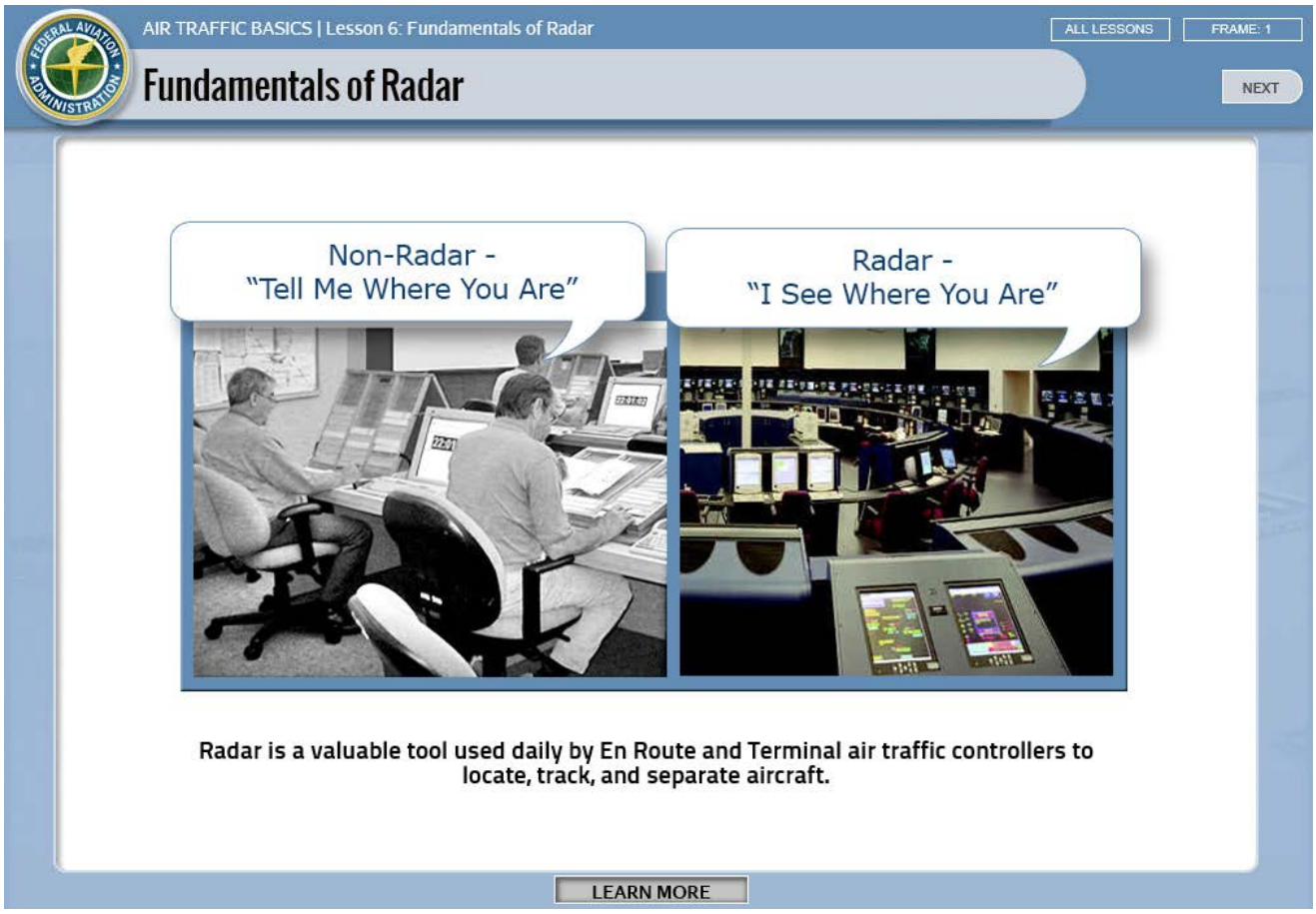
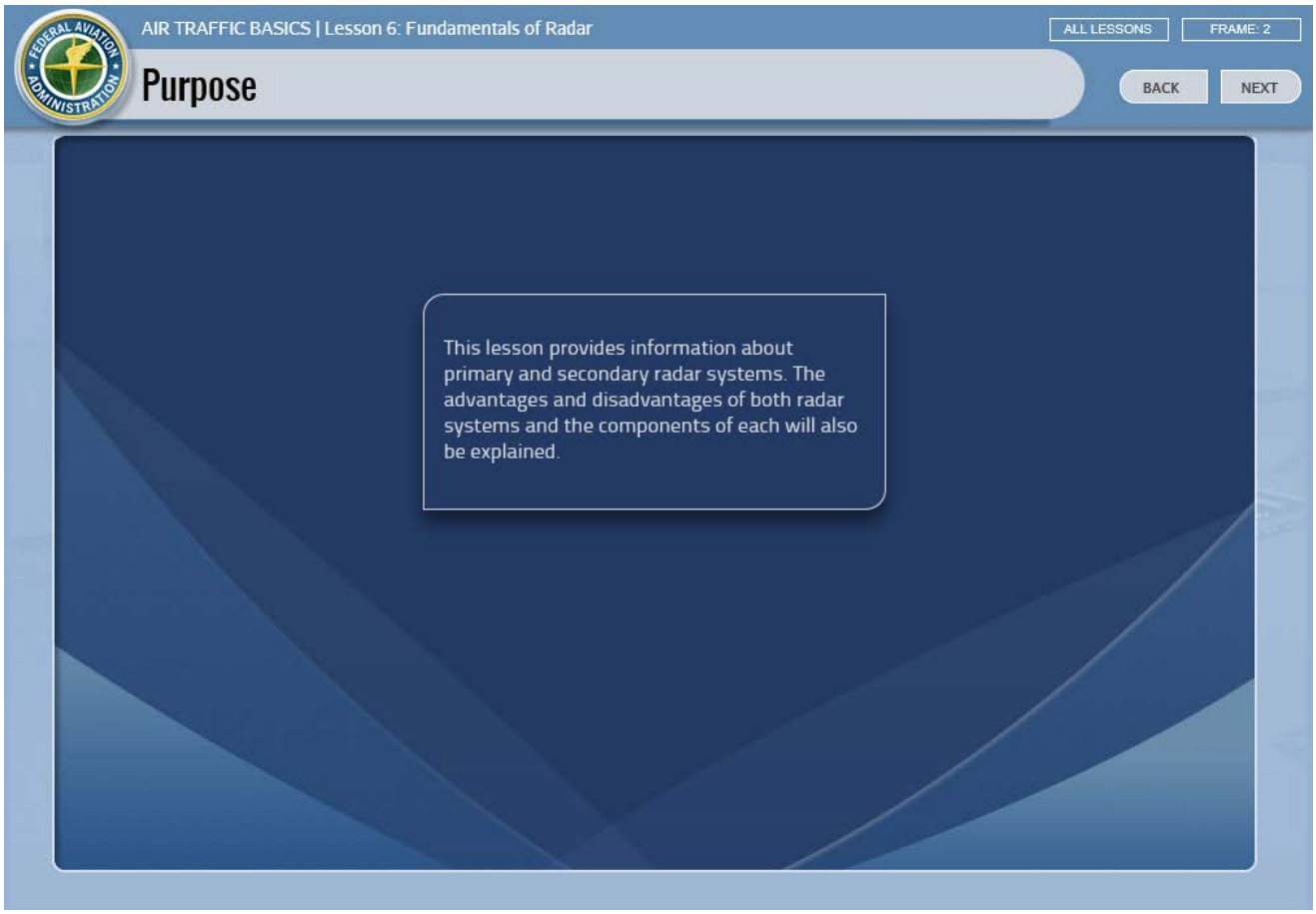
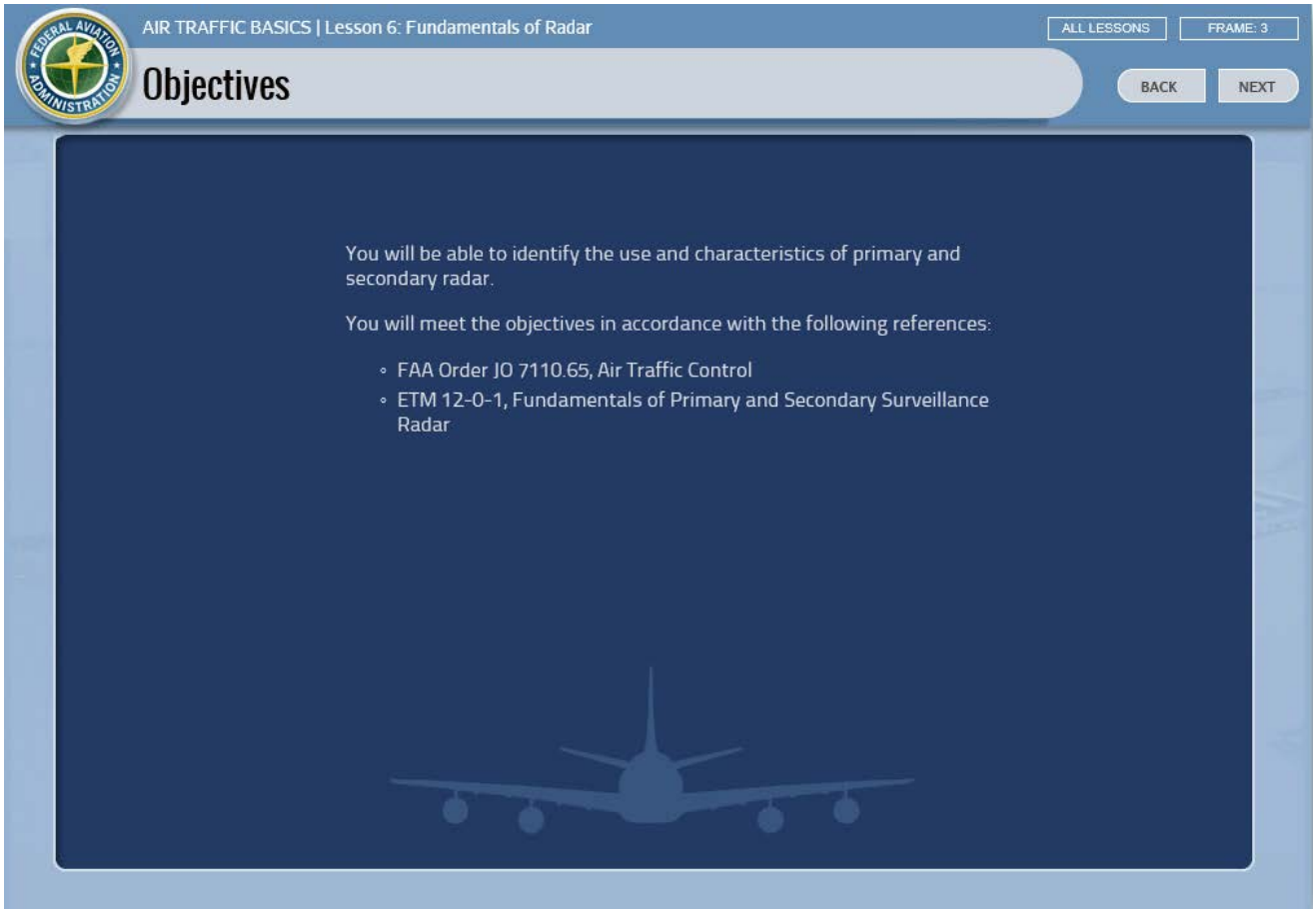


Understanding its uses, unique characteristics, and basic concepts will increase your ability to operate as an air traffic controller in the National Airspace System (NAS).

In a nonradar environment, controllers must visualize the airspace under their control. Controllers rely on pilot reports to determine the position of aircraft and to identify areas of adverse weather.


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 2
Purpose
BACK
NEXT
This lesson provides information about primary and secondary radar systems. The advantages and disadvantages of both radar systems and the components of each will also be explained.

