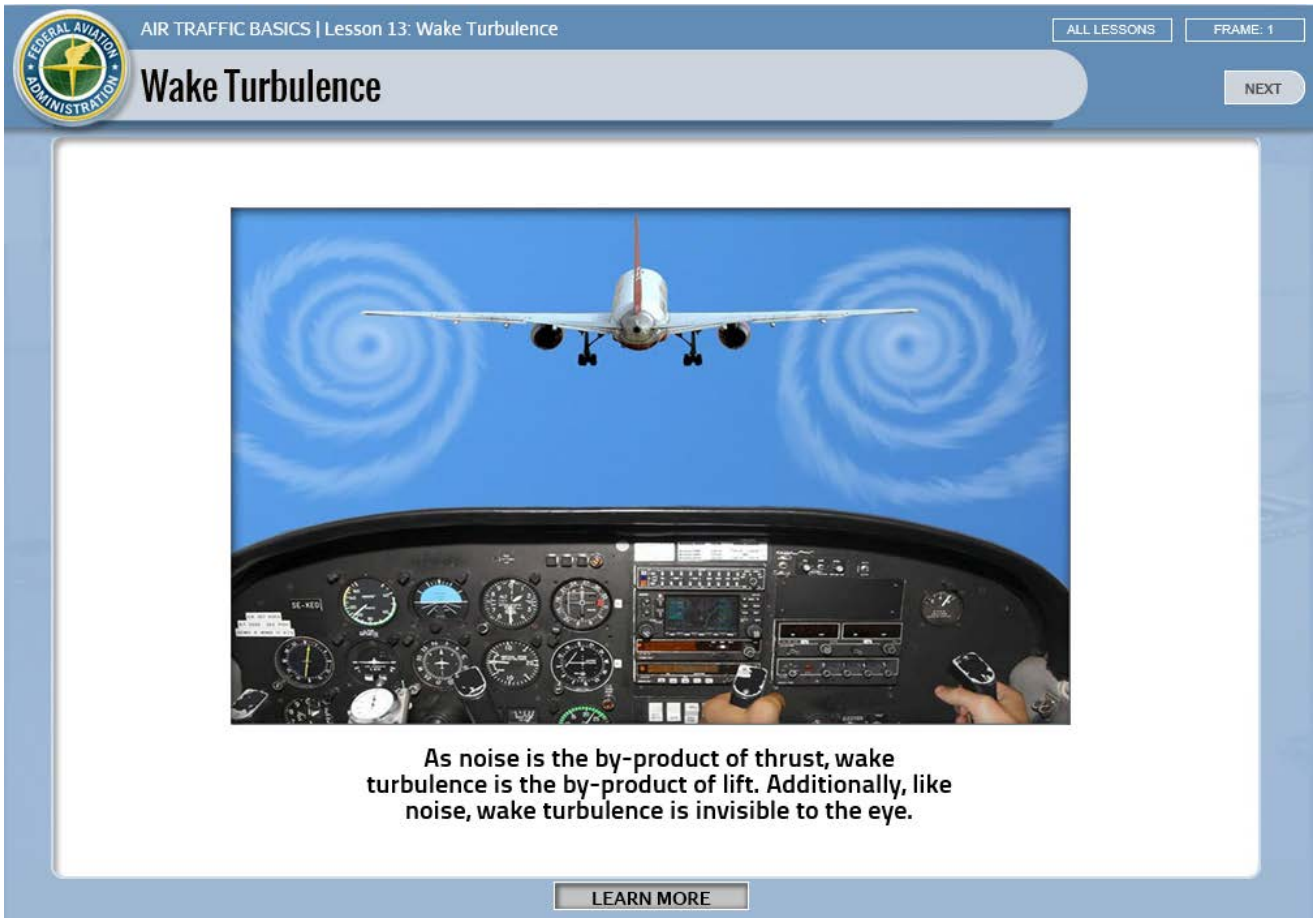
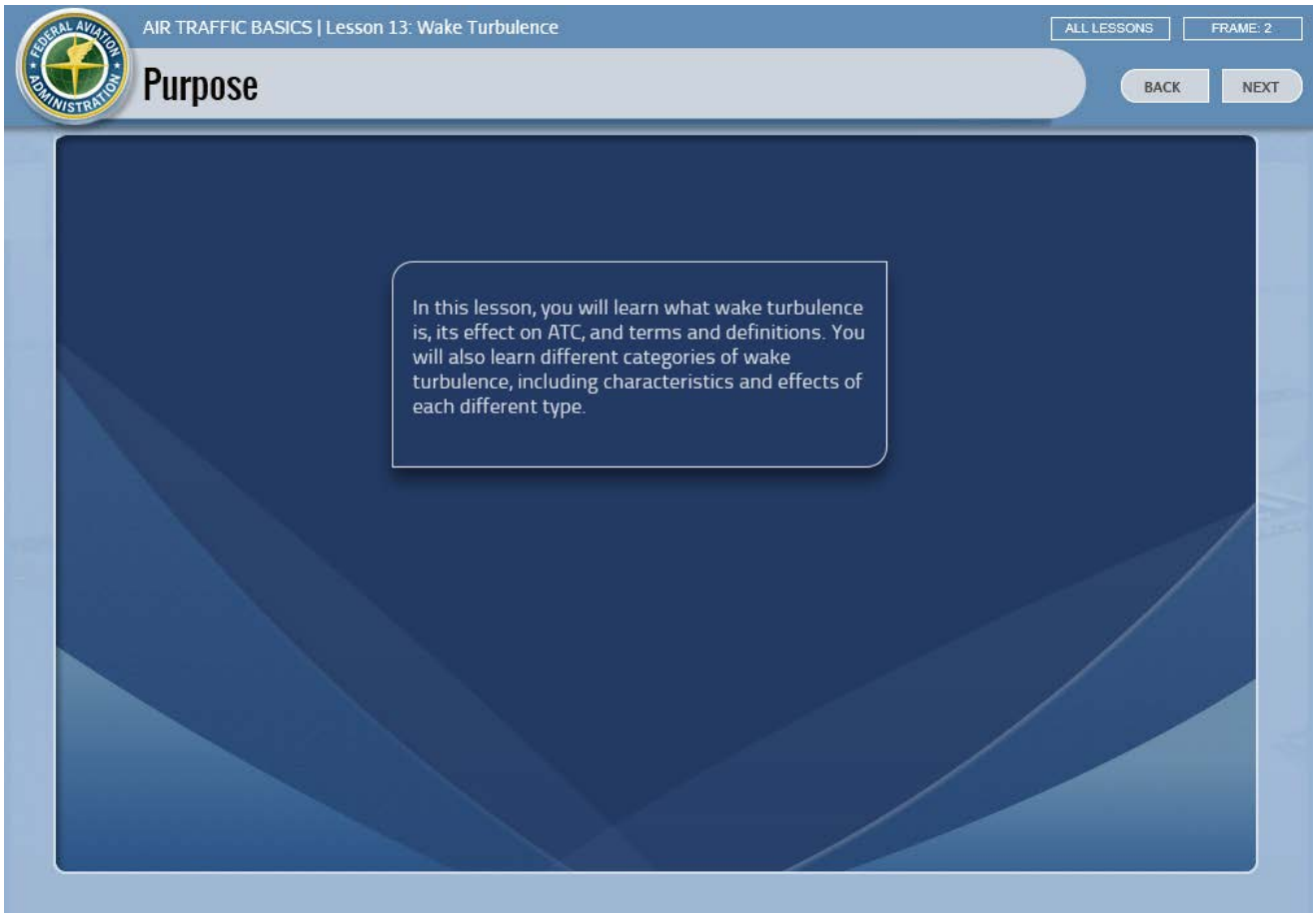
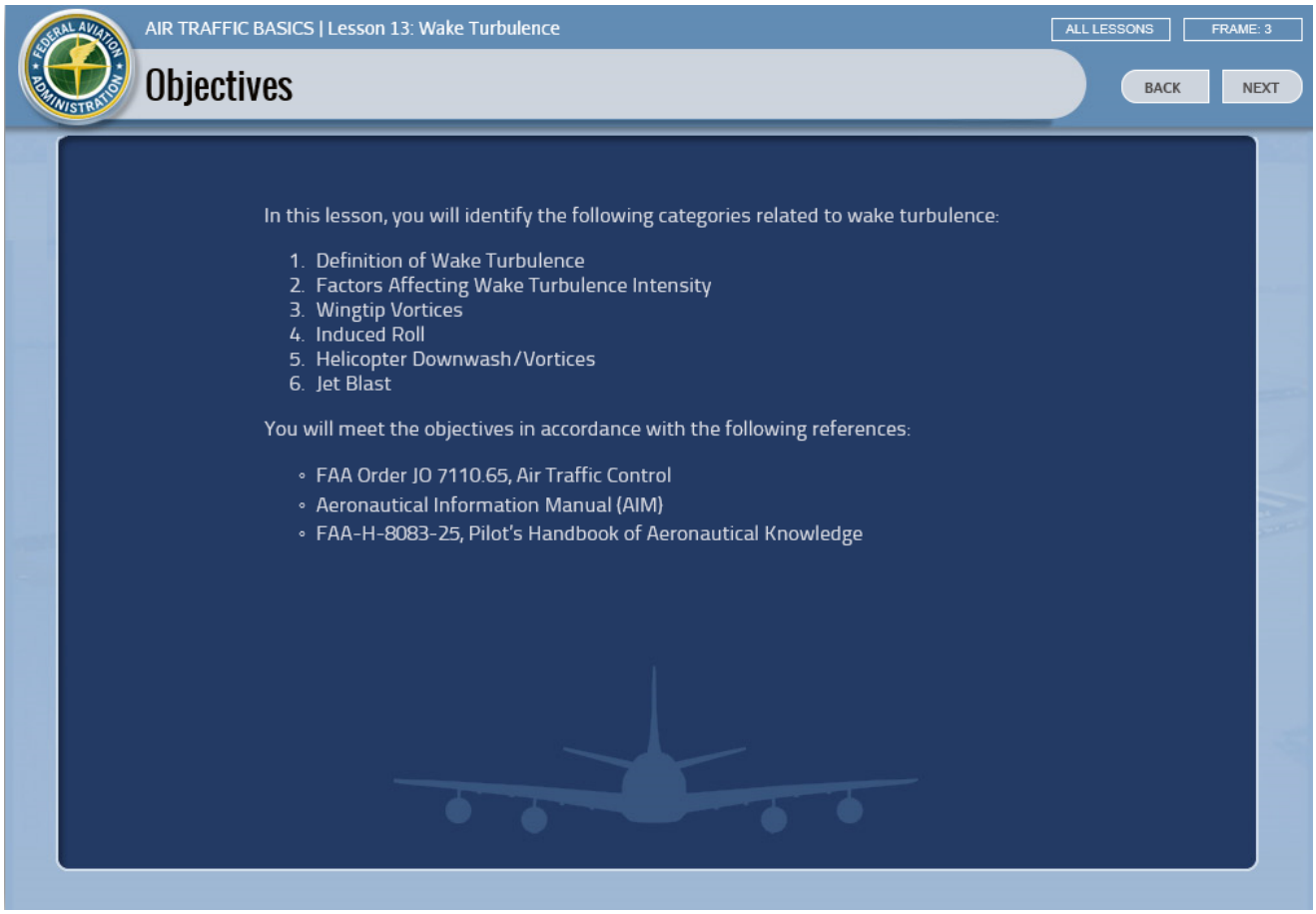


