BASICS FOR AIR TRAFFIC CONTROL – WAKE TURBULENCE

MODULE OVERVIEW

Purpose: This module describes wake turbulence, the different categories of wake turbulence, the characteristics of each category, and their effect on Air Traffic Control (ATC).

MODULE OUTLINE

Lesson: Wake Turbulence

Purpose: The purpose of this lesson is to explain the components and basic characteristics of wake turbulence.

Objectives:

- Define wake turbulence
- Identify factors affecting wake turbulence intensity
- Describe wingtip vortices
- Identify hazards associated with an induced roll
- Describe helicopter downwash and vortices
- Identify the impact of wake turbulence on Air Traffic Control (ATC)

Topics:

- Wake Turbulence
- Vortices
- Factors Affecting Wake Turbulence Intensity
  - Vortex Strength
  - Weight
  - Shape of Wing and Configuration
  - Speed
- Knowledge Check
- Wingtip Vortices
  - Vortex Circulation
  - Vortex Behavior and Generation
  - Vortex Sink Rate
  - Vortex Movement at the Ground With No Wind
  - Vortex Movement at the Ground With Crosswinds
  - Ground Effect With a Tailwind
- Knowledge Check
- Induced Roll
  - Hazards
  - Vortex Roll
  - Counter Control
- Knowledge Check
- Helicopter Downwash
- Helicopter Vortices
- Jet Blast and Hazards

- Impact of Wake Turbulence on ATC
  - General Impact of Wake Turbulence
- Knowledge Check
- Review/Summary

Video – Wake Turbulence Avoidance (19:11 mins.)

Question and Answer Session – *Parking Lot*

Game – Point to Point

Question and Answer Session – *Parking Lot*

End-of-Module (EOM) Test

INTRODUCTION

LESSON	■ Wake Turbulence
TOTAL ESTIMATED RUN TIME	2 hrs. 17 mins
MODULE CONTENT	■ Module Overview ■ Lesson: Wake Turbulence ■ Video – Wake Turbulence Avoidance (19:11 mins.) ■ Q&A Session – Parking Lot ■ Game – Point to Point ■ Q&A Session – Parking Lot ■ End-of-Module Test

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Instruct students to select ***Wake Turbulence*** module link within Blackboard ■ Instruct students to read the module introduction and then wait quietly for additional instructions	Blackboard **EST. RUN TIME** 2 mins.

As noise is the by-product of thrust, wake turbulence is the by-product of lift. Additionally, wake turbulence is invisible to the eye.

To effectively provide wake turbulence separation, you must first understand wake turbulence and its causes and effects.

The purpose of this module is to identify wake turbulence and associated characteristics, and explain the effects wake turbulence has on Air Traffic Control (ATC).

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Wake Turbulence*** lesson in Blackboard ■ Instruct students to navigate to the ***Wake Turbulence*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 30 mins.

WAKE TURBULENCE

Purpose: This lesson explains the components and basic characteristics of wake turbulence.

Objectives:

- Define wake turbulence
- Identify factors affecting wake turbulence intensity
- Describe wingtip vortices
- Identify hazards associated with an induced roll
- Describe helicopter downwash and vortices
- Identify the impact of wake turbulence on Air Traffic Control (ATC)

References for this lesson are as follows:

- FAA Order JO 7110.65, Air Traffic Control
- FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge
- Aeronautical Information Manual (AIM)

Wake Turbulence

Wake turbulence is a phenomenon resulting from the passage of an aircraft through the atmosphere. The term includes vortices, thrust stream turbulence, jet blast, jet wash, propeller wash, and rotor wash both on the ground and in the air.

Vortices

Vortices are circular patterns of air created by the movement of an airfoil through the air when generating lift.

- Vortices are a by-product of wing lift and are the most predominant factor contributing to aircraft wake turbulence
- As an airfoil moves through the atmosphere in sustained flight, an area of low pressure is created above it
- The air flowing from the high pressure area to the low pressure area around and about the tips of the airfoil tends to roll up into two rapidly rotating vortices, cylindrical in shape
- The vortices from large, heavy, and/or super aircraft can be extremely high velocity and hazardous to smaller aircraft

Factors Affecting Wake Turbulence Intensity

Vortex Strength

The strength of a vortex (rotational force) is governed by three factors:

- Weight of the generating aircraft
- Shape of the wing (wing configuration)
  - This determines wing loading, or how many pounds per square foot the wing is required to support
- Speed of the generating aircraft

The greatest vortex strength is generated when the aircraft is **heavy**, **clean**, and **slow**.

Some of the most intense vortices have been recorded at rotation speeds exceeding 300 feet per second (174 knots (kts)).

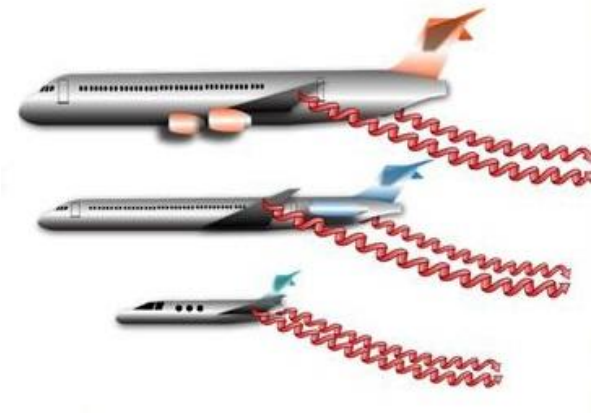
The strength of these vortices will diminish with **time** and **distance**.

Note: *The term "clean" refers to an aircraft's configuration when it has its gear up, no flaps extended, or any other type of wing extensions; e.g., air brakes.*

Weight

The weight of the aircraft is by far the greatest factor that affects the intensity of wake turbulence.