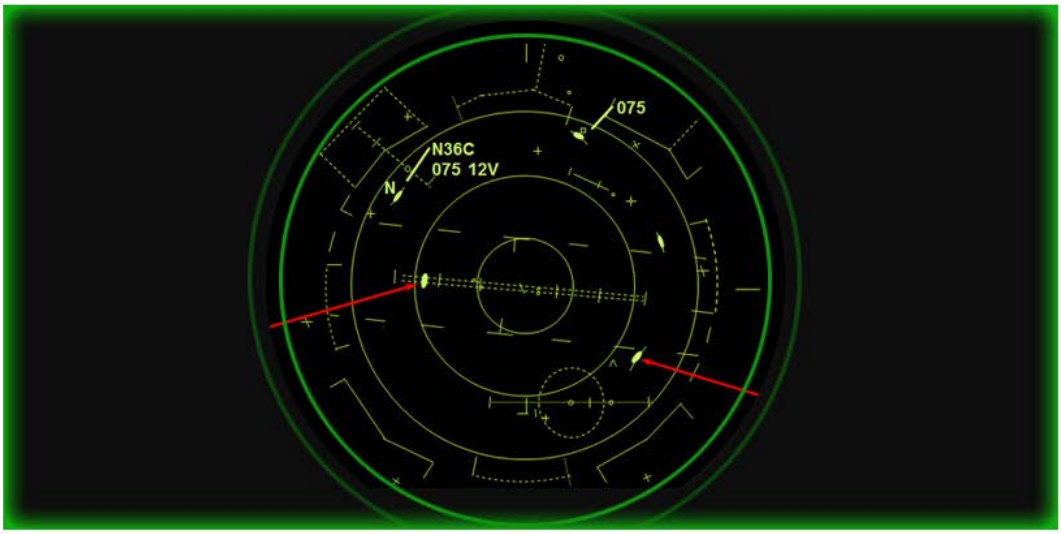

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 3
Objectives
BACK
NEXT
You will be able to identify the use and characteristics of primary and secondary radar.
You will meet the objectives in accordance with the following references:
FAA Order JO 7110.65, Air Traffic Control
ETM 12-0-1, Fundamentals of Primary and Secondary Surveillance Radar

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 4

Radar

BACK NEXT



Radar Display

Radar is a radio detection device which provides information on range, azimuth, and/or elevation of objects.

JO 7110.65, Pilot/Controller Glossary

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 5

Radar

BACK NEXT

Radar Weather Display

Air Traffic Control (ATC) uses several different display systems, each having their own display characteristics.

- This is an example of a digitized radar weather display.

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 6

Radar

BACK NEXT

Types of Radar Systems

Two types of radar systems are:

- Primary radar
- Secondary radar

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 7

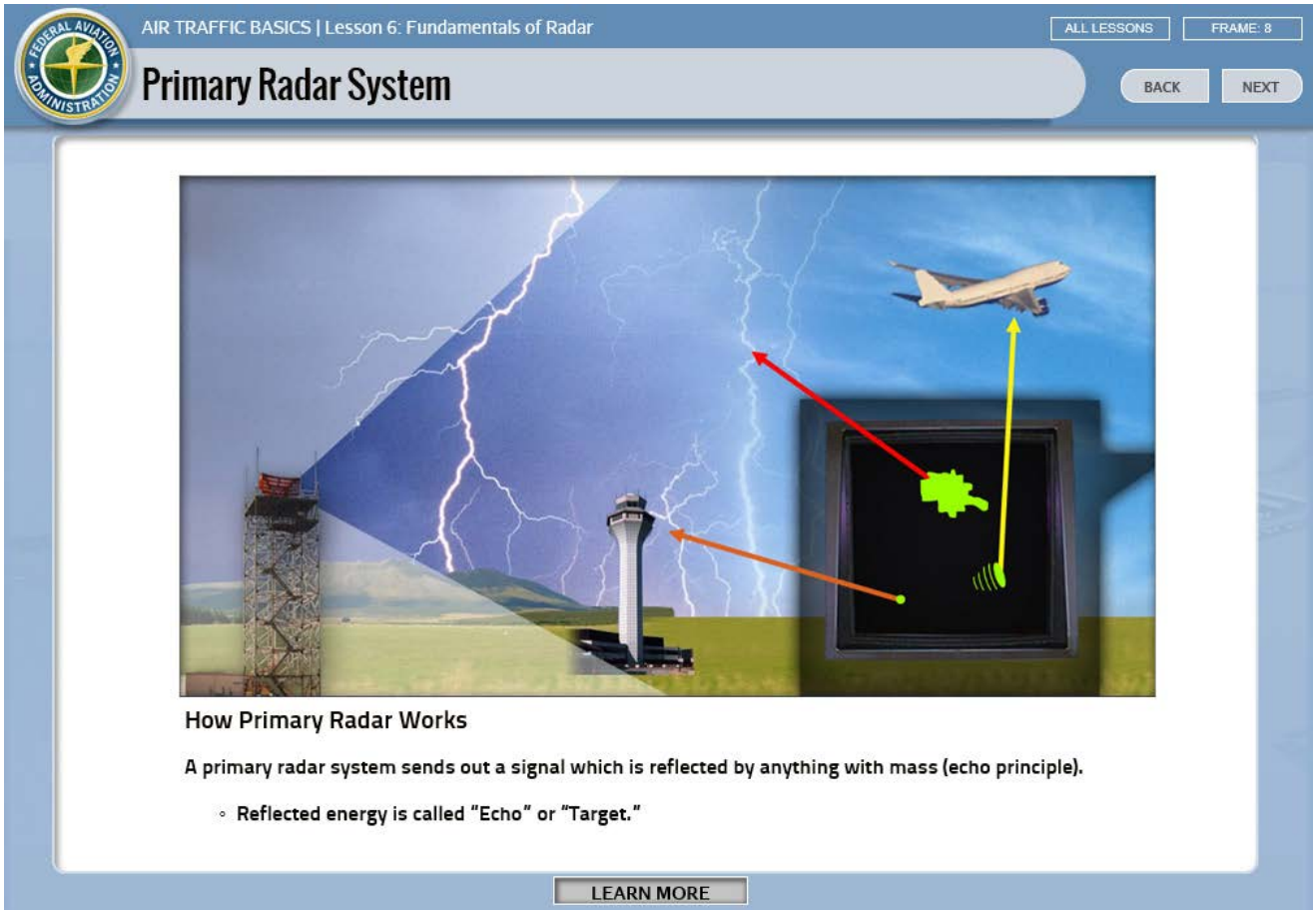
Primary Radar System

BACK NEXT

Primary Radar Definition

Primary radar is a radar system in which a minute portion of a radio pulse transmitted from a site is reflected by an object and then received back at the site for processing and display at an ATC facility.

JO 7110.65, Pilot/Controller Glossary



The primary radar signal is a pulse of radio energy similar to an X-ray or visible light.

This reflected signal is timed, processed, and presented on a radar display.

Primary radar requires no equipment in the aircraft.

Reference: ETM 12-0-1,pp. 5, 6, 35

The four major components of a primary radar system are:

- Transmitter
- Antenna
- Receiver
- Radar Display

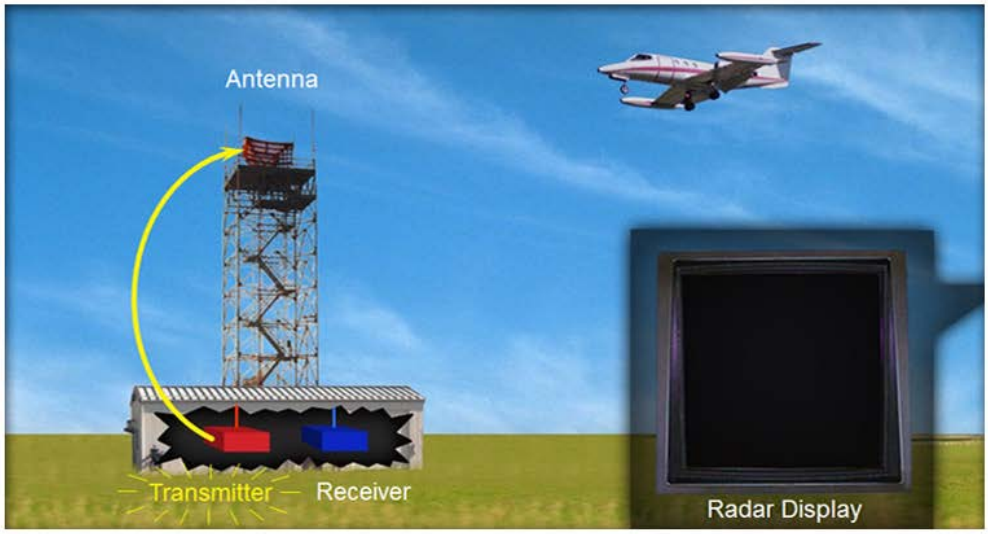
Reference: ETM 12-0-1,pp. 11 thru 14

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 10

Primary Radar System

BACK NEXT



Transmitter

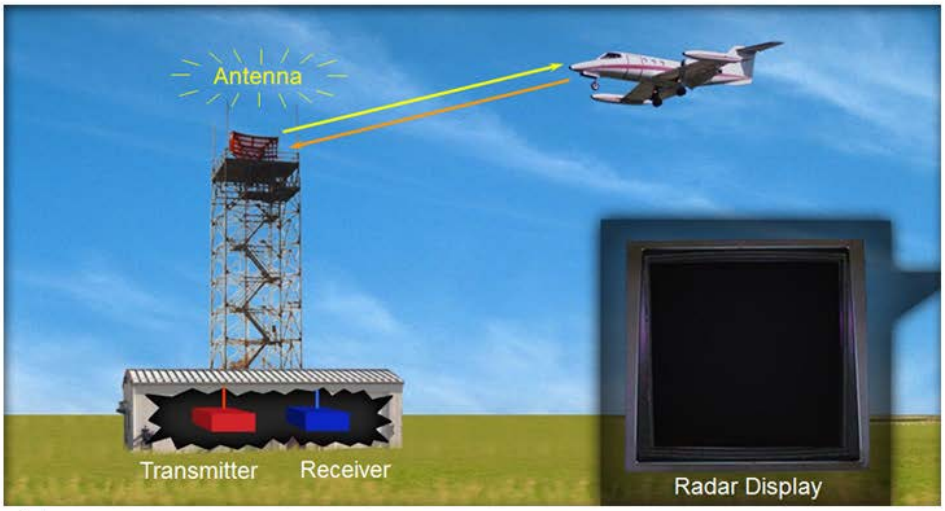
The transmitter generates a pulse of radio energy.

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 11

Primary Radar System

BACK NEXT



Antenna

The antenna focuses and broadcasts radio energy, then collects the reflected return.

- The area directly above the antenna is called the "blind zone" and is not included in the signal pattern.
  - Aircraft in the blind zone cannot be seen on the radar display.

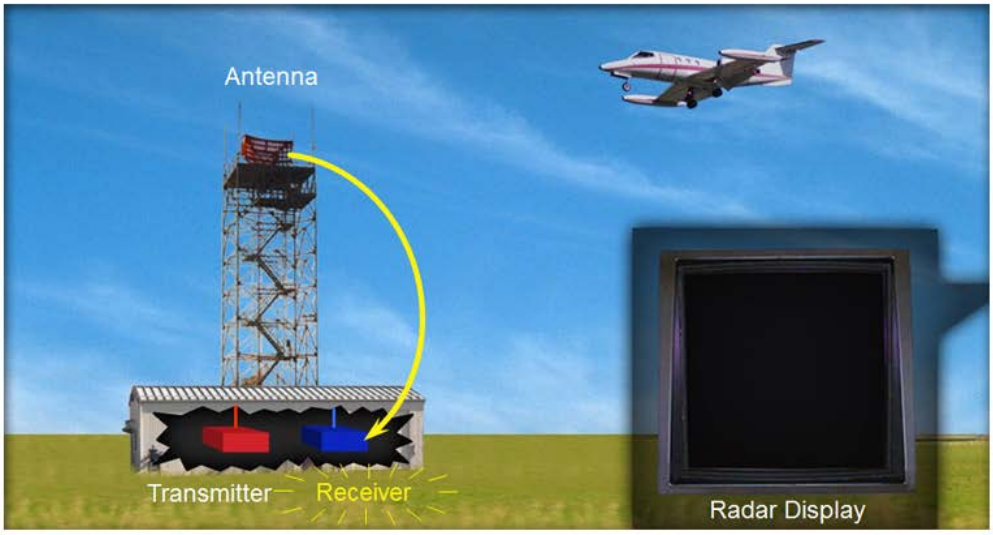
ETM 12-0-1, p. 13

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 12

Primary Radar System

BACK NEXT



Receiver

The receiver amplifies and converts the reflected energy into video.