To effectively provide wake turbulence separation, you must first understand wake turbulence and its causes and effects.


AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 2
Purpose
BACK
NEXT
In this lesson, you will learn what wake turbulence is, its effect on ATC, and terms and definitions. You will also learn different categories of wake turbulence, including characteristics and effects of each different type.


AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 3
Objectives
BACK
NEXT
In this lesson, you will identify the following categories related to wake turbulence:
1. Definition of Wake Turbulence
2. Factors Affecting Wake Turbulence Intensity
3. Wingtip Vortices
4. Induced Roll
5. Helicopter Downwash/Vortices
6. Jet Blast
You will meet the objectives in accordance with the following references:
FAA Order JO 7110.65, Air Traffic Control
Aeronautical Information Manual (AIM)
FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 4

Terms and Definitions

BACK NEXT

Wake Turbulence Definition

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.

Wake turbulence describes the effect of the rotating air masses generated behind the wing tips of aircraft or behind the rotor tips of helicopters in forward motion. "Wake vortex," or "vortices," describe the nature of the air masses.

JO 7110.65, Pilot/Controller Glossary; AIM, 3

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 5

Terms and Definitions

BACK NEXT

Vortices Definition

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

JO 7110.65, Pilot/Controller Glossary

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 6

Terms and Definitions

BACK NEXT

Vortices

Vortices are a by-product of wing lift, and are the most predominant parts of 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 to heavy aircraft can be of extremely high velocity and hazardous to smaller aircraft.

JO 7110.65, Pilot/Controller Glossary; AIM, Chap. 7

LEARN MORE

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 7

Factors Affecting Wake Turbulence Intensity

BACK NEXT

Vortex Strength

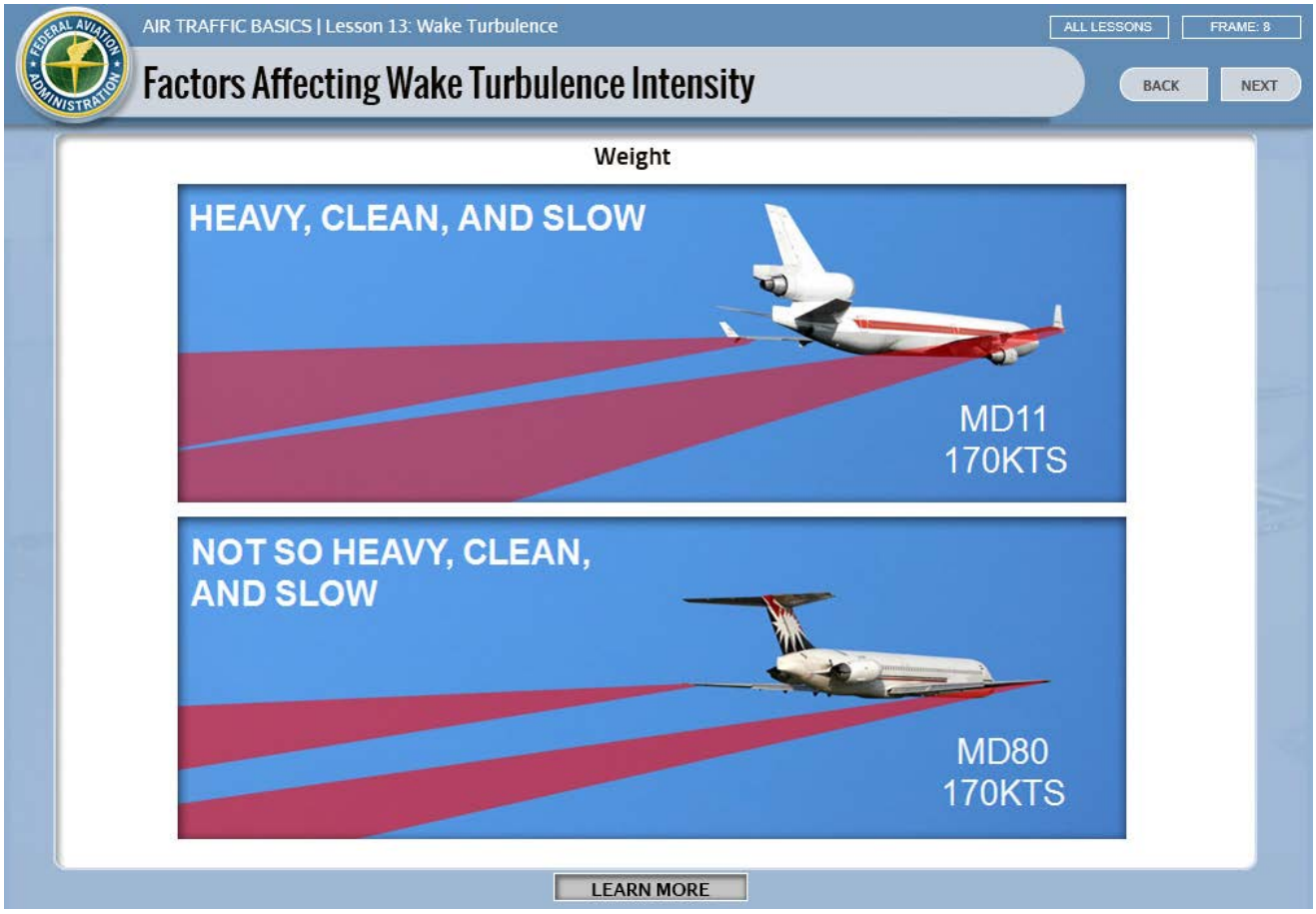
The strength of a vortex (rotational force) is governed by three factors:

- **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.