- Proportionately, the intensity and strength of the wake turbulence increase with the weight of the aircraft
- A heavier aircraft wing needs to support more weight, which results in greater wake turbulence



Every airplane and helicopter generates wake turbulence in flight regardless of its size.

Examples

Shape of Wing and Configuration

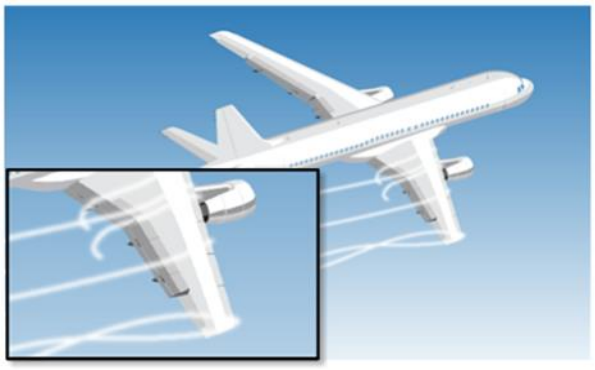
The intensity of the vortex can be changed when the flaps are extended.

Clean configuration

A clean configured wing allows for a stronger vortex to be generated because, without flaps, the wing has a smaller area and wing loading is therefore greater per square foot.

Dirty configuration

A dirty configuration wing increases the total wing area and decreases the wing loading. The flaps also disrupt the airflow over the wing and break down the formation of the vortex.



Speed

The slower the speed, the greater the chance for the wake to take form.

- This is especially critical for aircraft on approach to an airport

At higher speeds, the air flow over the wingtips is spread out and does not have as much of an opportunity to take form.

- A good example of this would be aircraft flying en route at flight levels

Aircraft at Slower Speed (On Approach)

Aircraft at Higher Speed (en route at Flight Levels)

Knowledge Check A

REVIEW what you have learned so far about wake turbulence and facts that affect wake turbulence. ANSWER the questions listed below.

1. The greatest wake turbulence is associated with which aircraft configuration? *(Select the correct answer.)*
   - ❑ Heavy, clean, fast
   - ❑ Heavy, dirty, slow
   - ❑ **Heavy, clean, slow**

2. Assuming similar aircraft, which aircraft would create a greater wake turbulence effect? *(Select the correct answer.)*
   - ❑ Aircraft cruising en route
   - ❑ **Aircraft on approach to the airport**
   - ❑ Aircraft on takeoff from airport

3. Which one of these has the greatest impact on wake turbulence? *(Select the correct answer.)*
   - ❑ Speed
   - ❑ **Weight**
   - ❑ Configuration

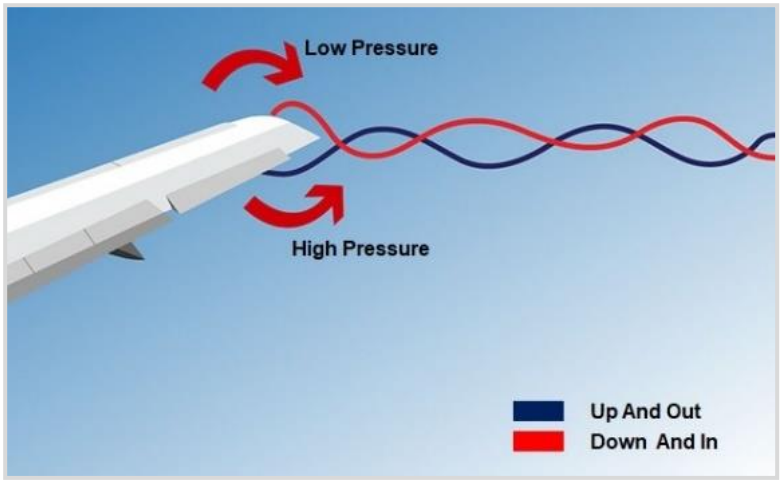
Wingtip Vortices

Lift is generated by the creation of pressure differential over the wing surface.

- Lowest pressure above the wing
- Highest pressure below the wing

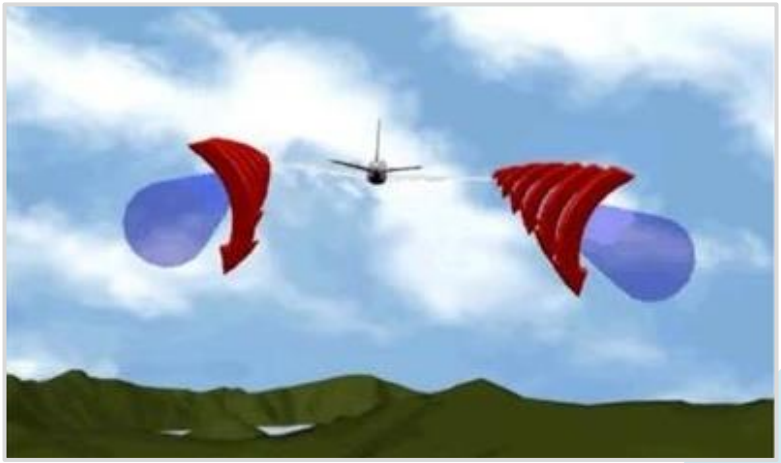
Pressure differential triggers a rollup of airflow.

- This results in a swirling air mass off of the wingtips trailing behind the aircraft
  - This is often known as ‘wake vortex’ or ‘wingtip vortices’



Vortex Circulation

When viewing aircraft from behind, vortex circulation off the wingtip is counterclockwise off right wing, clockwise off left wing. Both vortices will drift outward.