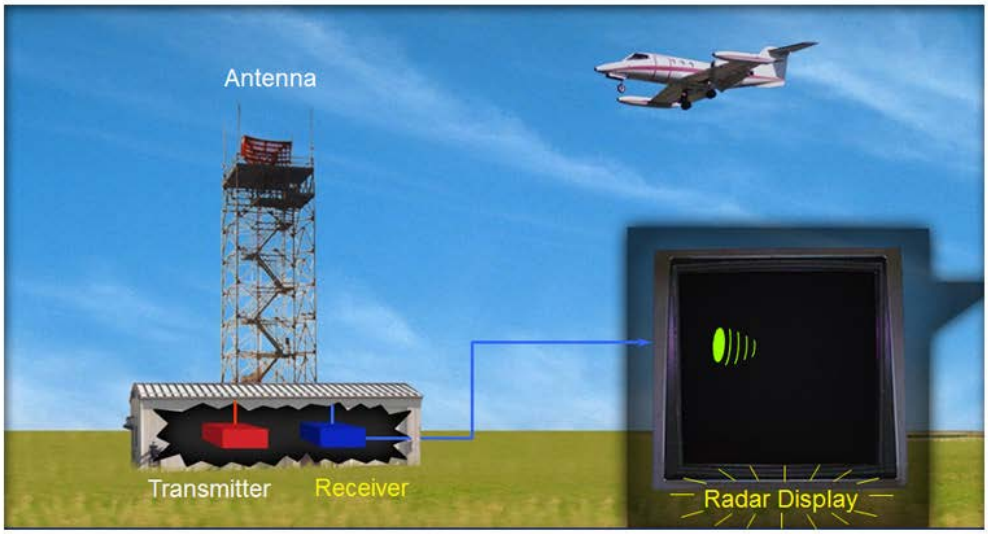
ETM 12-0-1, p. 13

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 13

Primary Radar System

BACK NEXT



Radar Display

The radar display depicts the position and movement of objects that reflect radio energy.

ETM 12-0-1, p. 14

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 14

Primary Radar System

BACK NEXT

Features of Primary Radar

Features which improve primary radar presentation are:

- Moving Target Indicator (MTI)
- Polarization

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 15

Primary Radar System

BACK NEXT

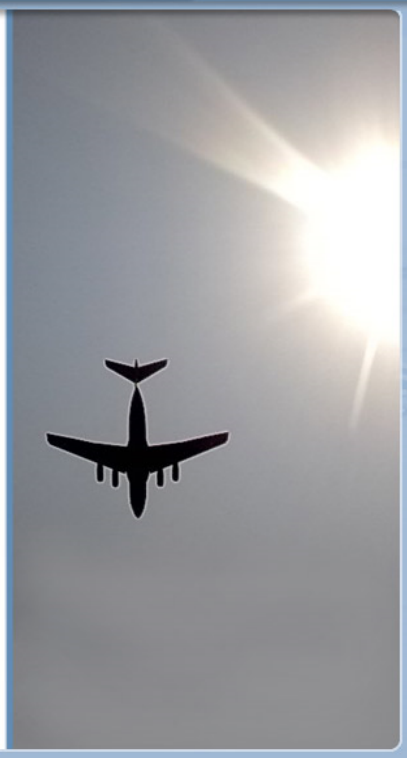
Moving Target Indicator (MTI) and Ground Clutter Definitions

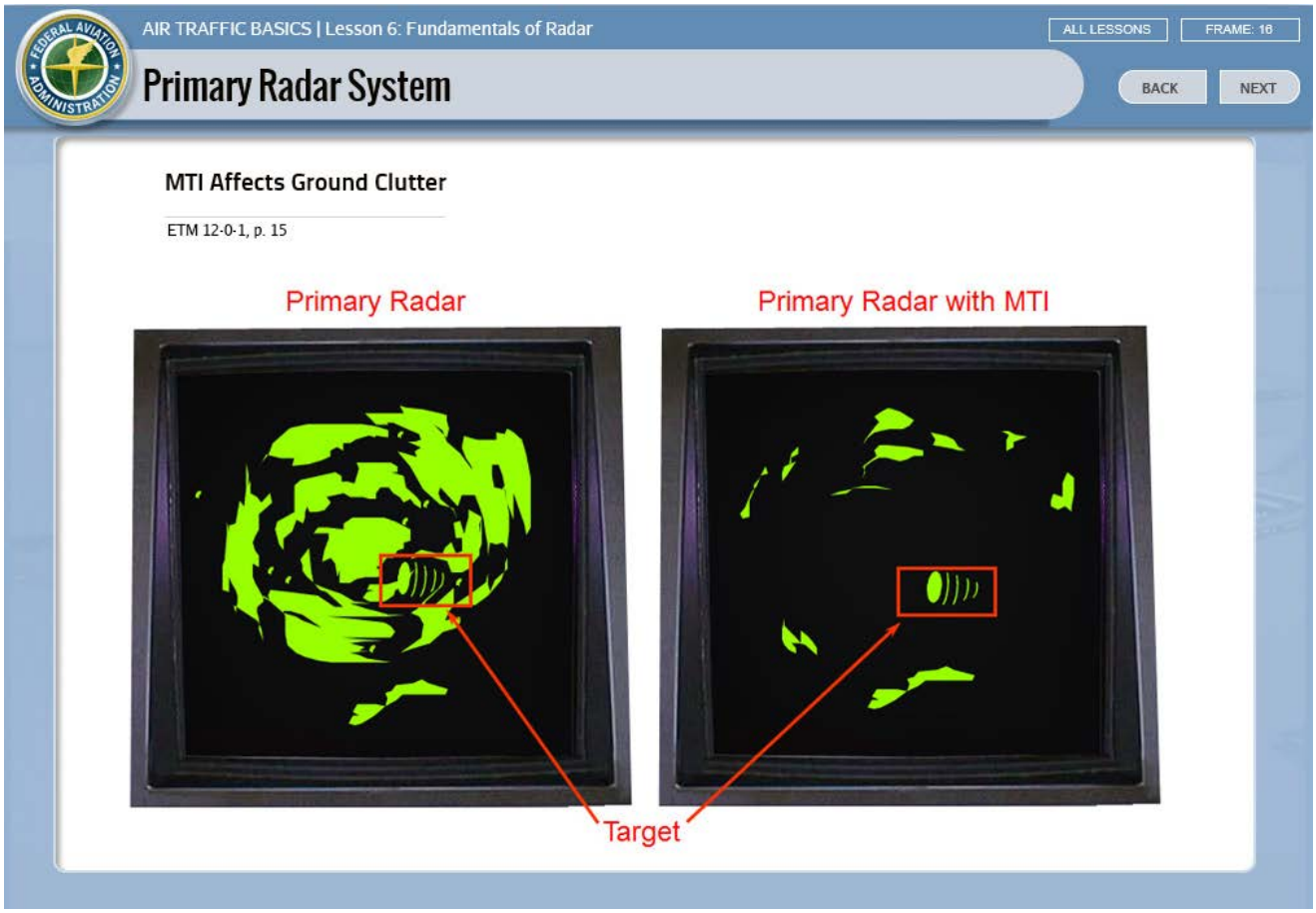
A Moving Target Indicator (MTI) is an electronic device which will permit radar scope presentations only from targets which are in motion.

MTI is considered a partial remedy for ground clutter.

Ground Clutter is a pattern produced on the radar scope by ground returns which may degrade other radar returns in the affected area.

JO 7110.65, Pilot/Controller Glossary




AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 16
Primary Radar System
BACK
NEXT
MTI Affects Ground Clutter
ETM 12-0-1, p. 15
Primary Radar
Primary Radar with MTI
Target