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).

AIM, Chap. 7



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.
- Since the wing needs to support more weight, the greater the amount of lift produced results in greater wake turbulence.

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

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 9

Factors Affecting Wake Turbulence Intensity

BACK NEXT

Shape of the Wing

Clean configuration

Dirty configuration

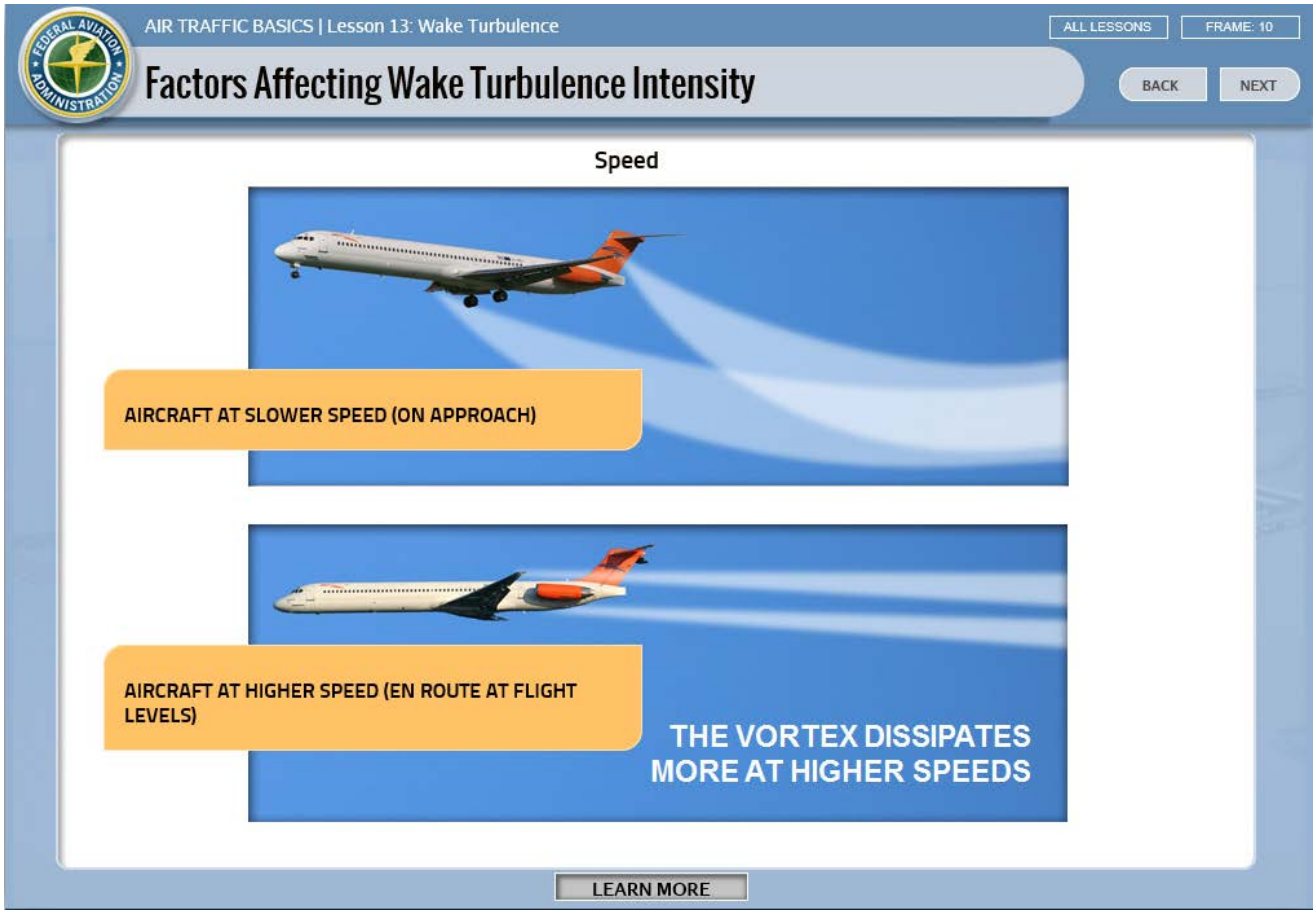
The intensity of the vortex can be changed when the flaps are extended.

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.

A dirty configured 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.

NOTE: If an aircraft extends flaps, lowers the gear, or changes the configuration of the wing, this is commonly referred to as a 'dirty configuration.'

AIM, Chap. 7



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 wing tips 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.

Reference: AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 11

Factors Affecting Wake Turbulence Intensity

BACK NEXT

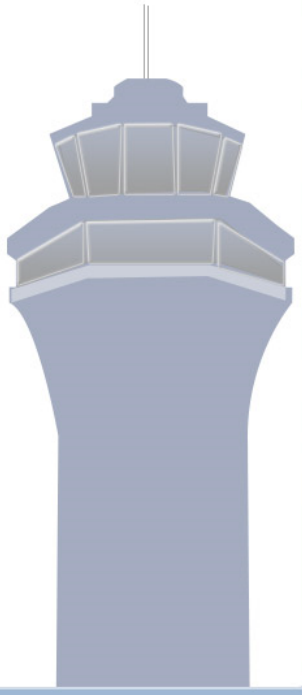
Vortex Strength

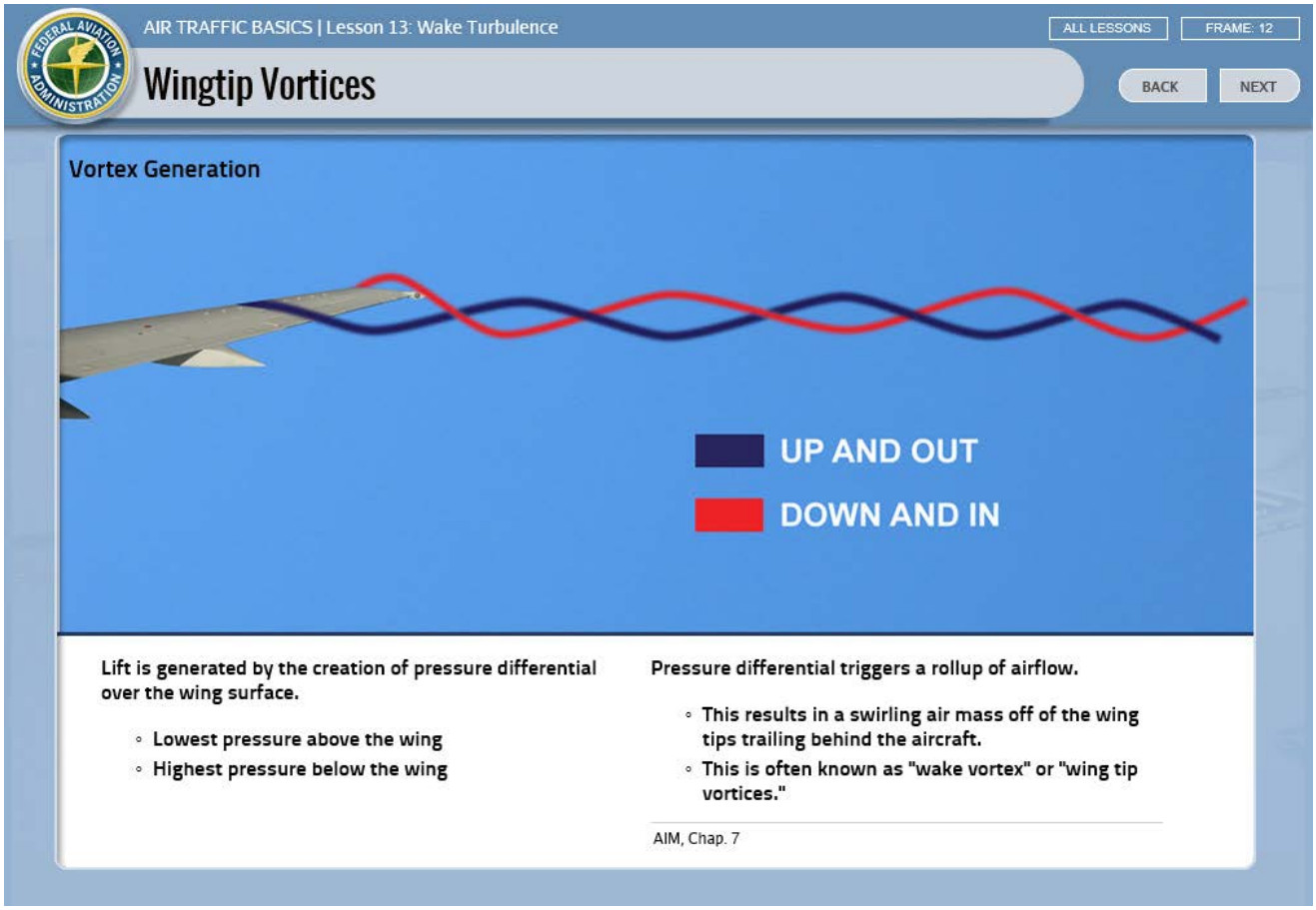
Some of the most intense vortices have been recorded at rotation speeds exceeding 300 feet per second (174 KTS).

