex encounter avoidance and mitigation. When ATC is providing separation services, the controller shares in this responsibility. ATC mitigates wake vortex encounter risk through minimum separation standards between leader aircraft and follower aircraft, as well as information reports to pilots such as wake turbulence cautionary advisories.

9.5.2 Wake Assessment. Wake assessment performed by the FAA defines the characteristics of an aircraft wake vortices, including the initial wake strength and the wake age required to reduce the residual wake strength encountered by a following aircraft. Wake assessment also quantifies the ability of a following aircraft to encounter wake vortices.

9.5.3 Wake Categorization. Wake assessments result in wake categorization of an aircraft to define separation standards (time or distance) between leader and follower aircraft pairs to be used by ATC. For example, on an approach, ATC may separate a "Heavy" follower aircraft behind another "Heavy" leader aircraft by the Minimum Radar Separation (MRS). If, instead, the follower aircraft was a "light" aircraft behind a "Heavy," the controller would increase the separation allowing for the wake vortices to decay and move away from the flightpath. Originally, wake categorization and minimum separation standards were based on the maximum gross takeoff weight of an aircraft. In this weight-only wake categorization of aircraft there is potential for aircraft with similar weights to have markedly different wake generation and behavior characteristics, as well as differing abilities to encounter wake as a following aircraft. Weight-only categorization, therefore, carries heightened safety risks or less efficient use of congested airspace. Advances in the understanding of wake behavior and computational simulations facilitated the development of Wake Turbulence Recategorization (RECAT). RECAT offered a multiparameter aircraft classification system that enhanced safety over the weight-only structure while yielding operational efficiency gains. RECAT was modified into different versions including RECAT 1.5 and RECAT II. Now, Consolidated Wake Turbulence (CWT) takes advantage of the continuing evolution of wake mitigation strategies to consolidate the benefits of previous RECAT efforts. ATC facilities are currently transitioning to CWT separation standards.

9.5.3.1 CWT categorizes aircraft into nine separate categories, labeled A through I. "A" is the category designator for a "Super" (e.g., Airbus A380), and "I" is the category designator for a smaller aircraft (e.g., Beechcraft King Air 200).

9.5.3.2 ICAO Wake Turbulence Category (WTC) is based on weight only. The designators are "L" for Light aircraft with a maximum certificated takeoff weight of 15,400 pounds or less. "M" for Medium aircraft with a maximum certificated takeoff weight of more than 15,400 pounds to 300,000 pounds. "H" for "Heavy" aircraft with a maximum certificated takeoff weight of more than 300,000 pounds. There is also a designator "J", which denotes a "Super" aircraft type (e.g., Airbus A380).

9.5.4 Flight Plan. An ICAO compliant flight plan such as FAA Form 7233-4, Pre-Flight Pilot Checklist and International Flight Plan, requires the input of an aircraft type designator of an aircraft as well as the ICAO WTC (Item 9 of FAA Form 7233-4). The aircraft type designators, ICAO WTCs, and the corresponding CWT category for an aircraft type can be found in the current version of Order JO 7360.1.

9.5.4.1 Automation in the ATC system will automatically adjust the wake separation category if the aircraft flight plan is filed correctly with the aircraft type designator found in Order JO 7360.1.

9.5.4.2 It is important that the standard abbreviation for an aircraft type designator is listed correctly in the flight plan. ATC automation systems will not present the correct information to the controller unless the current and proper aircraft type is listed in the flight plan. For example, an Eclipse 550 jet is listed as an EA50; if the operator listed E550, the automation system would recognize the aircraft as an Embraer Legacy that is in a different CWT category.

9.5.4.3 Operators of aircraft without an assigned aircraft type designator are to enter "ZZZZ" as the aircraft type designator in their flight plan. If an operator, or controller, enters a "ZZZZ" designator into the flight plan, or the aircraft type designator entered has not been assessed for wake separation standards, the ATC automation will present the controller with a no weight (NOWGT) classification. The NOWGT classification is better described as "no wake assessment." NOWGT aircraft are given added separation that may affect the efficiency of airspace use both in front of and behind the NOWGT aircraft.