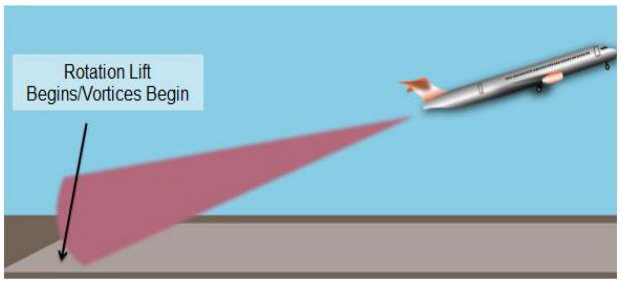
Vortex Behavior and Generation

Because vortices have certain behavioral characteristics, pilots can:

- Visualize the wake location
- Take precautions to avoid it

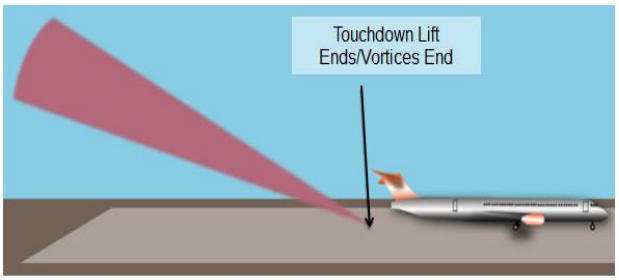
Vortices are generated at the moment the aircraft generates lift.

- Normally, this is when the nose wheel leaves ground



Vortices discontinue at the moment the aircraft stops generating lift.

- Normally, this is when all landing gear has touched down



Vortex Sink Rate

Vortices from larger aircraft:

- Sink several hundred feet per minute, approximately 300 to 500 feet per minute
- Normally level off 500 to 1,000 feet below the flight path
- Slowly move outward from their track
- Diminish in strength with time

Sink Rate = 300 to 500 Feet Per Minute

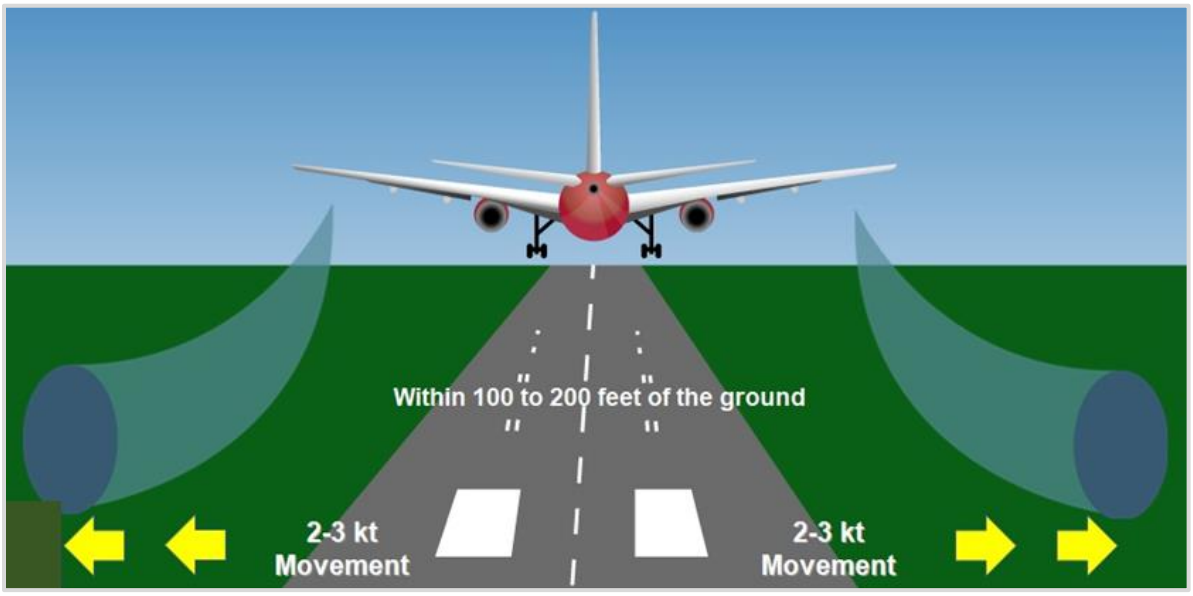
Under certain conditions, vortices may descend at a slower rate or may even climb slightly.

- A temperature inversion may slow the descent
- Light updrafts may cause the vortices to climb

Note: *You will be taught wake turbulence separation in the next stage of training. Separation is now based on time and/or distance.*