The strength of these vortices will diminish with:

- **Time**
- **Distance**

AIM, Chap. 7




AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 12
Wingtip Vortices
BACK
NEXT
Vortex Generation
UP AND OUT
DOWN AND IN
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 wing tips trailing behind the aircraft.
This is often known as "wake vortex" or "wing tip vortices."
AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 13

Wingtip Vortices

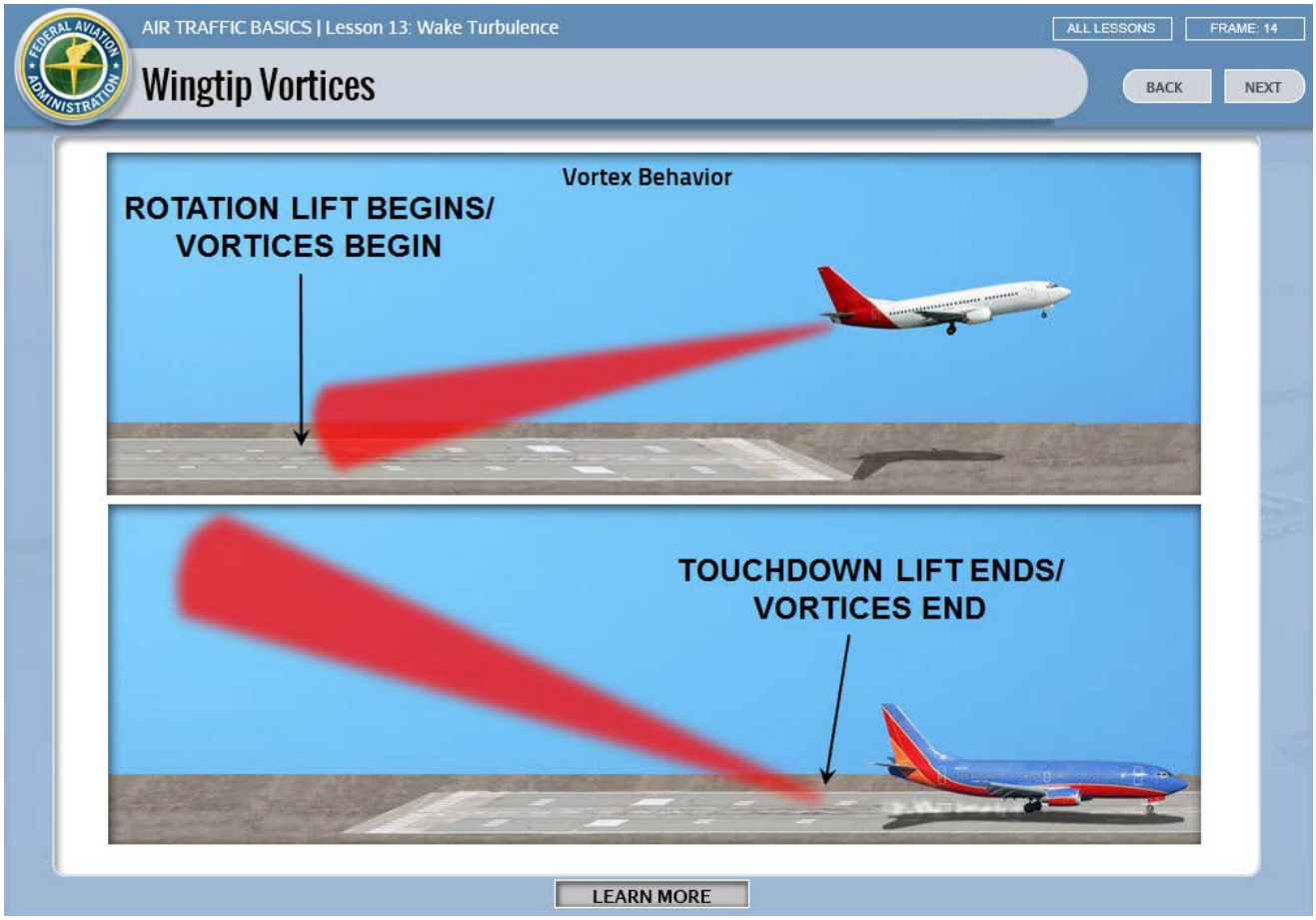
BACK NEXT

Vortex Generation

The rollup effect results in two counter-rotating cylindrical vortices causing wake turbulence.

AIM, Chap. 7

Play the video to observe the wake turbulence.



Because vortices have certain behavioral characteristics, pilots can:

- Visualize the wake location
- Take precautions to avoid it

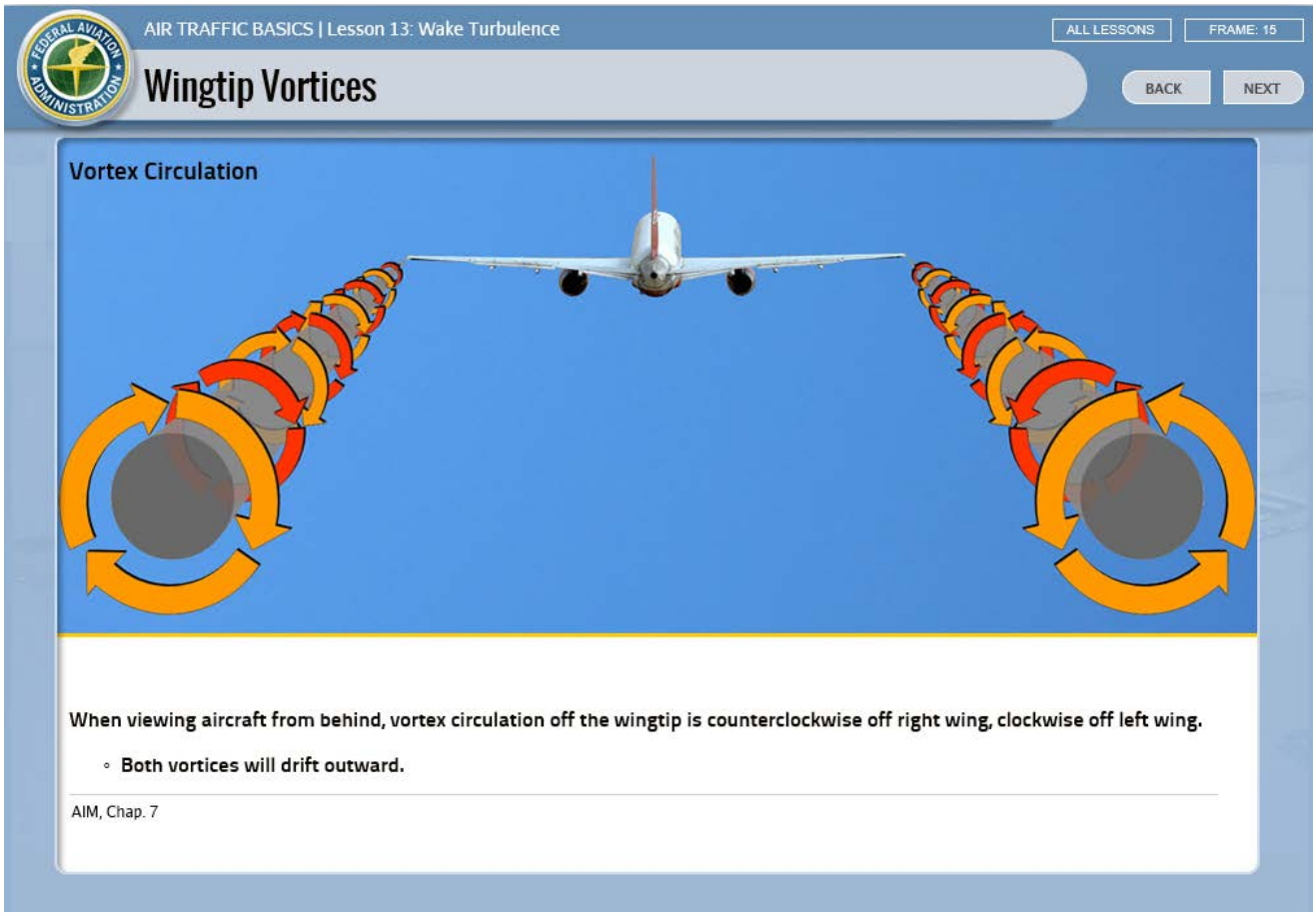
Vortices are generated at the moment the aircraft generates lift.