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

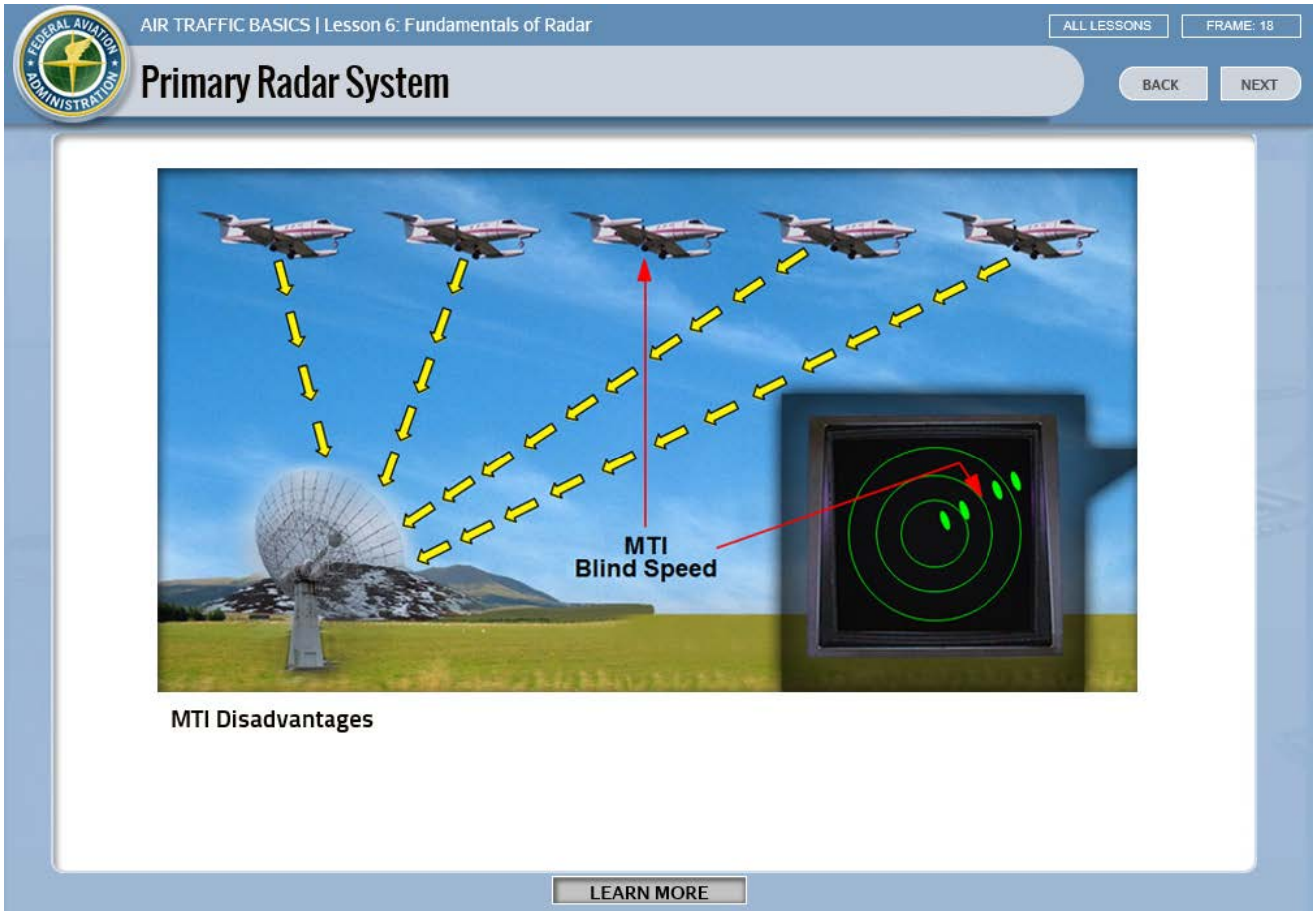
ALL LESSONS FRAME: 17

Primary Radar System

BACK NEXT

MTI Advantage

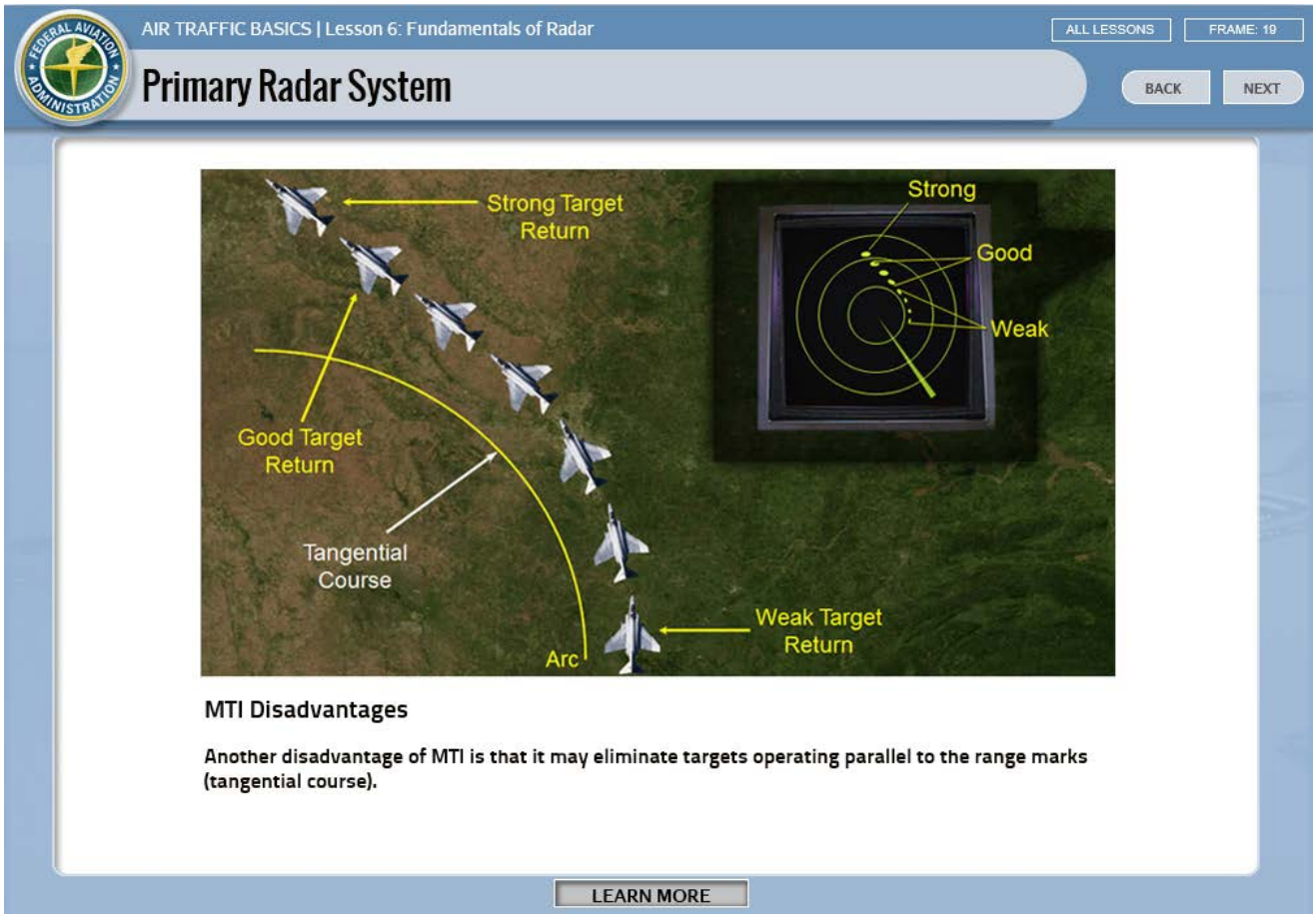
An advantage of MTI is that it displays only objects in motion.



One disadvantage of MTI is “MTI blind speed.” MTI blind speed occurs when the aircraft is moving directly toward or away from the radar antenna at a particular speed.

- MTI blind speed can result in either a weak or lost target.

Reference: ETM 12-0-1, pp. 16, 58



- MTI can be “fooled” into interpreting repeated identical range signals as meaning the target is not moving.
- MTI reduces the strength of the target return.

Reference: ETM 12-0-1, pp. 16, 58

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

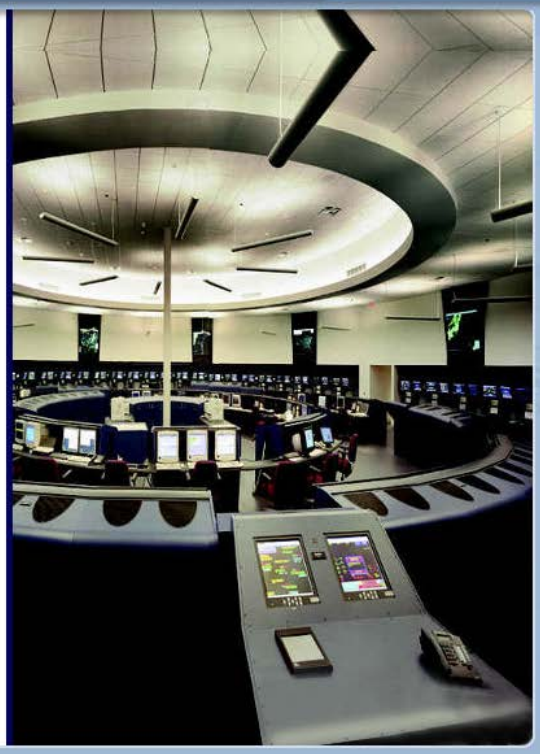
ALL LESSONS FRAME: 20

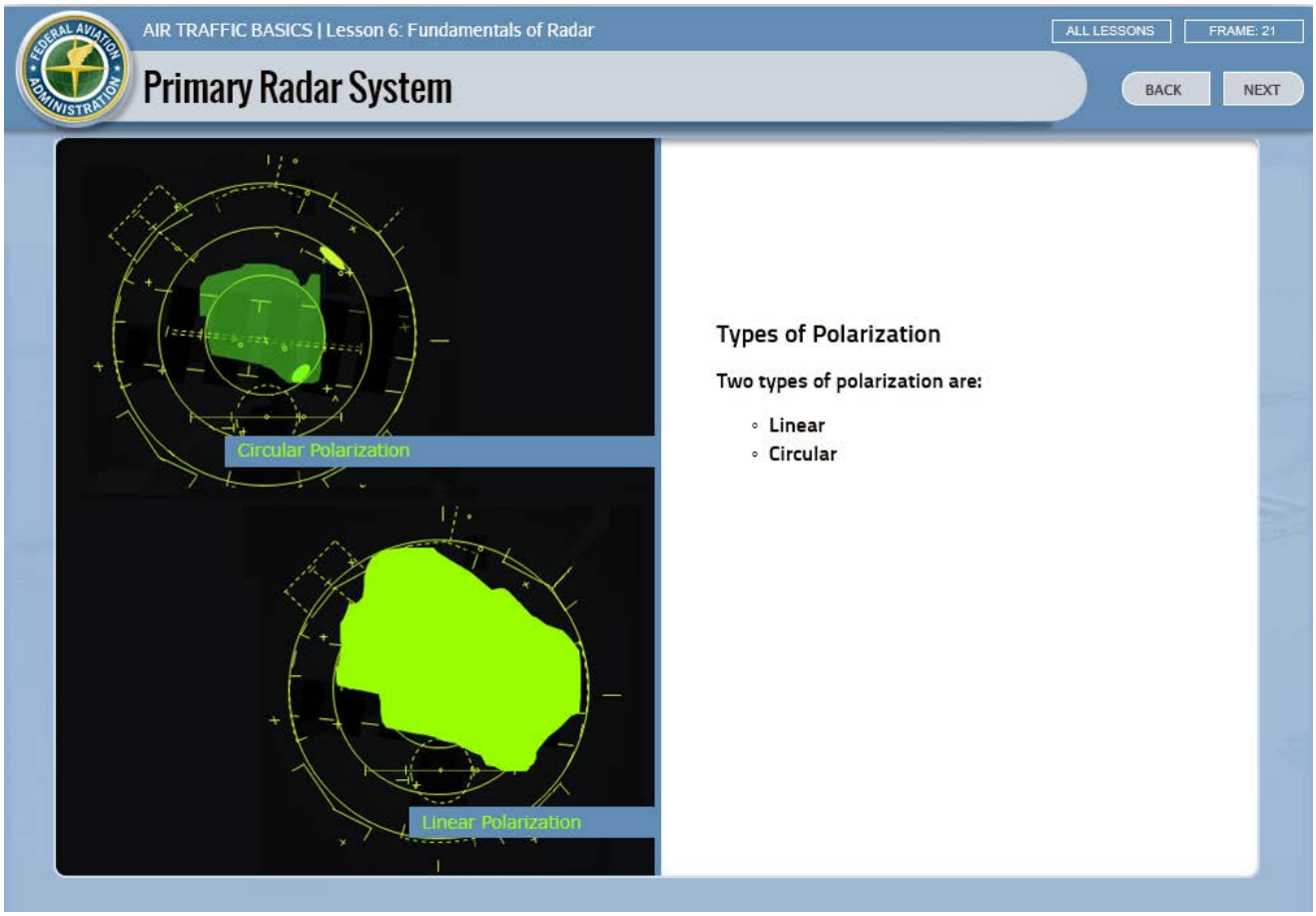
Primary Radar System

BACK NEXT

Polarization Definition

Polarization is the radar antenna configuration that determines the motion of radio energy as it is transmitted.




AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 21
Primary Radar System
BACK
NEXT
Circular Polarization
Linear Polarization
Types of Polarization
Two types of polarization are:
Linear
Circular

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 22

Primary Radar System

BACK NEXT

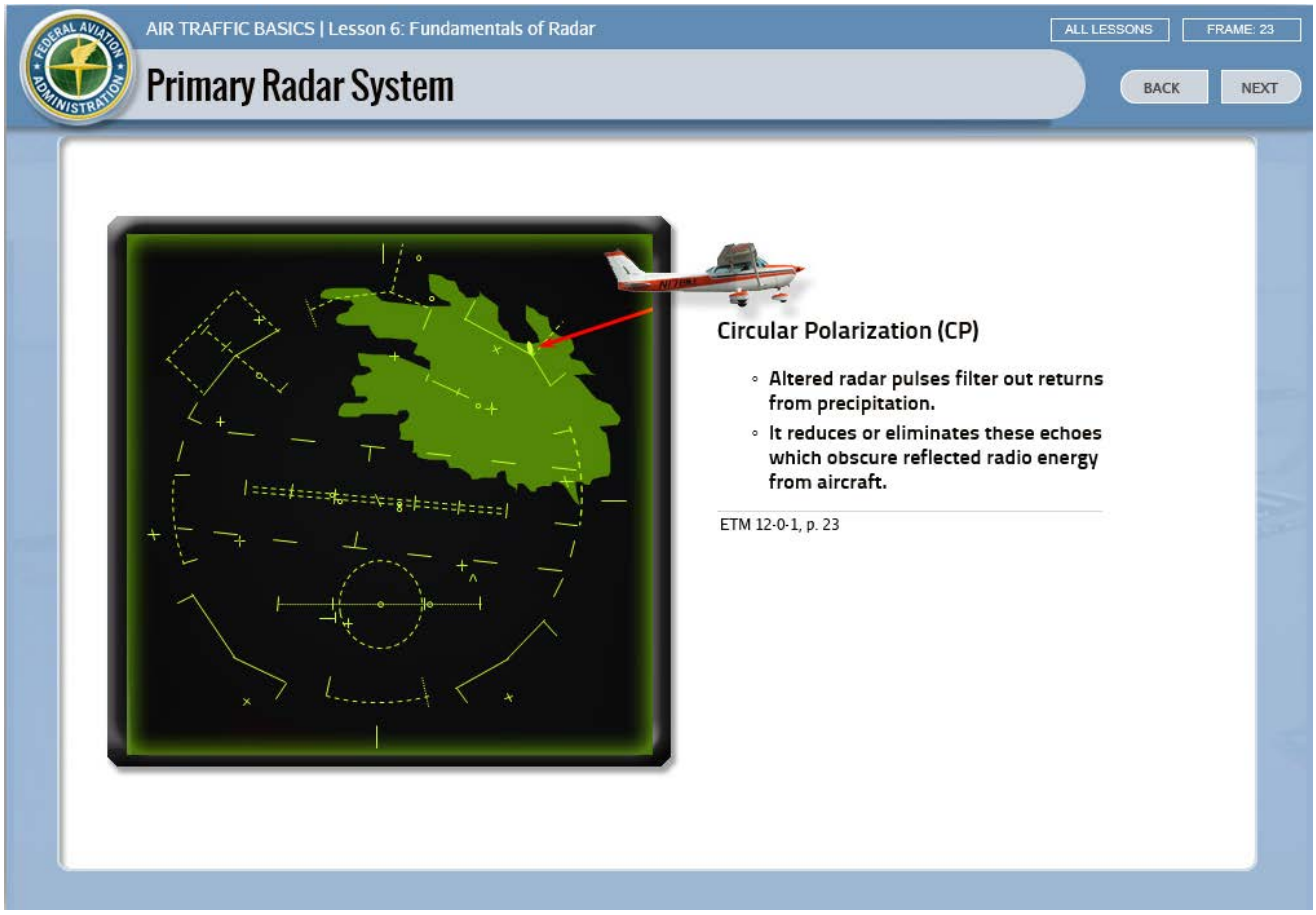
Linear Polarization

Linear Polarization (LP) is the normal radar transmission that will cause an echo from anything that has mass.