9.5.5 <u>Wake Turbulence Cautionary Advisories</u>. Wake turbulence cautionary advisories are issued when, in the opinion of the controller, wake turbulence may have an adverse effect on traffic. When traffic is known to be a "Super" or "Heavy" aircraft, ATC will include the word "Super" or "Heavy" in the description. ATC issues wake turbulence cautionary advisories that include the position, altitude (if known), direction of flight, and the phrase "Caution, Wake Turbulence" to aircraft operating behind an aircraft that requires wake turbulence separation. Wake turbulence cautionary advisories are issued to VFR aircraft not being radar vectored that are behind the larger aircraft, VFR arriving aircraft that have previously been radar vectored and the vectoring has been discontinued, and IFR aircraft accepting a visual approach or visual separation.

Note: Whether or not a warning or information has been given, the pilot is expected to adjust aircraft operations and flightpath as necessary to preclude wake vortex encounters.

9.5.6 <u>ATC Inquiry</u>. When any doubt exists about maintaining safe separation distances between aircraft to avoid wake turbulence, pilots are advised to ask ATC for updates on separation distance, groundspeed, and altitude.

10 WAKE VORTEX ENCOUNTER RECOVERY GUIDANCE. A wake vortex encounter does not always result in an unsafe condition. Depending on many variables discussed in this AC, a severe wake vortex encounter may include an undesired aircraft state, aircraft upset, or possibly a LOC-I aircraft accident. Incident and accident history has found that pilot inputs during a wake vortex encounter may have a positive or a negative effect. Refer to the Aircraft Flight Manual (AFM) and/or company policies for aircraft-specific upset recovery procedures.

10.1 Situational Awareness. The goal of situational awareness, as it relates to wake vortices, is avoidance. Furthermore, if a pilot is situationally aware and yet experiences a wake vortex encounter, the goal is to mitigate the encounter by recognizing and escaping (e.g., initiating a go-around/balked landing/missed approach when encountering a wake vortex on approach). If an aircraft encounters a severe wake vortex that causes an undesired aircraft state or aircraft upset, the goal of situational awareness is to understand the aircraft state in relation to the AOA, the load factor, the horizon, and energy state (kinetic energy, potential energy, chemical energy) so that the pilot will make the correct inputs to recover effectively. Recognition of the situation the aircraft is in is essential before a recovery may be effectively initiated. A pilot who is aware of the energy state and flightpath of the aircraft is less likely to be startled and therefore more likely to deal with a wake vortex encounter with the proper control inputs versus rapid reactive responses and reversals. The larger the excursion from normal flight, the more challenging an upset recovery becomes. Attitude instruments may be unreliable depending on the capabilities of the attitude instrument and the amount of roll and pitch experienced in the aircraft upset. Use all available resources, including looking outside the flight deck windows (including side windows for extreme pitch angles) for attitude information. Neglecting outside references or inadequate instrument cross-check (neglecting to monitor all the instruments or fixating on certain instrument indications and not detecting changes in others) may lead to a worsening of an aircraft upset. Regaining and then maintaining control of the aircraft is paramount.

10.2 Startle and Surprise. The expectations of an unprepared pilot may be violated when exposed to a sudden, intense event that may happen in a wake vortex encounter, and may produce a startle effect (e.g., automatic muscle reflex) and affect the mental processes used to respond to the event. Startle and surprise may cause the pilot to input inappropriate controls that overshoot the desired response. The inappropriate response to a wake vortex encounter that leads to an aircraft upset may lead to another aircraft upset in a different direction or axis. A pilot-induced oscillation (PIO) may occur when a pilot's commands become out of phase with the aircraft motion. A PIO may be initiated during an upset recovery if a pilot reacts with large rapid inputs before determining what is occurring. Precedent exists of wake vortex encounter events in which pilot inputs exacerbated the undesired aircraft state caused by the wake vortex encounter. A pilot who is aware of the energy state and flightpath is less likely to be startled and therefore more likely to deal with the situation with controlled inputs versus reactive responses.

10.3 Flight Control Inputs. Control inputs appropriate at one point in the flight envelope might not be appropriate in another part of the flight envelope. Pilots are to have a fundamental understanding of flight dynamics to correctly determine the control input(s) necessary for recovery. Aircraft upsets caused by a wake vortex encounter may involve a rapid roll reversal as the aircraft transitions across one wake vortex that induces a roll in one direction, and then enters the other wake vortex that induces a roll in the opposite direction. Pilots are advised to exercise caution with control inputs and ensure that control input is proportional to the situation, including the flight envelope unless ground contact is imminent. It may be advisable, if conditions permit, to allow the aircraft to transition through the wake vortex and then recover from any resultant undesired aircraft state versus aggressively trying to control the aircraft during the wake encounter.