Vortex Movement at the Ground with No Wind

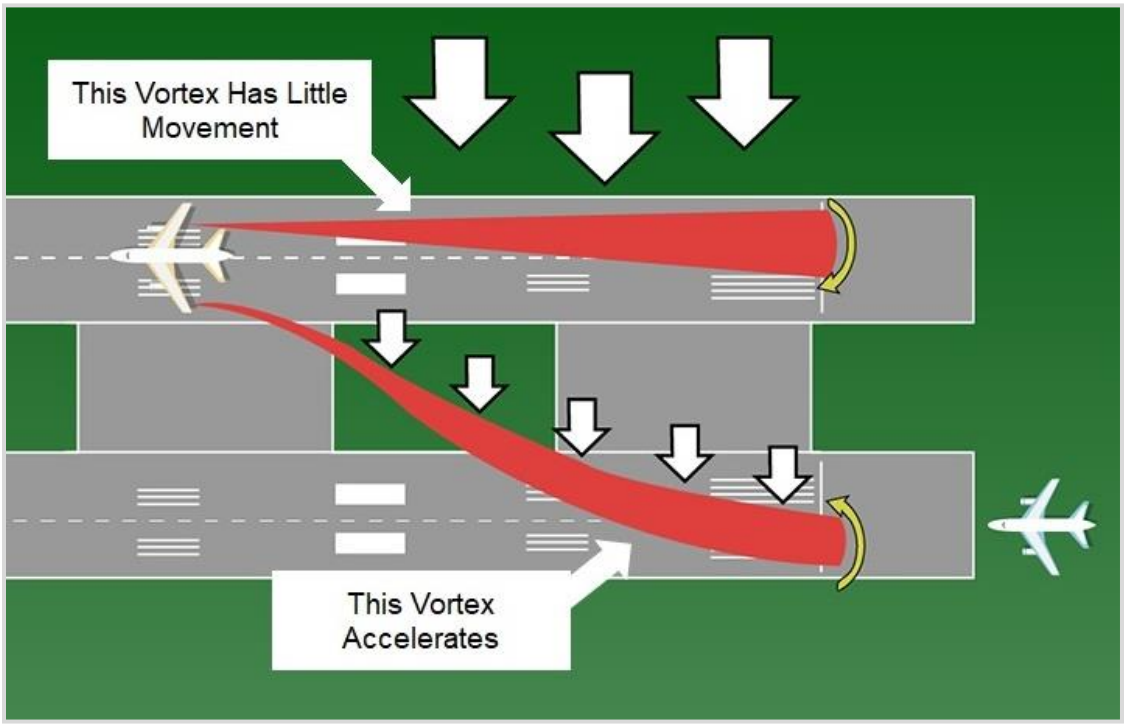
When close to the ground and there is zero wind, vortices from larger aircraft will move laterally.



Note: *Vortices move outward, away from the body of the aircraft because lift forms first at the root of the wing and then develops toward the wingtip. The associated vortices created as a result of this lift also move in the same manner and continue moving outward after spilling over the tips of the wings.*

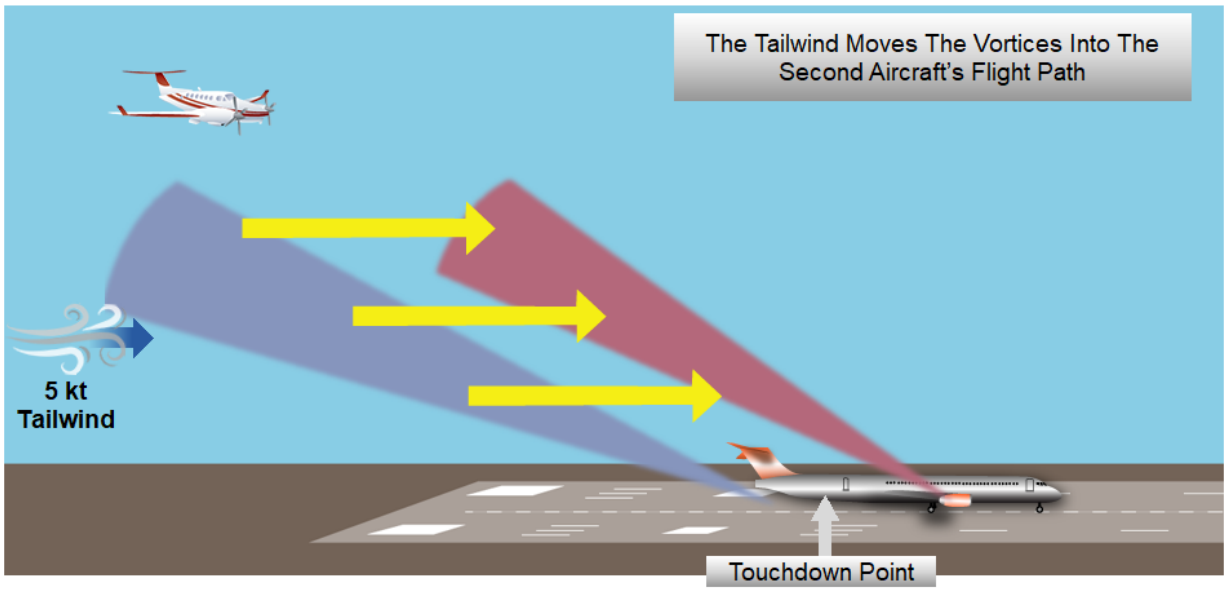
Vortex Movement at the Ground with Crosswinds

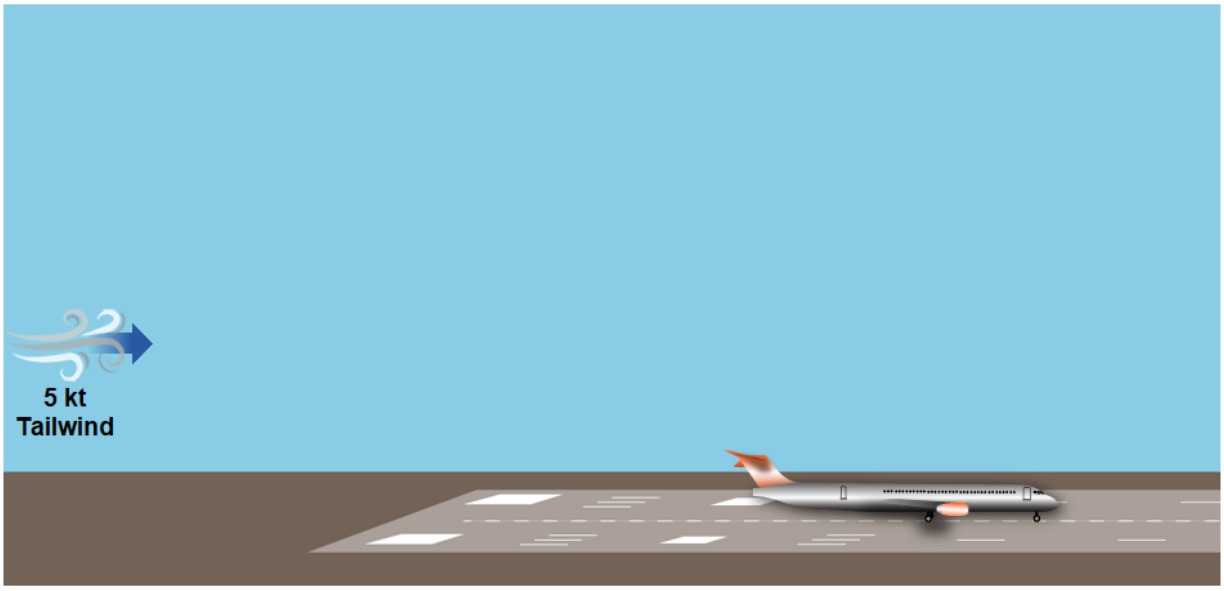
Crosswinds of 1 to 5 knots will decrease or stall the movement of one vortex while increasing the movement of another vortex. This increase could hasten the vortex arrival to another parallel runway.