Linear Polarization:

- **Presents all reflected signals either moving or stationary**
- **Selection provides the strongest possible return**
- **Allows the controller to inform pilots about observed precipitation areas**

ETM 12-0-1, *p.* 61

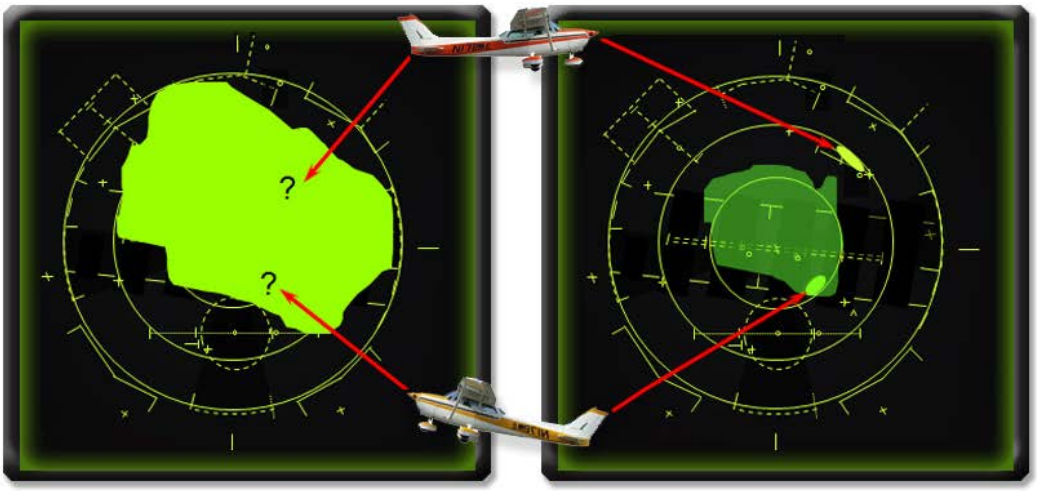

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 23
Primary Radar System
BACK
NEXT
Circular Polarization (CP)
Altered radar pulses filter out returns from precipitation.
It reduces or eliminates these echoes which obscure reflected radio energy from aircraft.
ETM 12-0-1, p. 23

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 24

Primary Radar System

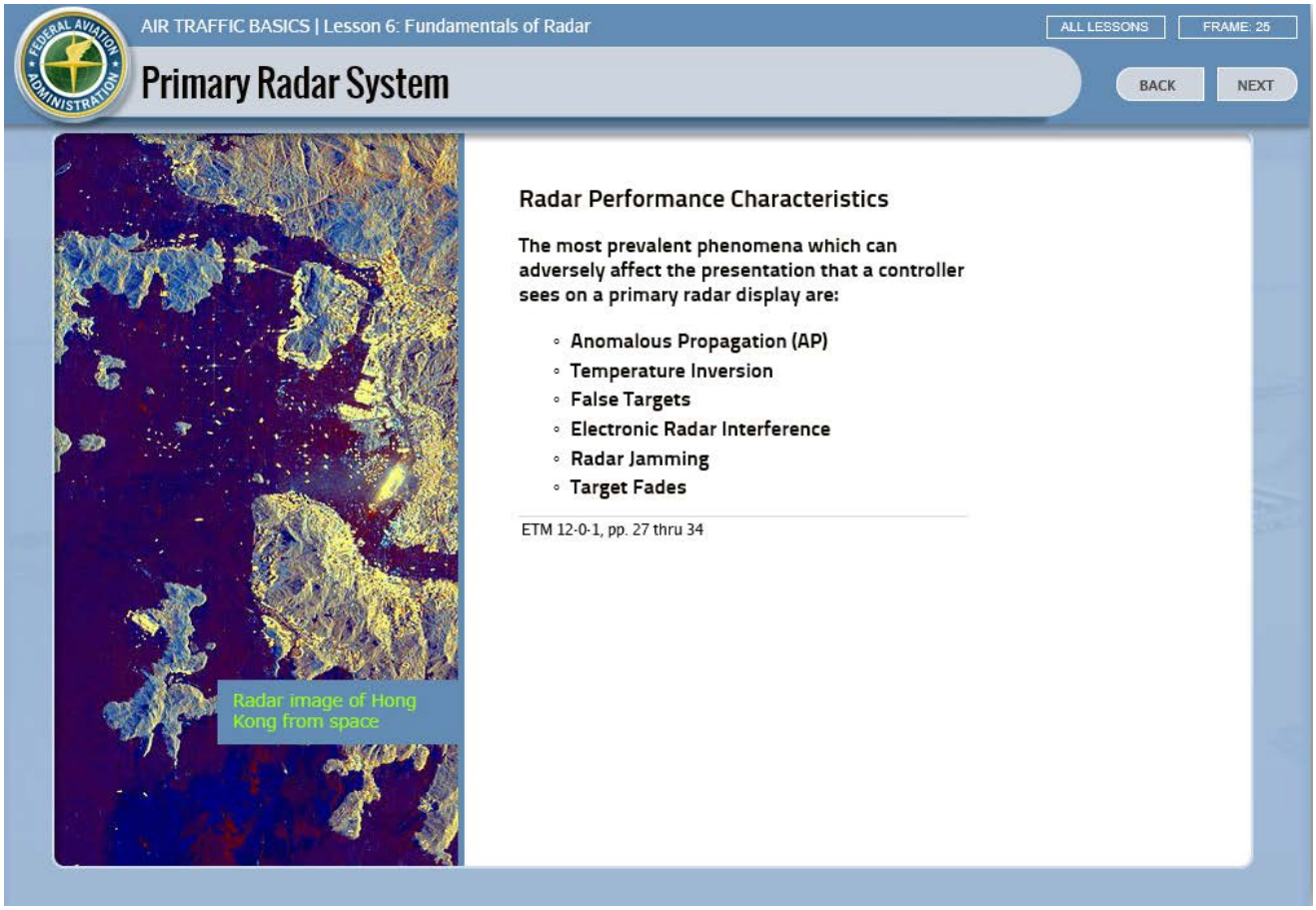
BACK NEXT



LP and CP Comparison

CP reduces target strength compared to LP.

ETM 12-0-1, pp. 21, 22


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 25
Primary Radar System
BACK
NEXT
Radar image of Hong Kong from space
Radar Performance Characteristics
The most prevalent phenomena which can adversely affect the presentation that a controller sees on a primary radar display are:
Anomalous Propagation (AP)
Temperature Inversion
False Targets
Electronic Radar Interference
Radar Jamming
Target Fades
ETM 12-0-1, pp. 27 thru 34

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 26

Primary Radar System

BACK NEXT

Anomalous Propagation (AP)

During AP, the radar beam does not travel in a straight line.

- The beam is bent either horizontally or vertically.

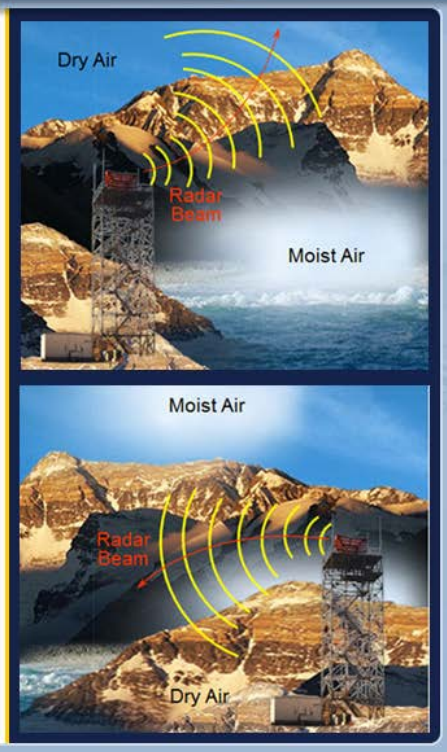
AP is caused by density or moisture.

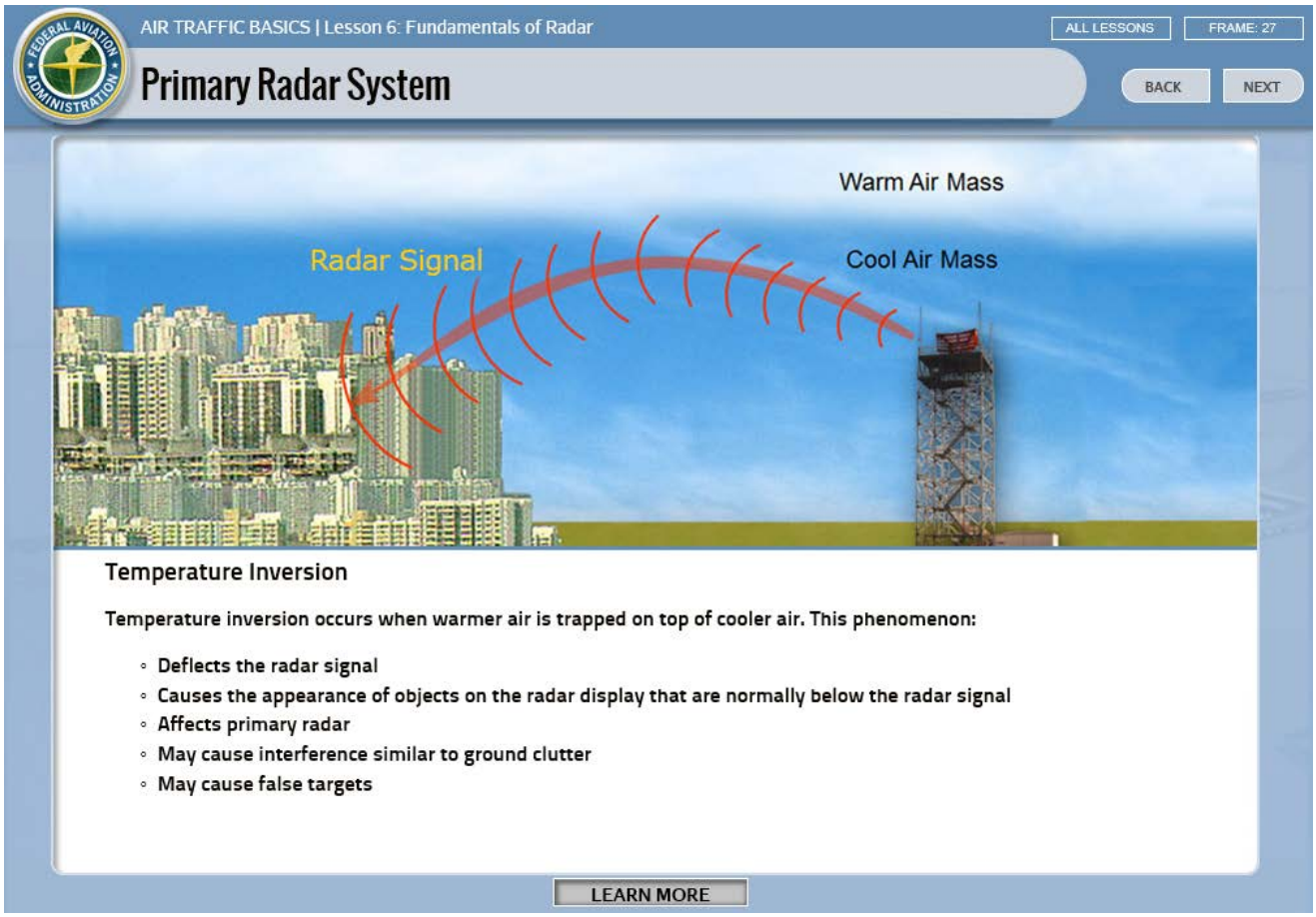
- The content is not uniform.
- It is most prevalent over water.

Radar beams are bent in the direction of dry dense air.

- Possible range or azimuth errors are likely due to the bending of radar beams.
- Downward bending is the most common.