10.3.1 Pitch (Movement About the Lateral Axis). Aircraft upset may lead to an aircraft at or close to the critical AOA and stall. An airplane wing may stall in any attitude, and at any airspeed. The elevator controls the load factor of the aircraft. "Load factor" is the measure of the acceleration being experienced by the aircraft also known as "G" loading. Higher load factors will increase the AOA and reduce flight control effectiveness compared to an aircraft at 1G or less than 1G. Zero or negative G's may have detrimental effects to the aircraft and occupants within. A priority in recovery from an aircraft upset is to manage the AOA and load factor as to recover from or prevent a stall and return the aircraft to a desired aircraft state without overstressing the aircraft. The pilot must manage the load factor to recover from an upset effectively without stalling or overstressing the aircraft. The use of actions affecting pitch (e.g., elevator input, pitch trim activation) may aggravate the upset situation or may result in high structural loads.

10.3.2 Roll (Movement About the Longitudinal Axis). The result of increasing bank is a reorientation of the lift vector from the vertical, which in turn creates a horizontal lift component as well as a reduced vertical lift component. When combined with an increased pitch input, an increase in bank will create an increased load factor. At any speed, large aggressive control deflection reversals may lead to a load factor that exceeds structural design limits.

10.3.3 Yaw (Movement About the Vertical Axis). A yaw input is not the preferred initial response to a wake vortex encounter. Yaw input should only be used in combination with roll inputs to eliminate sideslip, not to create sideslip or counter wake-induced roll. Prior experience and training that emphasized the use of yaw input to maneuver in roll may not apply to all aircraft operations. Using yaw to counter roll rate during a roll upset may lead to an undesirable aircraft response. Pilot overreaction in yaw may induce abrupt yawing moments and violent out-of-phase roll rates, which may lead to successive cyclic rudder deflections, known as rudder reversals, as the pilot tries to control the resulting motions. Accident precedent exists of pilot control inputs of aggressive rudder control reversals during a wake vortex encounter that caused structural failure.

10.3.4 Thrust. Increased chemical energy (thrust) may be used to increase kinetic energy, increase potential energy, or both. Some aircraft produce a thrust vector that is not coincident with the longitudinal axis of the aircraft and may produce a pitch up or down movement that may not be desired. Propeller-driven aircraft have a faster thrust build up compared to jet engines that have a longer spool up time. Propeller effects, however, may introduce rolling moments and unwanted slip or skid in response to power changes that require pilot compensation.

10.3.5 Auto Flight System (AFS). Refer to the AFM for specific guidance on the AFS, including autothrust systems and yaw damper controls. During a wake vortex encounter, if conditions permit, the AFS is engaged and remains engaged, and the aircraft is not in an undesired state, it may be appropriate to allow the AFS to fly the transition through the wake vortex, rather than aggressively trying to manually control the aircraft during the wake encounter. An AFS may disconnect unexpectedly because of excessive roll or pitch rates, roll or pitch angles, control surface deflection rates, or forces that are not normal. Approaching the limits of an AFS may mask the actual airplane trim state, as well as resultant changes in performance and handling qualities. A pilot must be prepared to assume manual control of the aircraft if the AFS disconnects or if the aircraft attains an undesired state or upset. If the aircraft progresses into an upset, disconnect the AFSs, including the autothrust to recover.

10.4 **Other Upset Recovery Considerations.** Depending on the severity of the wake encounter, the time allowance for the pilot to recognize the encounter, identify the resultant forces, and make an effective recovery is compressed. Proper situational awareness is paramount to upset recovery. When an encountering aircraft transits a wake vortex low to the ground (low potential energy), relatively slow (low kinetic energy), and at a higher AOA as would occur during takeoff or landing, the situation may be critical. Prevention and avoidance of wake vortices is always the goal, but if the pilot recognizes that their aircraft is beginning to encounter wake vortices, evasive actions are to be enacted to prevent aircraft upset.

11 **PILOT WAKE VORTEX ENCOUNTER REPORTING.** Wake vortex encounter reporting is an important aspect of ensuring current aircraft wake separation standards and guidance are effective. Only a pilot knows that they have had a wake vortex encounter. The pilot experiencing a wake vortex encounter is responsible for reporting it. When reporting, pilots are advised to be as specific as possible, including details such as location, altitude, aircraft configuration, phase of flight, roll rate, maximum bank angle, changes to altitude and airspeed, etc.