Ground Effect with a Tailwind

Tailwinds can move vortices into the landing zones of aircraft that were originally trying to avoid the wake. Pilots and controllers should be aware of the presence of larger aircraft upwind from the approach or takeoff paths of smaller aircraft.





Knowledge Check B

REVIEW what you have learned so far about wake turbulence and facts that affect wake turbulence. ANSWER the questions listed below.

1. What is/are the name(s) given to the circular patterns created by wake turbulence? *(Select all correct answers that apply.)*
   - ❑ **Wake vortex**
   - ❑ Crosswinds
   - ❑ **Wingtip vortices**

2. When do vortices begin for a fixed-wing aircraft? *(Select the correct answer.)*
   - ❑ During approach while landing
   - ❑ As soon as engines have begun
   - ❑ **At rotation or when lift begins**

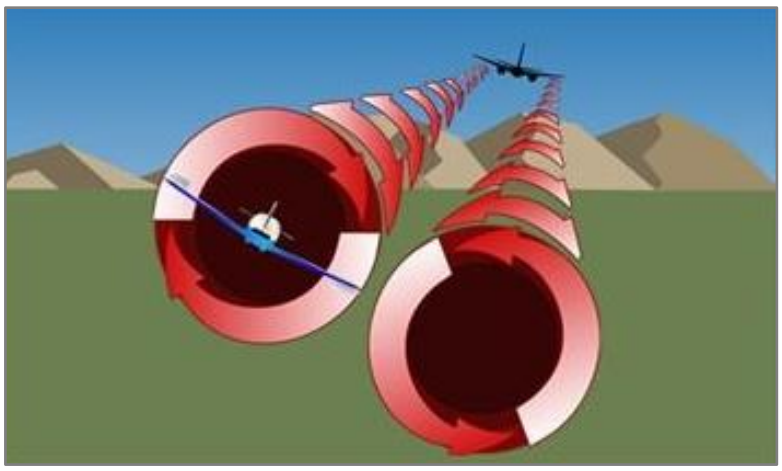
3. When observing an aircraft from behind, the circulation of vortices off the right wingtip is _____ and _____ off the left wingtip. *(Select the correct answer.)*
   - ❑ **Counterclockwise, clockwise**
   - ❑ Clockwise, counterclockwise
   - ❑ Down, outward

4. Vortices from larger aircraft will sink approximately 300 to 500 feet per minute and level off approximately _____ feet below the flight path. *(Select the correct answer.)*
   - ❑ 100 to 300
   - ❑ **500 to 1000**
   - ❑ 1000 to 2000

5. With no wind, vortices within 100 to 200 feet of the ground will move _____knots laterally across the ground. *(Select the correct answer.)*
   - ❑ 10 to 30
   - ❑ 5 to 10
   - ❑ **2 to 3**

Induced Roll

Induced Roll is the mechanical force a wake vortex has on an aircraft. With no counter control (roll control), the aircraft would roll completely, spinning on its longitudinal axis until the vortex sufficiently weakened.



Hazards

- In some rare cases, a wake turbulence encounter could cause inflight structural damage of catastrophic proportions
- The usual hazard is when the induced roll exceeds the level of roll control of the aircraft
  - Roll control is the ability of an aircraft to move around the longitudinal axis
- Serious and even fatal accidents induced by wake vortices do occur
- The heavier the aircraft, the more separation that must be given (or exist) for smaller aircraft when in trail (or following in trail)