- 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.

Reference: AIM, Chap. 7

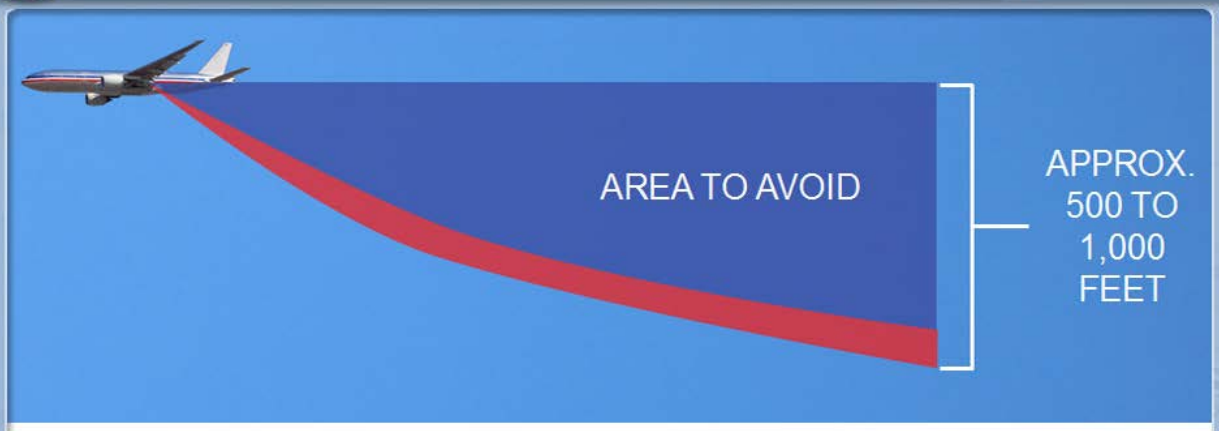

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 15
Wingtip Vortices
BACK
NEXT
Vortex Circulation
When viewing aircraft from behind, vortex circulation off the wingtip is counterclockwise off right wing, clockwise off left wing.
◦ Both vortices will drift outward.
AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 16

Wingtip Vortices

BACK NEXT



SINK RATE = 300 FEET TO 500 FEET PER MINUTE

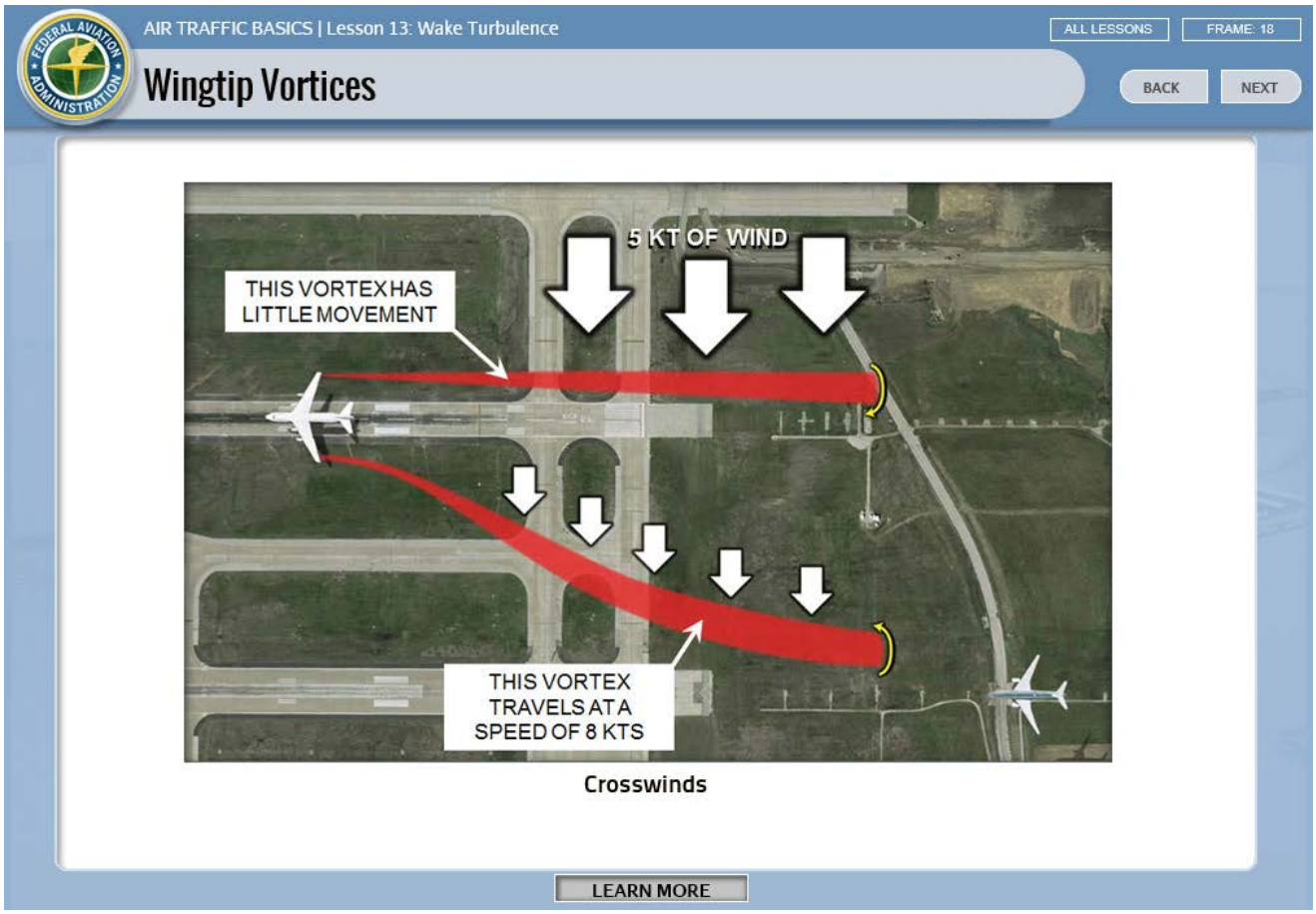
Vortex Sink Rate

Vortices from large 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
- Slow in descent and diminish in strength with time and distance

AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 17
Wingtip Vortices
BACK
NEXT
Ground Effect
2-3 KT MOVEMENT
2-3 KT MOVEMENT
When close to the ground and there is zero wind, vortices from large aircraft will move laterally:
Within 100 to 200 feet of the ground
2 to 3 knots laterally
AIM, Chap 7; FAA-H-8083-25, Chap 12