11.1 **Reporting to ATC.** When in contact with ATC, pilots are advised to report all suspected wake vortex encounters as soon as practical to ATC. When uncontrolled by ATC, pilots may call ATC by radio or telephone to report a wake vortex encounter. When reporting a wake vortex encounter, pilots are advised to take care to distinguish between a wake vortex encounter and atmospheric turbulence. Pilot reports of aircraft wake vortex encounters received through ATC are recorded as a Mandatory Occurrence Reports (MOR) per FAA Order JO 7210.632, Air Traffic Organization (ATO) Occurrence Reporting.

11.2 **Aviation Safety Reporting System (ASRS).** Pilots are advised to utilize the National Aeronautics and Space Administration (NASA) ASRS to report wake vortex encounters. A pilot may file ASRS reports by visiting the NASA Ames Research Center website at https://asrs.arc.nasa.gov/.

11.2.1 Pilot reports of wake vortex encounters through the NASA ASRS system are de-identified. As a part of the NASA Ames research system, de-identified quarterly reports of wake vortex encounters are supplied to the FAA. These reports document event dynamics and contributing factors underlying each reported wake vortex encounter. A sampling of the factors to be analyzed includes the assessed magnitude of the wake encounter, aircraft spacing, aircraft type, runway configuration, and consequences of the encounter.

11.3 **Operator Reporting Policies.** Additionally, air carriers and operators may have policies regarding how to report wake vortex encounters, including Aviation Safety Action Programs (ASAP), Aircraft Communications Addressing and Reporting System (ACARS), or other records used by that operator, such as a captain's report.

11.4 FAA Hotline. The FAA Hotline accepts reports related to the safety of the National Airspace System (NAS), violations of Title 14 of the Code of Federal Regulations (14 CFR), aviation safety issues, and reports related to FAA employees or FAA facilities. The FAA Hotline provides a single venue for FAA employees, the aviation community, and the public to file their reports. Visit the FAA Hotline web page at https://www.faa.gov/about/office_org/headquarters_offices/aae/programs_services/faa_hotlines.

11.5 Notification of Aircraft Accidents or Incidents. If an accident or incident occurs, pilots are advised to remain in compliance with the reporting requirements of 49 CFR part 830.

APPENDIX A. ADMINISTRATIVE INFORMATION

A.1 Advisory Circular (AC) Feedback Form. For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.

A.2 Related Publications.

A.2.1 ACs. The current editions of each of the following ACs can be found at at https://www.faa.gov/regulations_policies/advisory_circulars/ and on the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

- AC 91-79, Aircraft Landing Performance and Runway Excursion Mitigation.
- AC 120-88, Preventing Injuries Caused by Turbulence.
- AC 120-109, Stall Prevention and Recovery Training.
- AC 120-111, Upset Prevention and Recovery Training.
- AC 120-123, Flightpath Management.

A.2.2 Orders. You can find current and historical FAA orders at https://www.faa.gov/regulations_policies/orders_notices/ and on DRS at https://drs.faa.gov under "Air Traffic Organization (ATO)," "Air Traffic Plans and Publications."

- FAA Order JO 7110.65, Air Traffic Control.
- FAA Order JO 7110.126, Consolidated Wake Turbulence (CWT).
- FAA Order JO 7110.308, Simultaneous Dependent Approaches to Closely Spaced Parallel Runways.
- FAA Order JO 7110.316, Reduced Wake Turbulence Separation on Departure from Heavy/B757 Aircraft Departing Parallel Runways, Spaced Less Than 2,500 Feet, Using Wake Turbulence Mitigation for Departures (WTMD).
- FAA Order JO 7360.1, Aircraft Type Designators.

A.2.3 International Civil Aviation Organization (ICAO) Guidance. ICAO Doc 4444, Procedures for Air Navigation Service (PANS).

A.2.4 Other Related References.

- Wake Turbulence Training Aid: https://www.faa.gov/training_testing/training/wake.
- Airplane Upset Prevention and Recovery Training Aid: https://www.icao.int/safety/LOCI/AUPRTA/index.html.

- FAA-H-8083-3, Airplane Flying Handbook.
- Pilot's Guide to Takeoff Safety: https://www.faa.gov/sites/faa.gov/files/other_visit/aviation_industry/airline_operators/training/takeoff_safety.pdf.

A.3 Abbreviations and Acronyms.