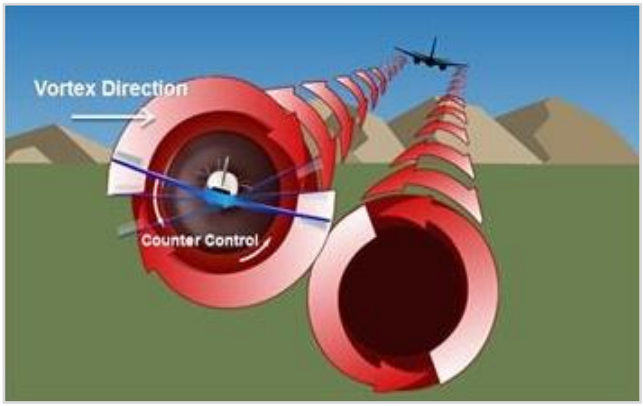
Vortex Roll

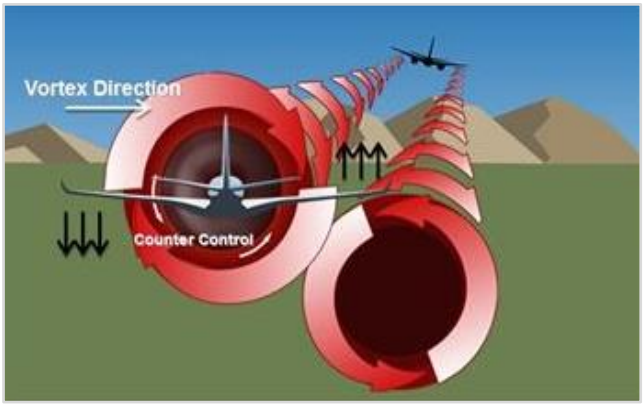
In experiments, it was shown that the ability of an aircraft to counteract the effects of the roll (counter control) is based on two things:

- The wingspan of the aircraft
- The counter control capability of the aircraft

Counter Control

An aircraft with a larger wingspan that extends beyond the outer edges of a vortex is better able to counter the roll effects of the vortex than a smaller aircraft whose wingspan is completely engulfed within a vortex.





Knowledge Check C

REVIEW what you have learned so far about wake turbulence and facts that affect wake turbulence. ANSWER the questions listed below.

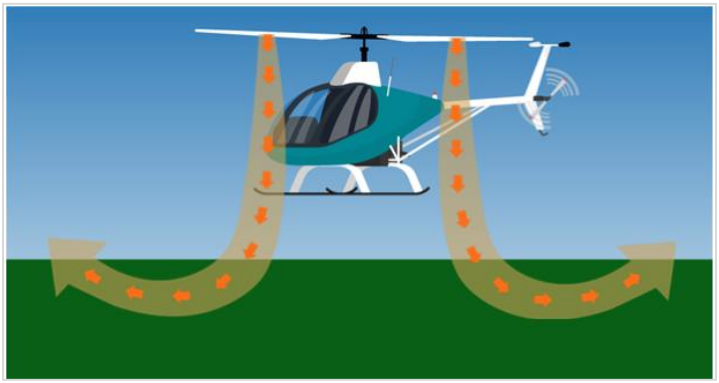
1. Why would extra spacing be necessary when smaller aircraft are following larger aircraft at a terminal environment? *(Select the correct answer.)*
   - ❑ To prevent obstructed sight of the runway
   - ❑ **To avoid the aircraft's wake turbulence vortices**
   - ❑ To clear a path for larger aircraft to maneuver

2. Counter control is most effective and roll is minimal when the wingspan and the ailerons extend beyond the _____ of the vortex. *(Select the correct answer.)*
   - ❑ End of vortex
   - ❑ Inside edges
   - ❑ **Outer edges**

Helicopter Downwash

In a slow hover taxi or a stationary hover, a helicopter will generate a downwash from its main rotors.

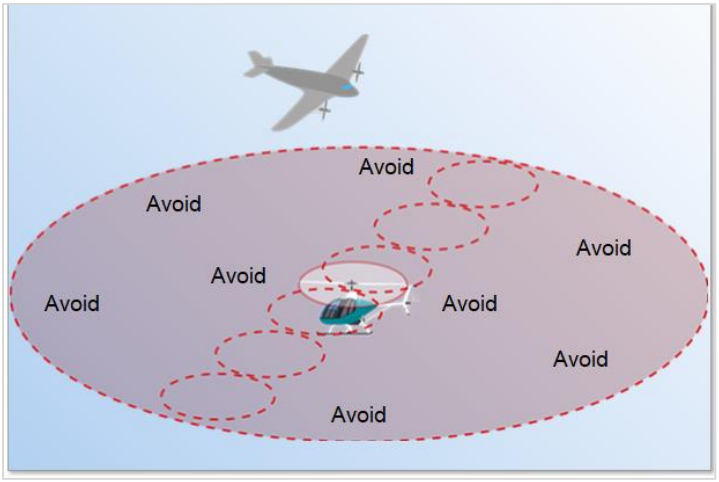
- This downwash produces a high-speed outward vortex as it reaches the ground
- These vortices spread outward to a distance of approximately 3 times the diameter of the rotor
- The downwash circulation is outward, upward, around, and away from the main rotors in **all** directions



Pilots should avoid operating within three rotor diameters of any helicopter that is in any type of hover.

Example

Slow Hover Taxi or Stationary Hover: Avoid Operations Within Distances of 3 Times Rotor Diameter



Helicopter Vortices

Helicopters will generate a pair of wingtip vortices when in forward flight.

- These vortices are strong, high-speed trailing vortices that are similar to wingtip vortices produced by larger fixed-wing aircraft

Pilots of smaller aircraft should use extreme caution when operating directly behind a helicopter in forward motion.

Jet Blast and Hazards

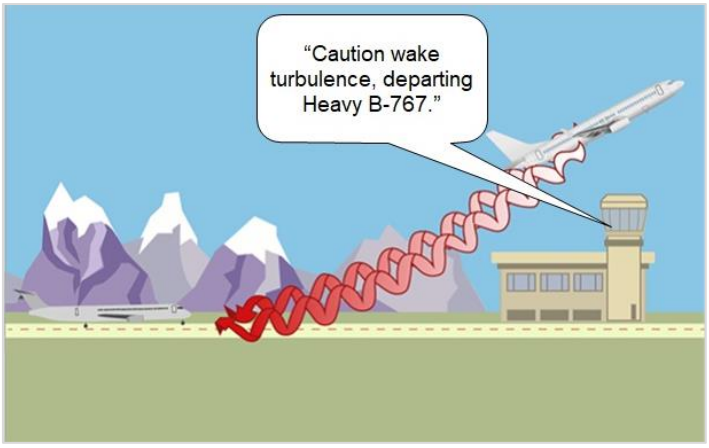
Jet blast is jet engine exhaust (thrust stream turbulence).