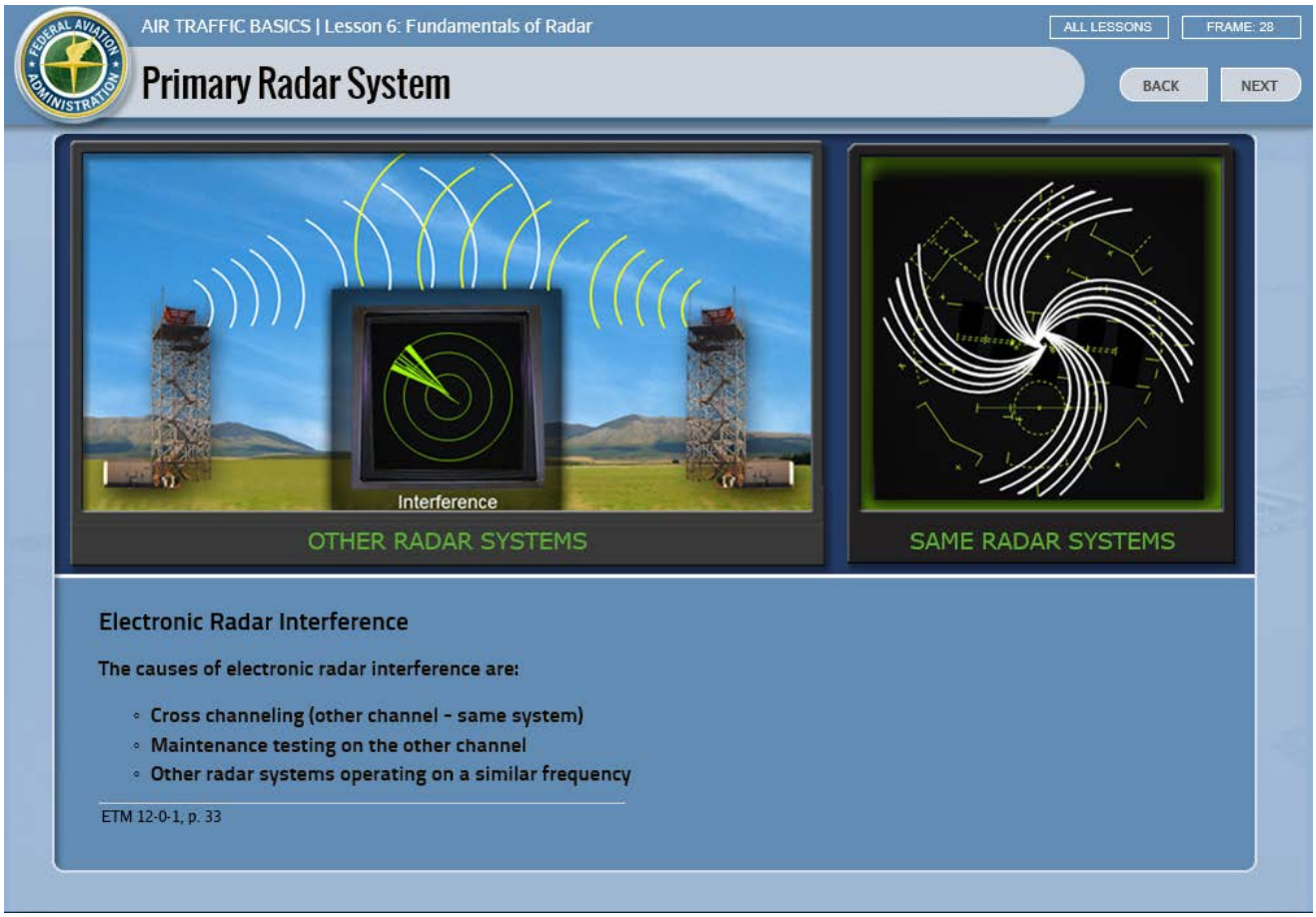
ETM 12-0-1, p. 30





False targets are targets that lack validity or authenticity often produced as a result of temperature inversion or Anomalous Propagation.

Reference: ETM 12-0-1, p. 30, 31


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 28
Primary Radar System
BACK
NEXT
Interference
OTHER RADAR SYSTEMS
SAME RADAR SYSTEMS
Electronic Radar Interference
The causes of electronic radar interference are:
◦ Cross channeling (other channel - same system)
◦ Maintenance testing on the other channel
◦ Other radar systems operating on a similar frequency
ETM 12-0-1, p. 33

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 29

Primary Radar System

BACK NEXT

Jamming

Jamming is the disruption of the radar display or radio reception by means of electronic or mechanical interference. Jamming may produce large amounts of clutter on the radar display and in some cases render the display unusable.

There are two types of radar jamming:

- Passive jamming
- Active jamming

ETM 12-0-1, pp. 31, 32, 61

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 30

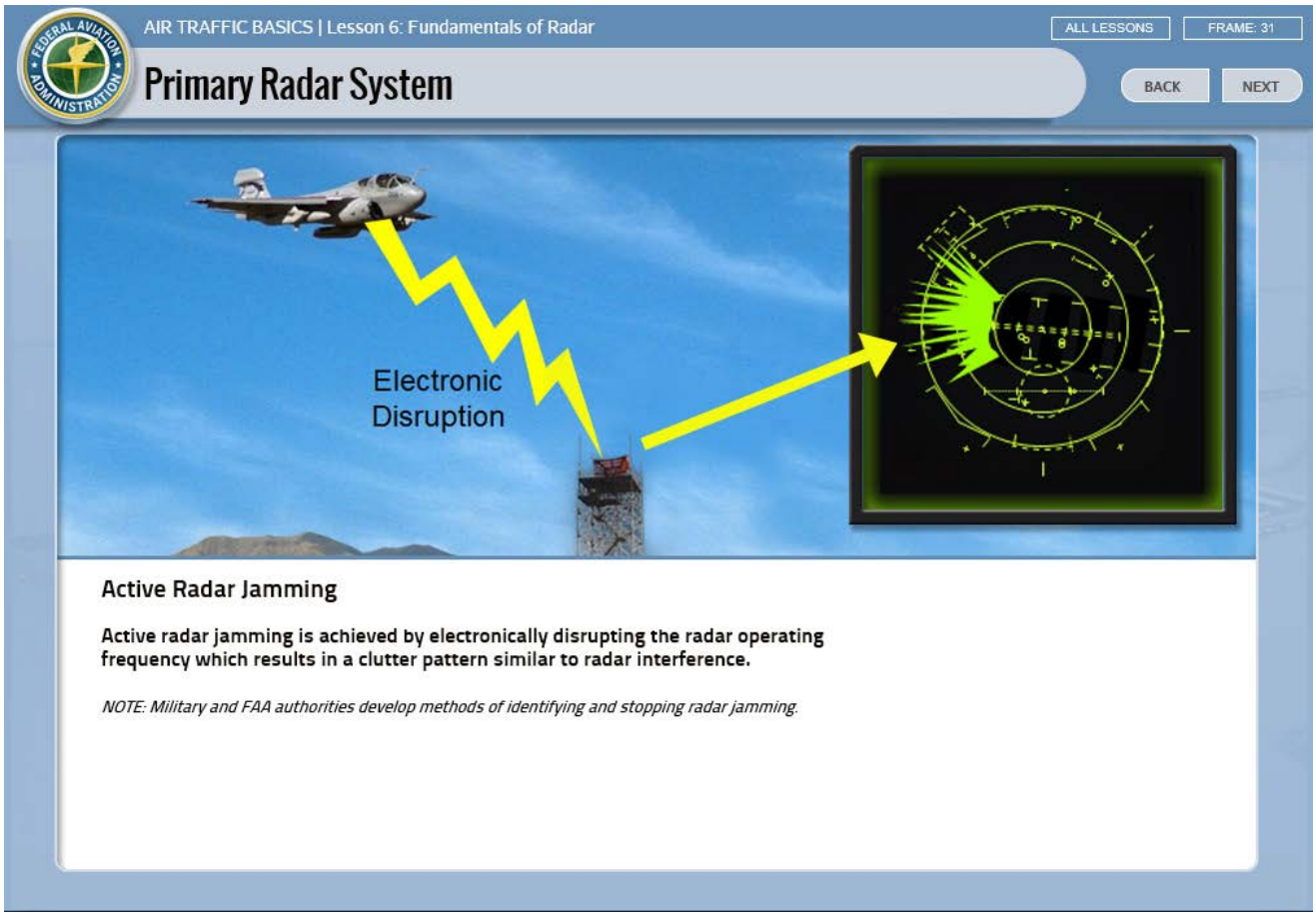
Primary Radar System

BACK NEXT

Passive Radar Jamming

Passive radar jamming is the appearance of clutter on the radar display achieved by dropping large amounts of shredded foil (called chaff).

ETM 12-0-1, p. 31

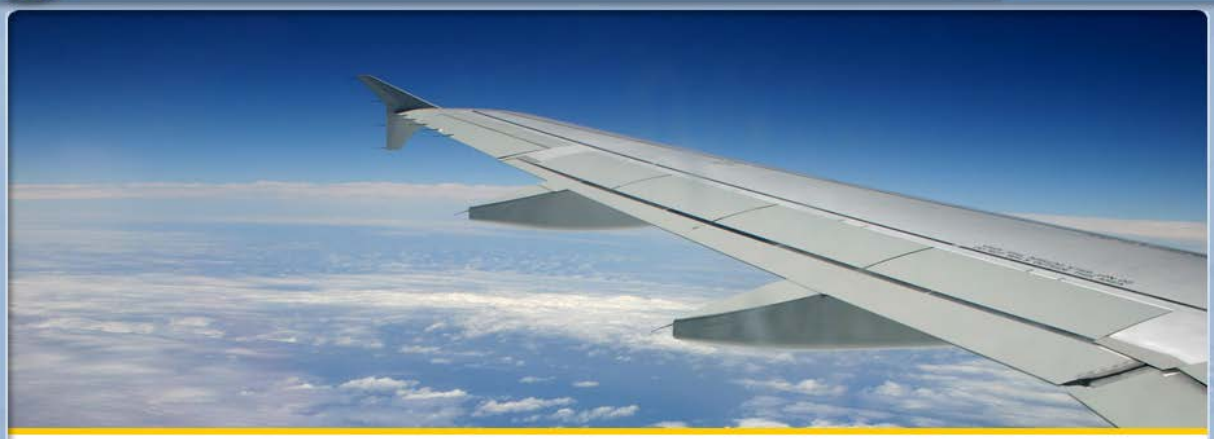

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 31
Primary Radar System
BACK
NEXT
Electronic
Disruption
Active Radar Jamming
Active radar jamming is achieved by electronically disrupting the radar operating frequency which results in a clutter pattern similar to radar interference.
NOTE: Military and FAA authorities develop methods of identifying and stopping radar jamming.