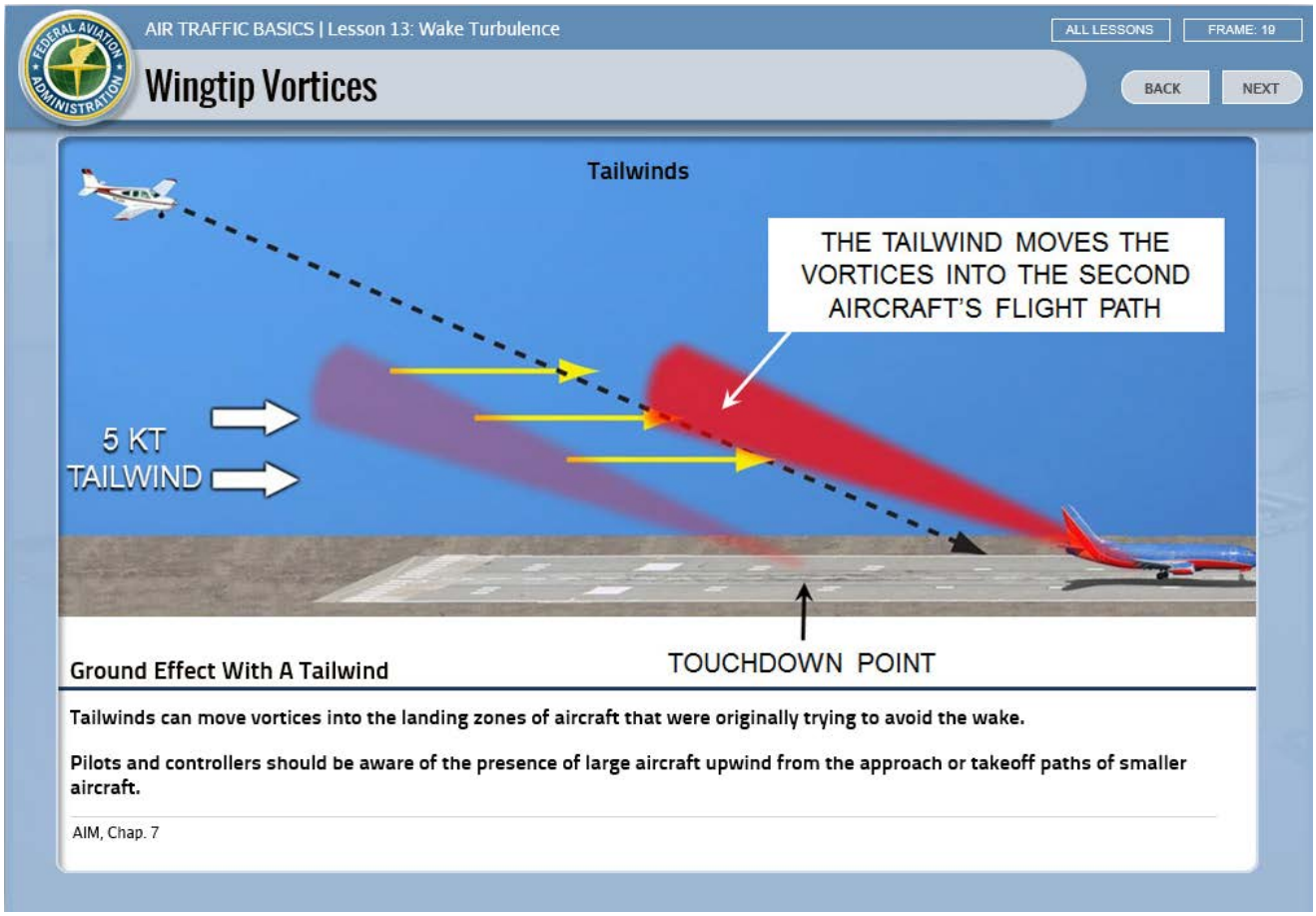


Ground Effect With Crosswinds

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.

Reference: AIM, Chap. 7


AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 19
Wingtip Vortices
BACK
NEXT
Tailwinds
THE TAILWIND MOVES THE VORTICES INTO THE SECOND AIRCRAFT'S FLIGHT PATH
5 KT TAILWIND
TOUCHDOWN POINT
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 large aircraft upwind from the approach or takeoff paths of smaller aircraft.
AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 20

Induced Roll

BACK NEXT

Hazards

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.

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 larger the aircraft the more separation must be given when following.

AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 21

Induced Roll

BACK NEXT

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

AIM, Chap. 7

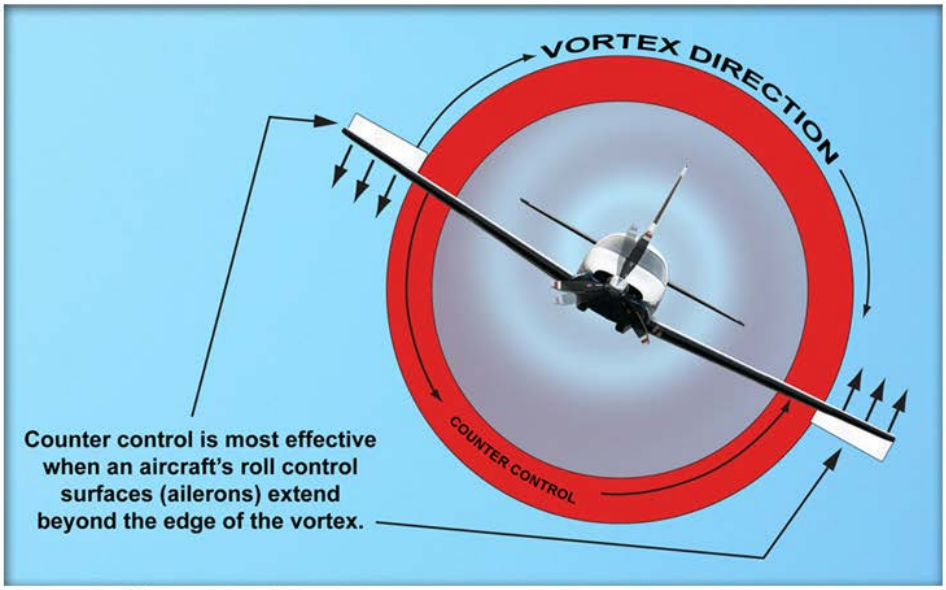
AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 22