Hazards
Jet blast is normally experienced during ground operations and during initial takeoff roll prior to lift.

- It can cause damage and upsets if encountered at close range
- Light aircraft need to maintain adequate distance
- Pilots of larger aircraft should consider the effects of their jet blast on smaller aircraft or ground vehicles around them

The Impact of Wake Turbulence on ATC

- Wake turbulence can be encountered in flight or on the ground
- Because wake turbulence is unpredictable, the controller is not responsible for anticipating its existence or effects
- Although not mandatory, when issuing a cautionary advisory during ground operations, controllers may use the following terms in lieu of the term “wake turbulence”:
  - Jet blast
  - Prop wash
  - Rotor wash



General Impact of Wake Turbulence

The greatest impact wake turbulence has on ATC is increased separation for:

- Tower operations, both ground and airborne
- Radar operations for both approach and en route environments

Delays may occur due to increased separation, resulting in a lower airport acceptance rate.

Note: *The subject of “Wake Turbulence Separation” will be discussed in complete detail when you enter the next level of your training.*

An incident involving an Airbus (A380) and a Challenger (CL60) vividly illustrates the potential hazard of wake turbulence. The A380 passed 1000’ above the CL60, causing it to roll 3 to 5 times and lose 10,000’ feet in altitude. The CL60 was forced to make an emergency landing where stress fractures and popped rivets were discovered in the fuselage. Several passengers suffered injuries and the aircraft was damaged beyond repair. Incidents such as these have prompted the FAA to increase separation standards for the A380.

Knowledge Check D

REVIEW what you have learned so far about wake turbulence and facts that affect wake turbulence. ANSWER the questions listed below.

1. A hovering helicopter creates a downwash from its main rotors that can travel how far? *(Select the correct answer.)*
   - ❑ Five times the diameter of its rotors
   - ❑ **Three times the diameter of its rotors**
   - ❑ Two times the diameter of its rotors

2. When do helicopters generate wingtip vortices? *(Select the correct answer.)*
   - ❑ **Must be in forward flight**
   - ❑ While parked on a helipad
   - ❑ In a stationary hover

3. Why is the controller **NOT** responsible for anticipating the existence or effects of wake turbulence? *(Select the correct answer.)*
   - ❑ Increased separation and delays
   - ❑ Resources and staffing
   - ❑ **Because it is unpredictable**

4. Wake turbulence has the greatest impact on ATC in the areas of _____. *(Select the correct answer.)*
   - ❑ Damage and money
   - ❑ Resources and delays
   - ❑ **Increased separation and traffic delays**

Wake Turbulence Summary

Because wake turbulence is unpredictable, air traffic controllers are not responsible for anticipating its existence or effects of wake turbulence, but they must be knowledgeable of the phenomenon to effectively respond to hazardous situations generated by wake turbulence.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Wake Turbulence Avoidance: Pilot and Air Traffic Controller Briefing*** video in Blackboard ■ Instruct students to navigate to the ***Exercises and Activities*** folder in Blackboard ■ Instruct students to navigate to the video ***Wake Turbulence Avoidance: Pilot and Air Traffic Controller Briefing*** in Blackboard ■ ***Note:*** Movie controls in BB are limited to “Play” and “Pause” while not in full screen ■ Instruct students to select play to view the video ■ Upon completion of the video, students should review previously introduced content or wait quietly until other students have completed	Video **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in video ***Wake Turbulence Avoidance: Pilot and Air Traffic Controller Briefing*** ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the video content	Facilitated Discussion **EST. RUN TIME** 15 mins.

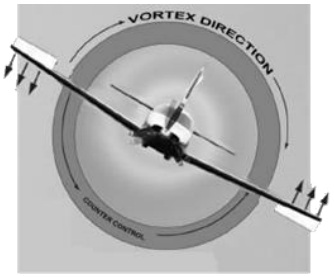
FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Point to Point*** game in Blackboard ■ Instruct students to navigate to the ***Exercises and Activities*** folder in Blackboard ■ Instruct students to complete ***Point to Point*** game located in this folder ■ The game will be performed individually ■ Instruct students to answer each question ■ The game will evaluate the students' performance at the end ■ Suggest allowing opportunities to repeat the game during periods of down time	Game **EST. RUN TIME** 15 mins.

GAME: POINT TO POINT (ANSWER KEY)

Note: *The questions in the key and their distractors may appear in a different order than displayed here due to game question randomization.*

Question	Answer
1. The term "wake turbulence" involves which of the following features?	**Thrust stream turbulence** **Rotor wash** **Jet blast** **Propeller wash** **Jet wash** Rotor blast Jet turbulence
2. Vortices…	**Are a by-product of wing lift** **Occur when low pressure is created above a moving airfoil** **Can be hazardous to small aircraft if they come from large, fast aircraft** Begin forming before an aircraft lifts off Are secondary features of aircraft wake turbulence