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 32

Primary Radar System

BACK NEXT

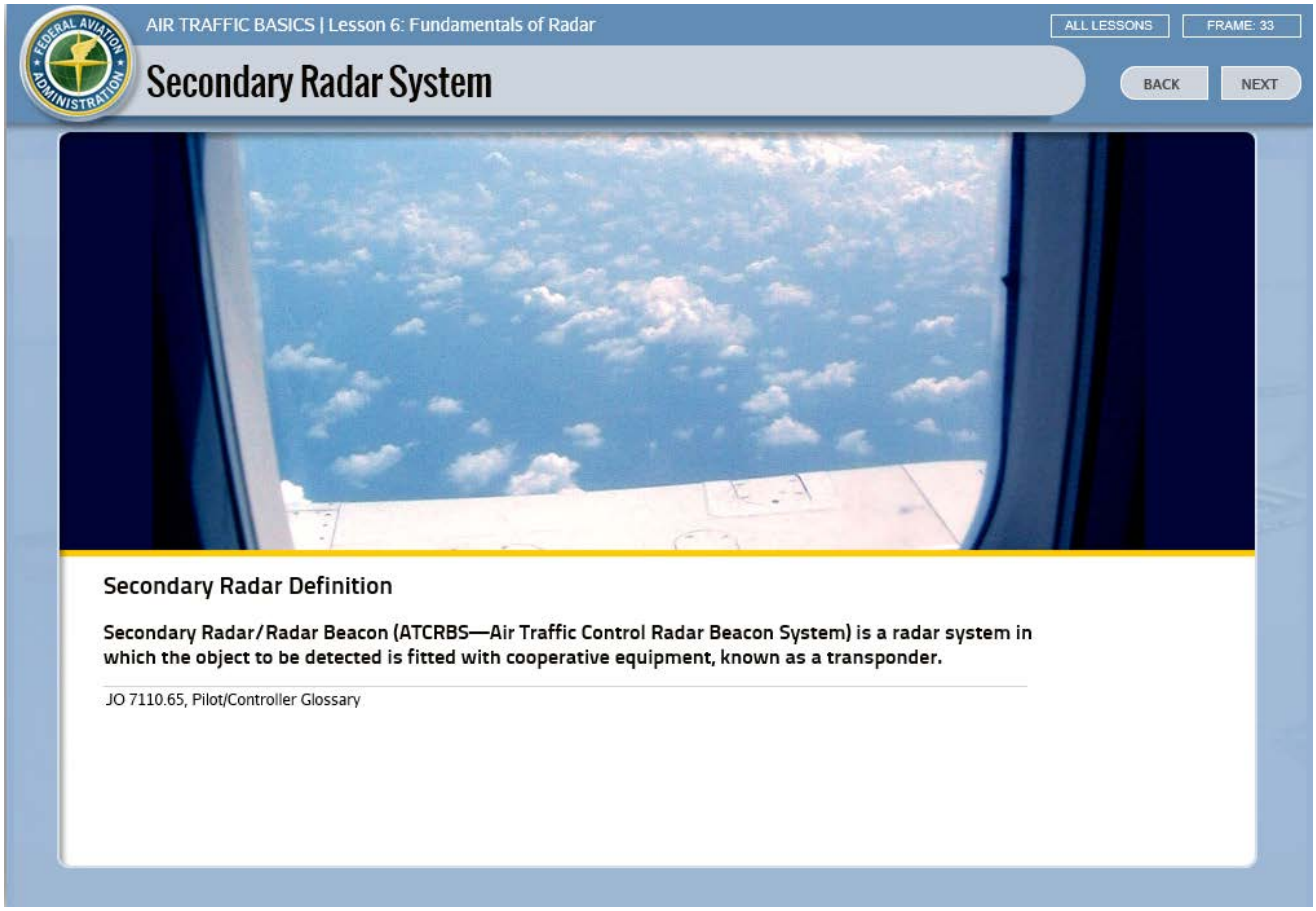


Target Fades (Fringe Areas)

Target fades (fringe areas) are an inherent feature of all radar systems.

- They vary with equipment and antenna tilt.
- The area of no coverage will occur over the antenna and below the coverage pattern.

ETM 12-0-1, p. 29


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 33
Secondary Radar System
BACK
NEXT
Secondary Radar Definition
Secondary Radar/Radar Beacon (ATCRBS—Air Traffic Control Radar Beacon System) is a radar system in which the object to be detected is fitted with cooperative equipment, known as a transponder.
JO 7110.65, Pilot/Controller Glossary

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 34

Secondary Radar System

BACK NEXT

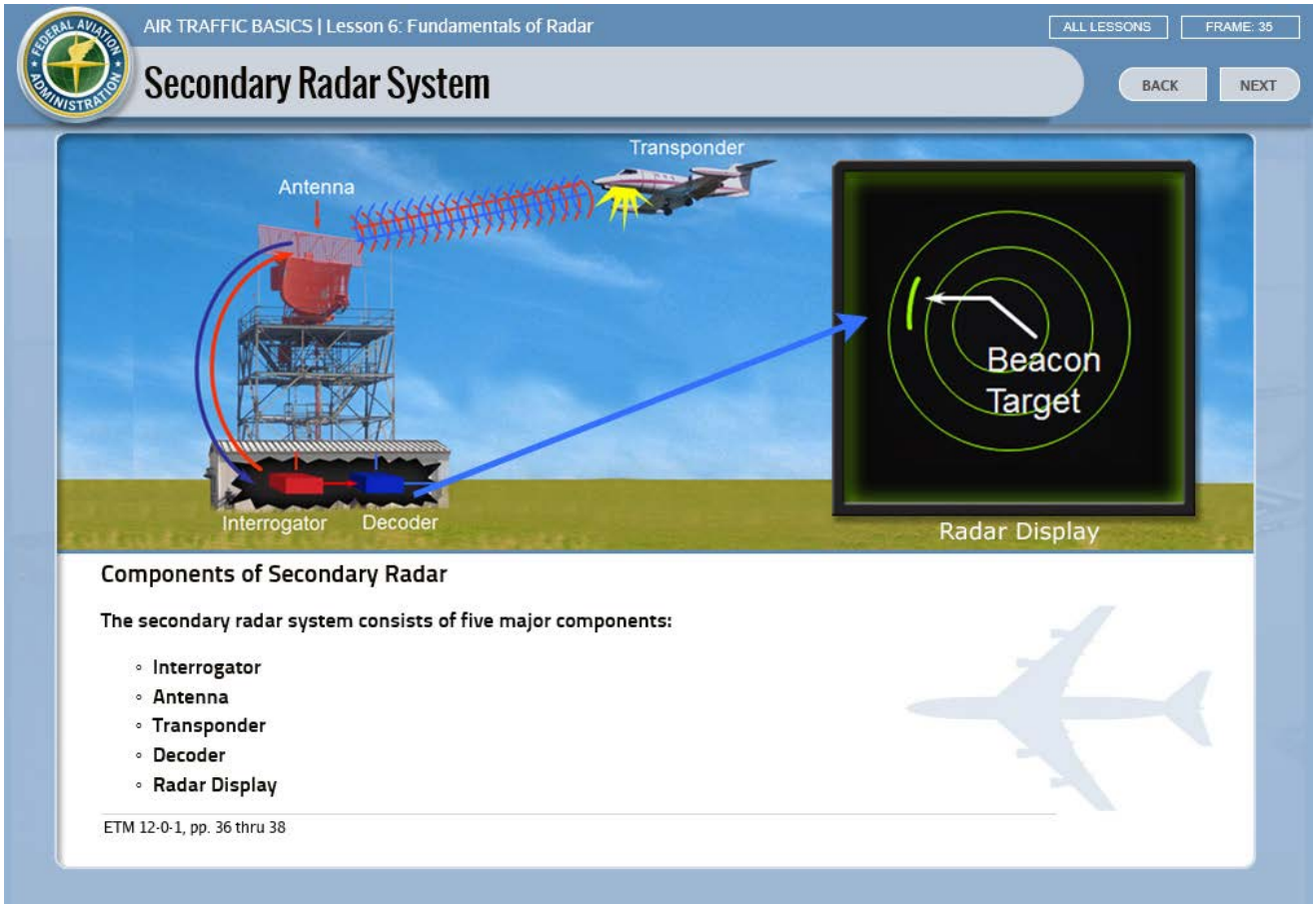
How Secondary Radar Works

Radio signals from the searching interrogator (transmitter/receiver) ground site are:

- **Received by the transponder (receiver/transmitter) in the aircraft**
- **Used to trigger a distinctive reply signal, which is transmitted back to the interrogator**

The interrogator relays the incoming signal to the decoder where it is processed for the radar display.

JO 7110.65, Pilot/Controller Glossary


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 35
Secondary Radar System
BACK
NEXT
Transponder
Antenna
Beacon
Target
Interrogator
Decoder
Radar Display
Components of Secondary Radar
The secondary radar system consists of five major components:
Interrogator
Antenna
Transponder
Decoder
Radar Display
ETM 12-0-1, pp. 36 thru 38

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 36

Secondary Radar System

BACK NEXT

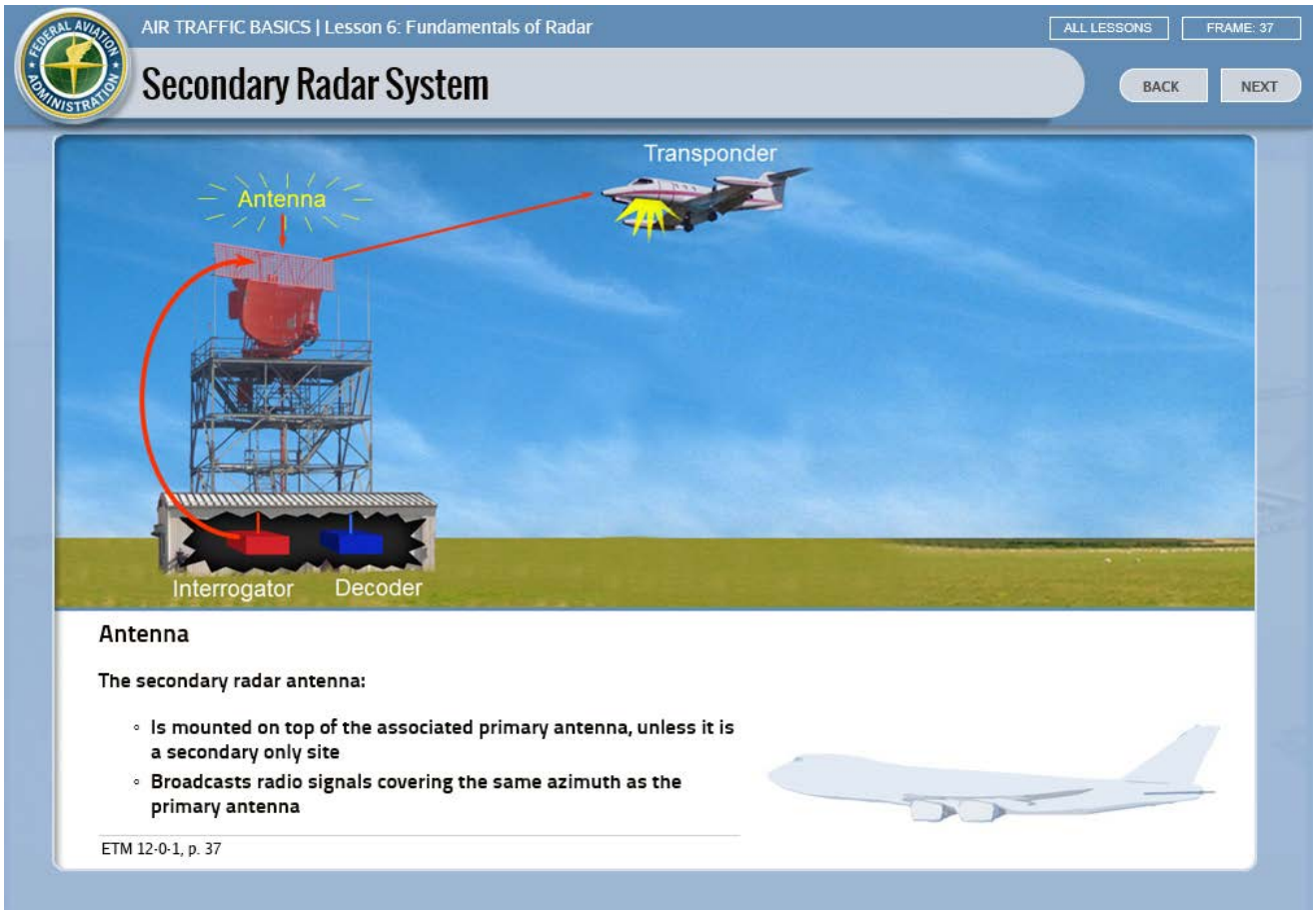
Interrogator

The interrogator is a ground-based transmitter.

The interrogator generates radio signals which are sent to the antenna for broadcast.

- These radio signals request all transponders within range to reply.

ETM 12-0-1, p. 36

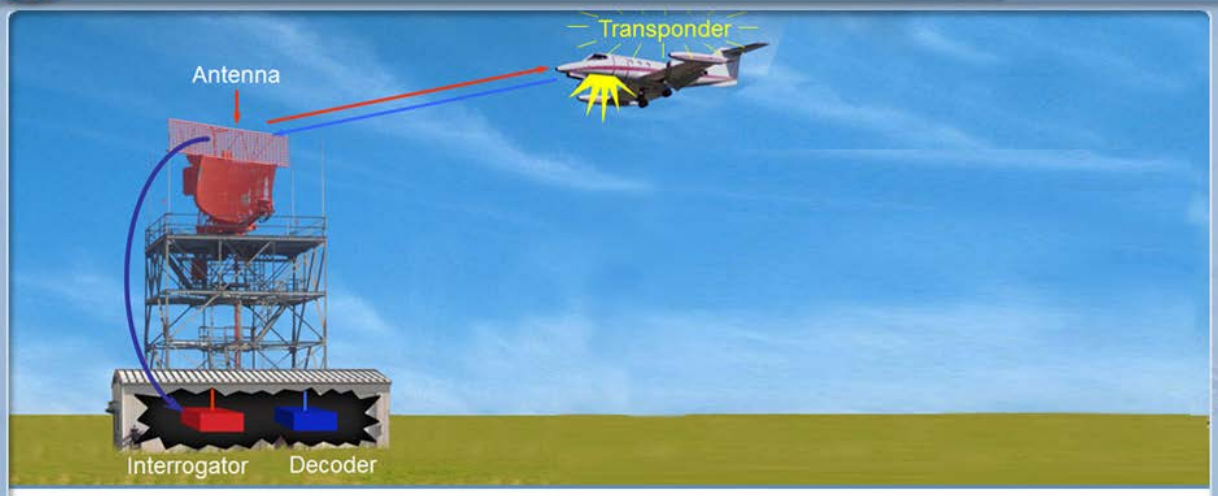

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 37
Secondary Radar System
BACK
NEXT
Transponder
Antenna
Interrogator
Decoder
Antenna
The secondary radar antenna:
Is mounted on top of the associated primary antenna, unless it is a secondary only site
Broadcasts radio signals covering the same azimuth as the primary antenna
ETM 12-0-1, p. 37

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 38

Secondary Radar System

BACK NEXT



Transponder

The transponder is located in the aircraft.