Induced Roll

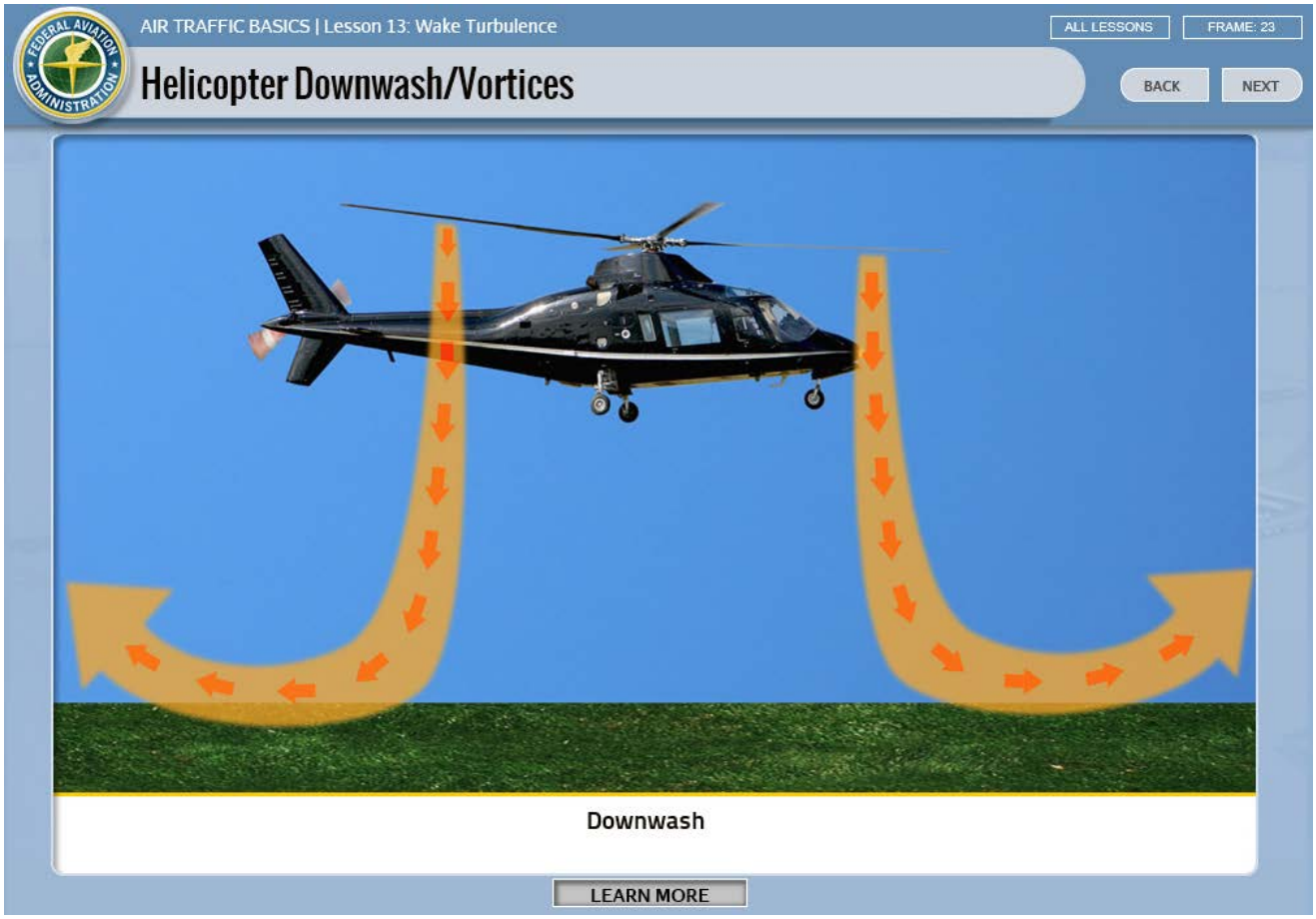
BACK NEXT

Counter Control



Counter control is most effective and roll is minimal when the wingspan and the ailerons extend beyond the outer edges of the vortex.

AIM, Chap. 7

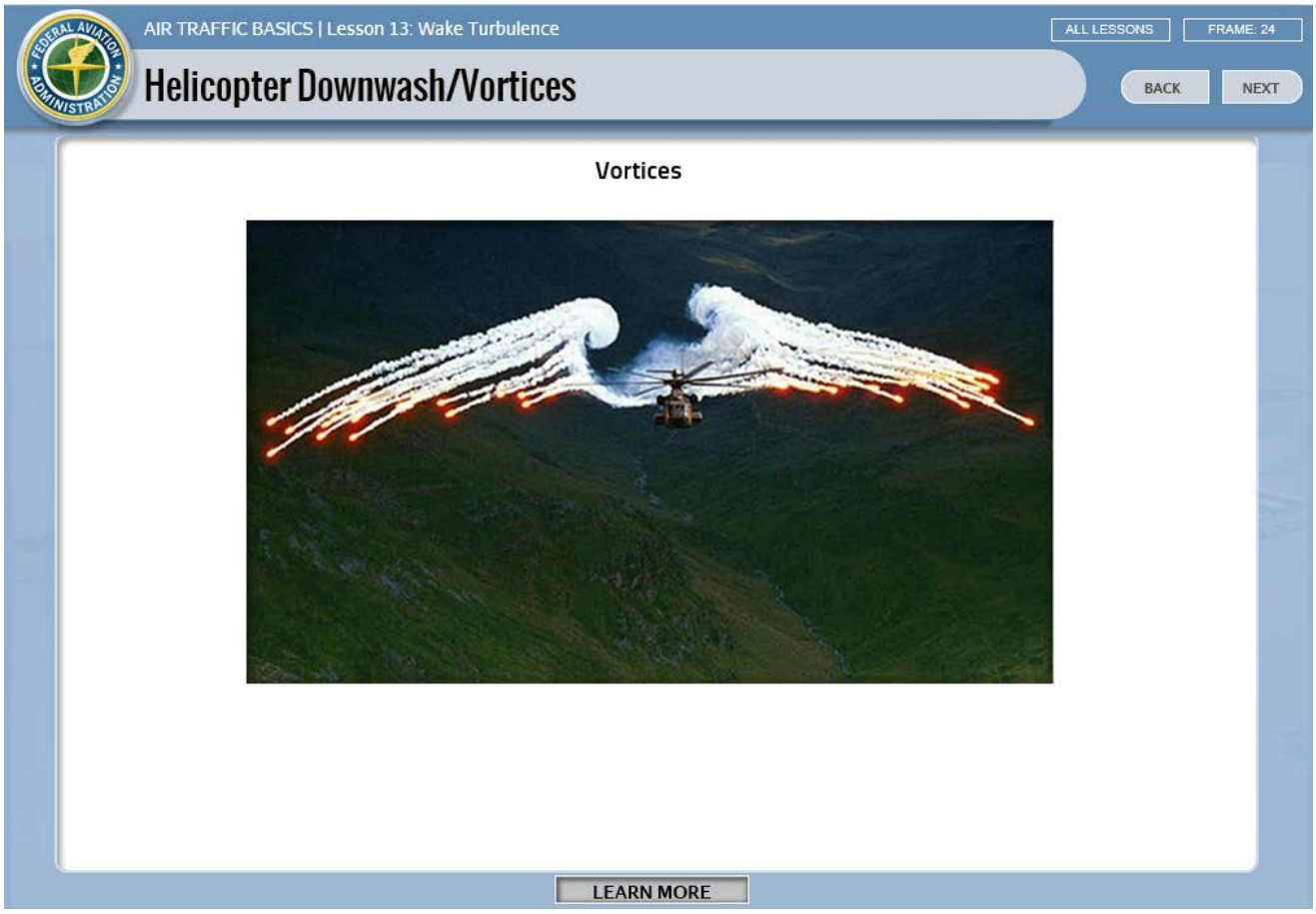


In a slow hover taxi, or a stationary hover, a helicopter will generate a downwash from its main rotors.

- This downwash produces a high speed outward vortex as it reaches the ground.
- These outward vortices will spread out to a distance of approximately three 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.