Acronym	Definition
AC	Advisory Circular
ACARS	Aircraft Communications Addressing and Reporting System
AFM	Aircraft Flight Manual
AIM	Aeronautical Information Manual
AIP	Aeronautical Information Publication
AOA	Angle of Attack
ASAP	Aviation Safety Action Program
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
ATO	Air Traffic Organization
AURTA	Airplane Upset Recovery Training Aid
CFR	Code of Federal Regulations
Contrails	Condensation Trails
CVFP	Charted Visual Flight Procedures
CWT	Consolidated Wake Turbulence
DRS	Dynamic Regulatory System
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
LOC-I	Loss of Control In Flight
MOR	Mandatory Occurrence Report
MRS	Minimum Radar Separation
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NM	Nautical Mile
NOWGT	No Weight

Acronym	Definition
PIO	Pilot-Induced Oscillation
RBDM	Risk-Based Decision Making
RECAT	Wake Turbulence Recategorization
SOIA	Simultaneous Offset Instrument Approach
SLOP	Strategic Lateral Offset Procedure
SRS	Same Runway Separation
TDZ	Touchdown Zone
TDZE	Touchdown Zone Elevation
V_A	Maneuvering Speed
V_B	Turbulent Air Penetration Speed
V_O	Operating Maneuvering Speed
WTC	Wake Turbulence Category
WTMA	Wake Turbulence Mitigation for Arrivals
WTMD	Wake Turbulence Mitigation for Departures
VFR	Visual Flight Rules

APPENDIX B. MISCELLANEOUS ATC WAKE SEPARATION EFFORTS

B.1 Same Runway Separation (SRS). SRS, per FAA Order JO 7110.65, Air Traffic Control, separates aircraft taking off from the same or a parallel runway separated by less than 2,500 feet. Air traffic control (ATC) will not issue clearances that imply or indicate approval of rolling takeoffs by "Super" or "Heavy" aircraft or clear a small aircraft to line up and wait on the same runway behind a departing "Super" or "Heavy" aircraft to apply the necessary intervals. ATC categorizes aircraft in this scenario in 3 categories. As specified in Order JO 7110.65, Paragraph 3-9-6, Same Runway Separation, SRS Category I is single-engine propeller driven aircraft weighing 12,500 pounds or less and all helicopters, Category II is twin-engine propeller driven aircraft weighing 12,500 pounds or less, and Category III is all other aircraft.

B.2 Intersecting Runway/Intersecting Flightpath Operations. ATC will separate aircraft taking off behind a departing or landing aircraft on an intersecting runway if flightpaths will cross. An example of separation required is 2 minutes behind a "Heavy" (3 minutes behind a "Super").

B.3 Converging Runway Operations. If the extended centerline of a runway crosses a converging runway or the extended centerline of a converging runway at 1 nautical mile (NM) or less from either departure end, the operation will be considered an intersecting runway/intersecting operation, with some exceptions.

B.4 Adjacent Airport Operations. ATC, at adjacent airports, must separate arriving or departing instrument flight rules (IFR) aircraft on a course that will cross the flightpath of an aircraft requiring wake turbulence separation. An example of separation required is 2 minutes behind a "Heavy" (3 minutes behind a "Super").

B.5 Non-Radar Interval Minima. In a nonradar environment, ATC will separate aircraft based on time or passage of known waypoints for distance. An example of the required interval behind a "Heavy" is 3 minutes or 6 miles (up to 4 minutes or 8 miles behind a "Super").

B.6 Wake Turbulence Mitigations for Arrivals (WTMA) Simultaneous Dependent Approaches. At airports with runways that are separated by 2,500 feet or less, per FAA Order JO 7110.308, Simultaneous Dependent Approaches to Closely Spaced Parallel Runways, certain airports are authorized simultaneous dependent approaches. Simultaneous approaches mean that two or more parallel runway may have approaches occurring at the same time. Dependent approaches are approaches where there is a relationship of the timing of the parallel approaches. In this case, it means that there is a required diagonal spacing between aircraft pairs on separate approaches, a lead aircraft and a trail aircraft. Specific conditions are required such as staggered runway thresholds that result in a vertical difference between approaches and/or adjustments to glidepath angles to achieve vertical separations.

B.7 Wake Turbulence Mitigations for Departures (WTMD). At airports with runways that are separated by 2,500 feet or less, authorized by FAA Order JO 7110.316, Reduced Wake Turbulence Separation on Departure from Heavy/B757 Aircraft Departing Parallel

Runways, Spaced Less Than 2,500 Feet, Using Wake Turbulence Mitigation for Departures (WTMD), departures from the upwind (WTMD-enabled) runway of the designated parallel runway pairs are allowed without wake turbulence separation when the appropriate meteorological conditions exist.