Question	Answer
3. The strength of a vortex (rotational force) is governed by…	**Weight, wing shape, and speed** Size, wing location, and speed Mass, direction, and fuselage shape
4. The intensity and strength of the wake turbulence will increase at the same rate with the _____ of the aircraft more than any other factor.	**Weight** Speed Altitude
5. Which statement is **NOT** true concerning how weight affects wake turbulence?	**Lighter aircraft will not generate wake turbulence in flight** The greater the amount of lift, the greater the wake turbulence Weight is the greatest factor that affects the intensity of wake turbulence The intensity and strength of wake turbulence increase with the weight of the aircraft
6. A _____configured wing is one where the flaps are up, resulting in a smaller wing area. Wing loading is greater, which allows for a stronger vortex to be generated.	**Clean** Dirty Smooth Rough
7. There is a greater chance for wake turbulence to take form when the aircraft is...	**Going slow** Going fast At a low altitude
8. How is lift generated over the wing surface?	**Lowest air pressure above the wing and highest pressure below the wing** Highest air pressure above the wing and lowest pressure below the wing None of the above
9. Which of the following statements are **NOT** true about wingtip vortices from large aircraft?	**Vortices remain the same under every condition** **A temperature inversion may increase the descent** **Wake vortices increase in strength with time** Vortices slowly move outward from their track Light updrafts may cause the vortices to climb When close to the ground, vortices will move laterally at zero wind Tailwinds can move vortices into the landing zones of aircraft

Question	Answer
10. Which plane would be in the most danger when being caught in wake turbulence?	  
11. If a helicopter is in any type of hover, how far away should a pilot distance themselves when operating an aircraft?	**Three rotor diameters** Eight rotor diameters Half-length of runway Twice the distance of the aircraft
12. On a slow hover helicopter, in which direction does the downward circulation generate from the main rotors?	**All directions** Outward Upward Around
13. During which of the following situations is jet blast typically experienced?	**Initial takeoff roll prior to lift** **Ground operations** Encounters with tailwinds Landing gear has touched down
14. Who is responsible for anticipating the existence or effects generated by wake turbulence?	**Pilot** Air traffic controller
15. A _____configured wing occurs when the flaps are down, resulting in an increased wing area. Wing loading is decreased, causing the flaps to disrupt the airflow over the wing and breaking down the formation of the vortex.	**Dirty** Clean Smooth Rough

SUMMARY

Because wake turbulence is unpredictable, air traffic controllers are not responsible for anticipating its existence or effects of wake turbulence, but they must be knowledgeable of the phenomenon to effectively respond to hazardous situations generated by wake turbulence.

In accordance with FAA Order JO 7110.65, Air Traffic Control; FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge; and the AIM, you should now be able to:

- Define wake turbulence
- Identify factors affecting wake turbulence intensity
- Describe wingtip vortices
- Identify hazards associated with an induced roll
- Describe helicopter downwash and vortices
- Identify the impact of wake turbulence on ATC

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content ■ Instruct students to prepare for the End-of-Module test by putting away their Student Guides	Facilitated Discussion **EST. RUN TIME** 15 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Wake Turbulence End-of-Module Test*** link in Blackboard ■ Instruct students: ○ Clear desks ○ Do not write anything during or after the test ○ Navigate to the ***Wake Turbulence End-of-Module Test*** link in Blackboard ○ Once they are satisfied with their responses, click “Save and Submit;” do not click “OK” to review results until directed to do so ○ Choose “Cancel” if they receive a warning message that the test has unanswered questions; choosing OK will submit the test and not allow them to go back and answer the questions ○ Leave the room after submitting the test and return at the “Be Back” time ■ ***Note:*** *This test is scored but not graded* ■ During test, monitor students to ensure a secure testing environment ■ Identify the most commonly missed questions by reviewing student statistics in Blackboard ■ Instruct students to click “View Results” when ready to review commonly missed questions ■ Review commonly missed questions with students	Blackboard Assessment **EST. RUN TIME** 20 mins.

END-OF-MODULE TEST (ANSWER KEY)

Note: *Test questions in Blackboard are presented to the students in random order. Please be aware the test key question order will not match the student version.*

1. According to the definition of wake turbulence, which of the following is **NOT** a phenomenon affecting flight safety? *(Select the correct answer.)*
   - ❑ **Mach buffet**
   - ❑ Rotor Wash
   - ❑ Propeller Wash
   - ❑ Jet blast

   Reference(s): JO 7110.65 Pilot/Controller Glossary

2. A _____ wing allows a stronger vortex to be generated because, without flaps, the wing has a smaller area and wing loading is greater per square foot. *(Select the correct answer.)*
   - ❑ **Clean-configured**
   - ❑ Delta
   - ❑ High
   - ❑ Low

   Reference(s): Aeronautical Information Manual (AIM), 7-3-3

3. What are the circular patterns created by wake turbulence? *(Select all correct answers that apply.)*
   - ❑ **Wake vortex**
   - ❑ **Wingtip vortices**
   - ❑ Vortex circulation
   - ❑ Vortex generation

   Reference(s): FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge 5-7

4. The ability of an aircraft to counteract the effects of the roll (counter control) is based on which of the following? *(Select all correct answers that apply.)*
   - ❑ **Wingspan of the aircraft**
   - ❑ **Counter control capability of the aircraft**
   - ❑ Current speed aircraft is traveling
   - ❑ Difference in weight distribution

   Reference(s): Aeronautical Information Manual (AIM), 7-3-3

5. What is the approximate distance the outward vortices generated from a helicopter in a slow hover taxi or stationary hover? *(Select the correct answer.)*
   - ❑ **Three times the diameter of the rotor**
   - ❑ Two times the diameter of the rotor
   - ❑ Three times the wingspan of the approaching aircraft
   - ❑ Two times the wingspan of the approaching aircraft

   Reference(s): Aeronautical Information Manual (AIM), 7-3-7

6. Which of the following terms may be used by controllers in lieu of the term “wake turbulence” when issuing a cautionary advisory during ground operations? *(Select all correct answers that apply.)*
   - ❑ **Jet blast**
   - ❑ **Rotor wash**
   - ❑ Vortex
   - ❑ Downwash

   Reference(s): JO 7110.65, 2-1-20