Reference: AIM, Chap. 7

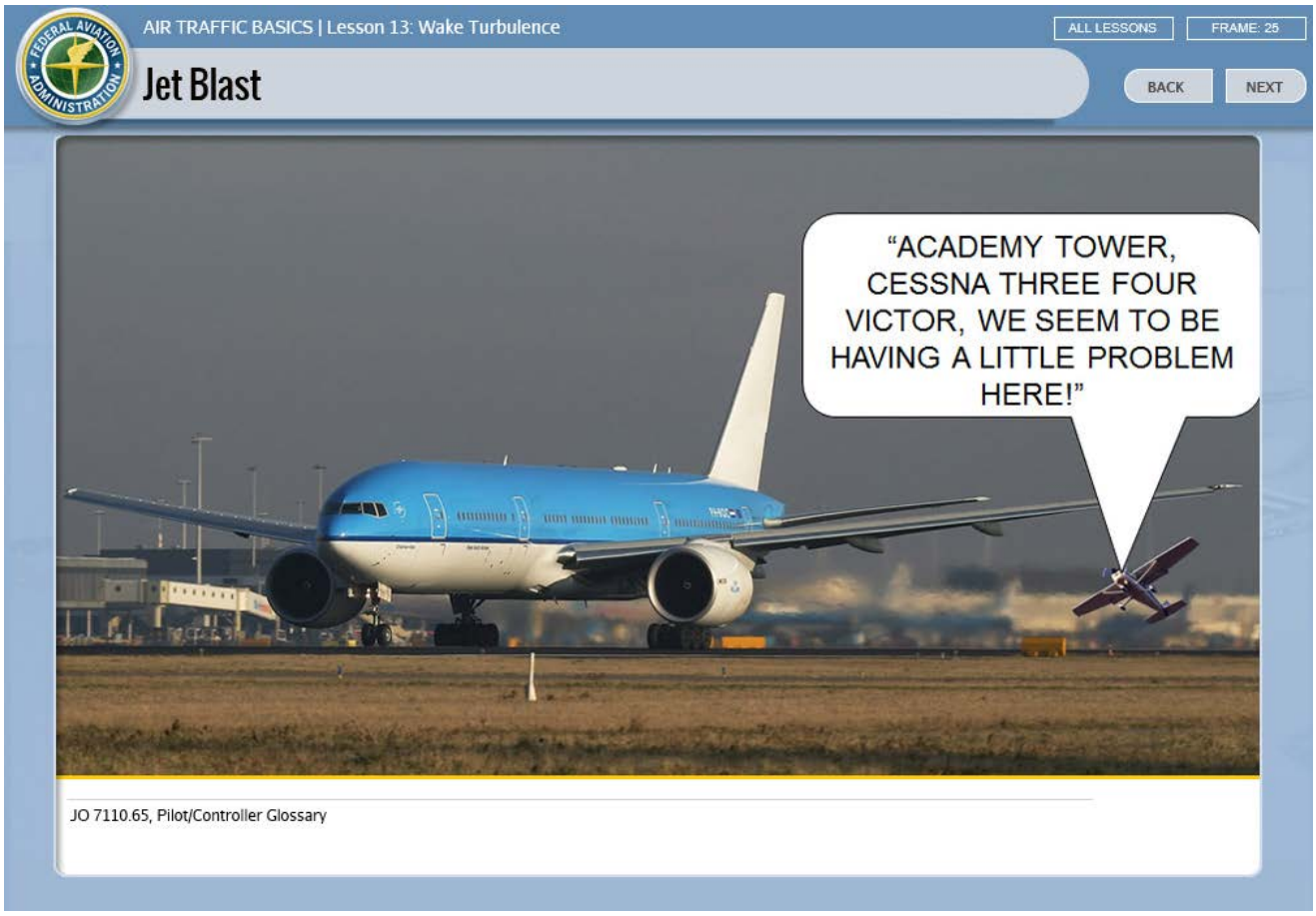


Helicopters will generate a pair of wingtip vortices when in forward flight.

- These vortices are strong, high-speed trailing vortices that are similar to wing tip vortices produced by larger fixed-wing aircraft.
- Some evidence indicates that per pound of gross mass, helicopter vortices are more intense than those of a fixed-wing aircraft.

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

Reference: AIM, Chap. 7


AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 25
Jet Blast
BACK
NEXT
"ACADEMY TOWER, CESSNA THREE FOUR VICTOR, WE SEEM TO BE HAVING A LITTLE PROBLEM HERE!"
JO 7110.65, Pilot/Controller Glossary

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 26

Jet Blast

BACK NEXT

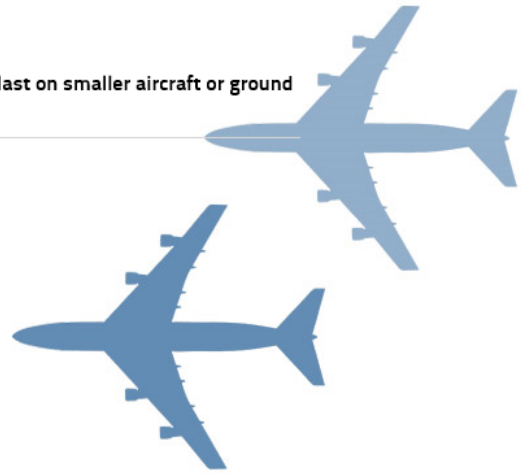
Jet Blast Hazards

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

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

- **Another name for jet blast is "thrust stream turbulence."**
- **It can cause damage and upsets if encountered at close range.**
- **It requires light aircraft to maintain adequate distance.**
- **Pilots of larger aircraft should consider the effects of their jet blast on smaller aircraft or ground vehicles around them.**

AIM, Chap. 7



AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 27

Impact of Wake Turbulence on ATC

BACK NEXT

Cautionary Information

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**

JO 7110.65, Chap. 2

AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence

ALL LESSONS FRAME: 28

General Impact of Wake Turbulence

BACK NEXT

General Impact of Wake Turbulence

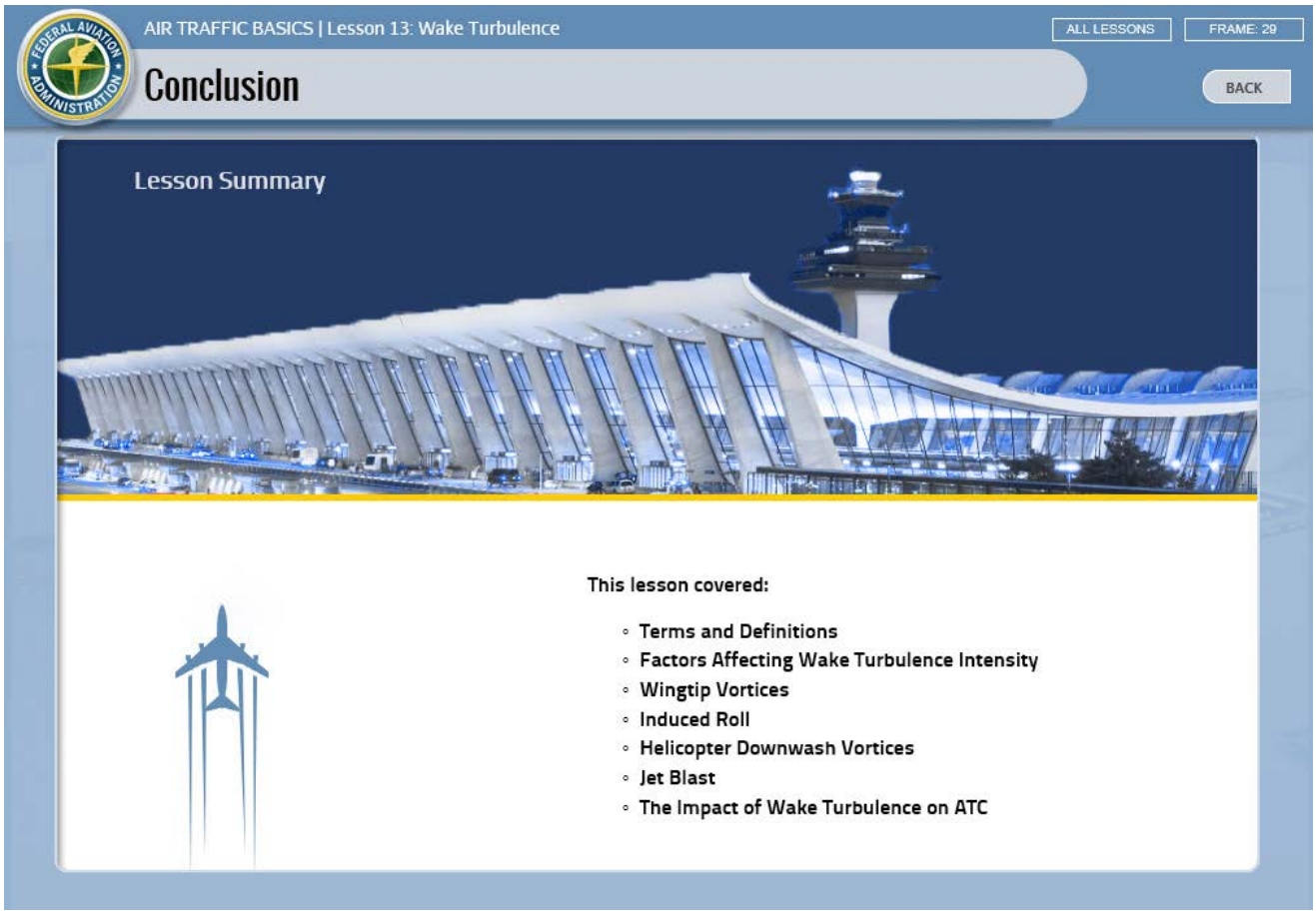
The greatest impact wake turbulence has on ATC is increased separation for:

- **Terminal operations, both ground and airborne.**
- **Radar operations for both approach and En Route environments.**

Traffic management delays may occur as a result of:

- **Increased separation, meaning 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.


AIR TRAFFIC BASICS | Lesson 13: Wake Turbulence
ALL LESSONS
FRAME: 29
BACK
Conclusion
Lesson Summary
This lesson covered:
Terms and Definitions
Factors Affecting Wake Turbulence Intensity
Wingtip Vortices
Induced Roll
Helicopter Downwash Vortices
Jet Blast
The Impact of Wake Turbulence on ATC