The transponder automatically receives the interrogator's signals and replies with the code assigned by ATC.

- **The transponder reply is received by the antenna, sent to the interrogator, and relayed to the decoder.**

ETM 12-0-1, *pp.* 37, 38

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 39

Secondary Radar System

BACK NEXT

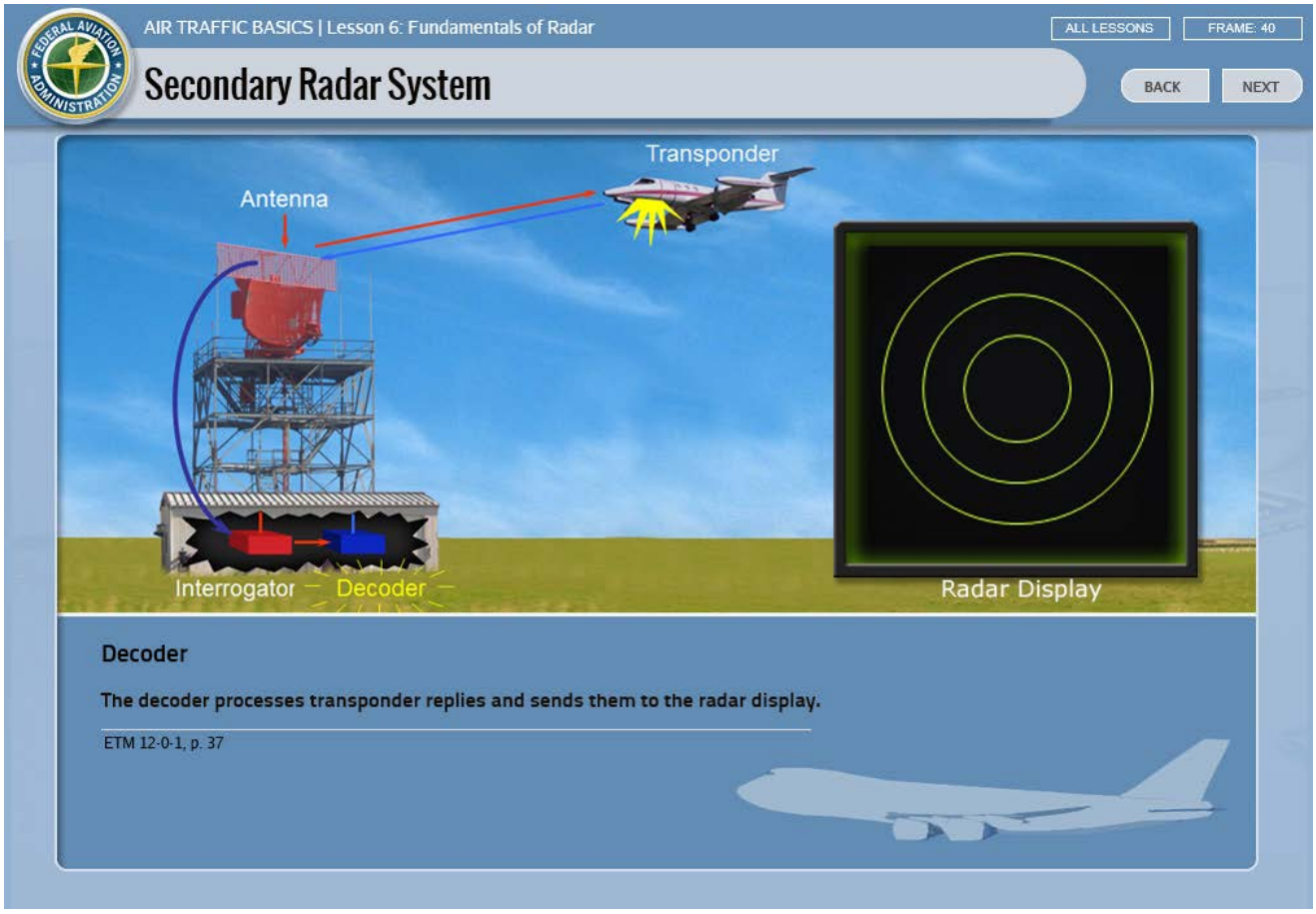
Equipment Suffixes

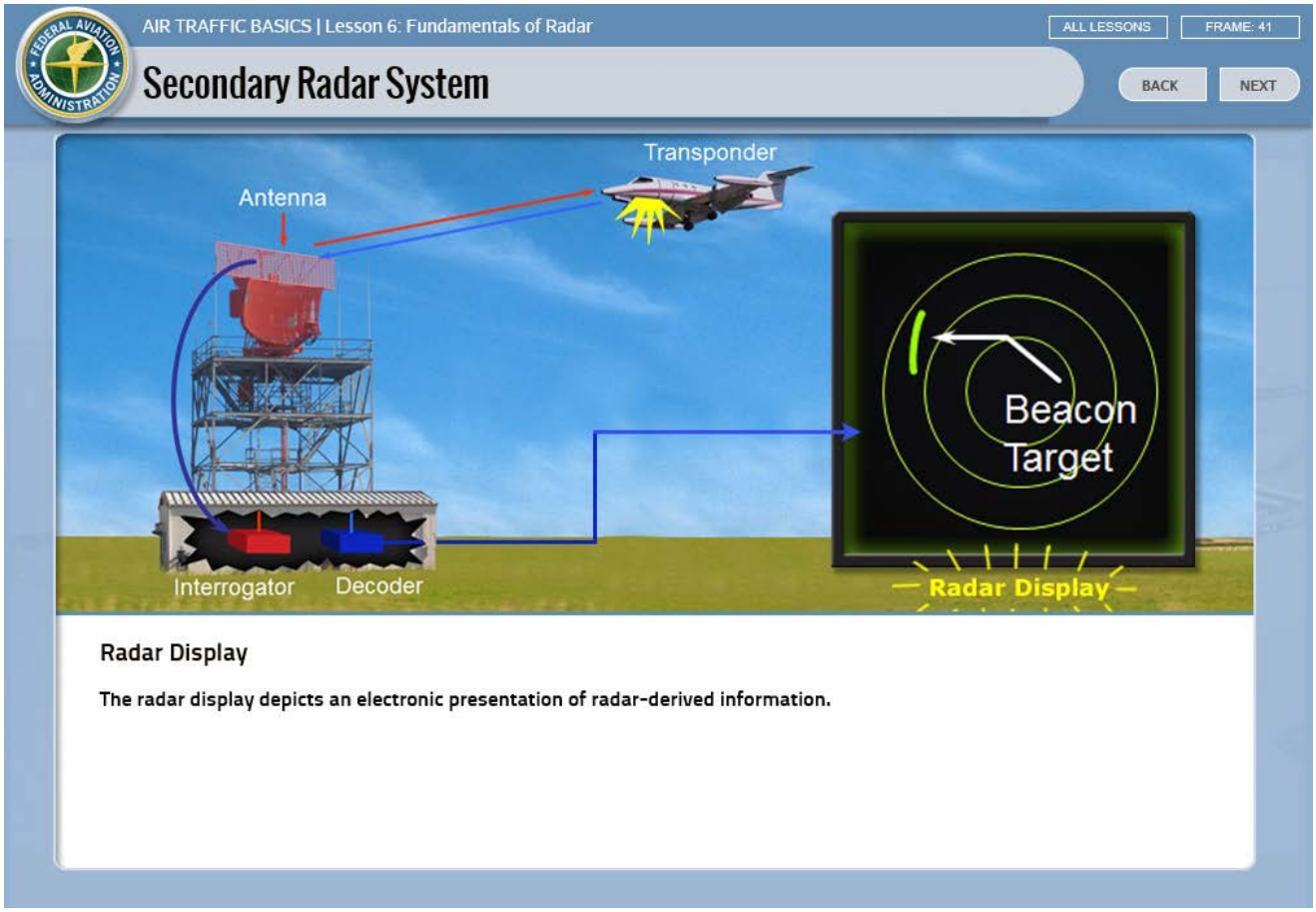
Controllers know if an aircraft is transponder-equipped by a coded equipment suffix that appears on each aircraft's flight plan.

- **Other aircraft suffixes will be discussed in a later lesson.**

JO 7110.65, Chap. 2

AIRCRAFT HAS A TRANSPONDER	ADDITIONAL INFORMATION
/ A	Also has Distance Measuring Equipment (DME) and altitude reporting capability
/ B	Also has DME, but does not have altitude reporting capability
/ P	Equipped with TACAN and altitude reporting capability
/ I	Advanced area navigation equipment and altitude reporting capability
/ T	Does not have altitude reporting capability
/ U	Has altitude reporting capability


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 40
Secondary Radar System
BACK
NEXT
Transponder
Antenna
Interrogator
Decoder
Radar Display
Decoder
The decoder processes transponder replies and sends them to the radar display.
ETM 12-0-1, p. 37


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
FRAME: 41
Secondary Radar System
BACK
NEXT
Transponder
Antenna
Beacon
Target
Interrogator
Decoder
Radar Display
Radar Display
The radar display depicts an electronic presentation of radar-derived information.

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 42

Secondary Radar System

BACK NEXT

Secondary Radar Phenomena

The following phenomena may cause false targets to appear on a secondary radar display:

- Transponder Operating Near Obstructions
- Ring Around

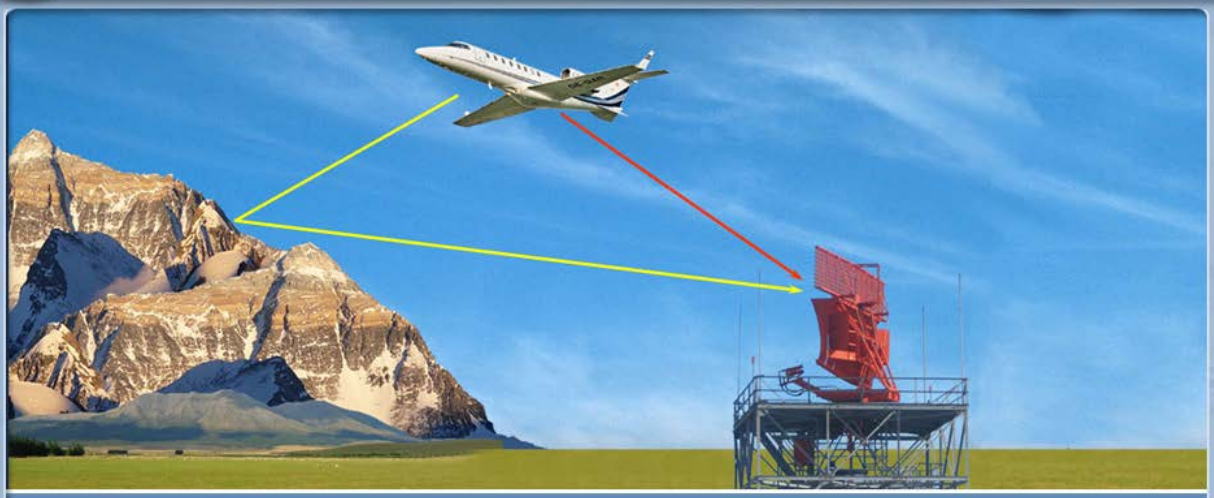
ETM 12-0-1, pp. 38, 39

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

ALL LESSONS FRAME: 43

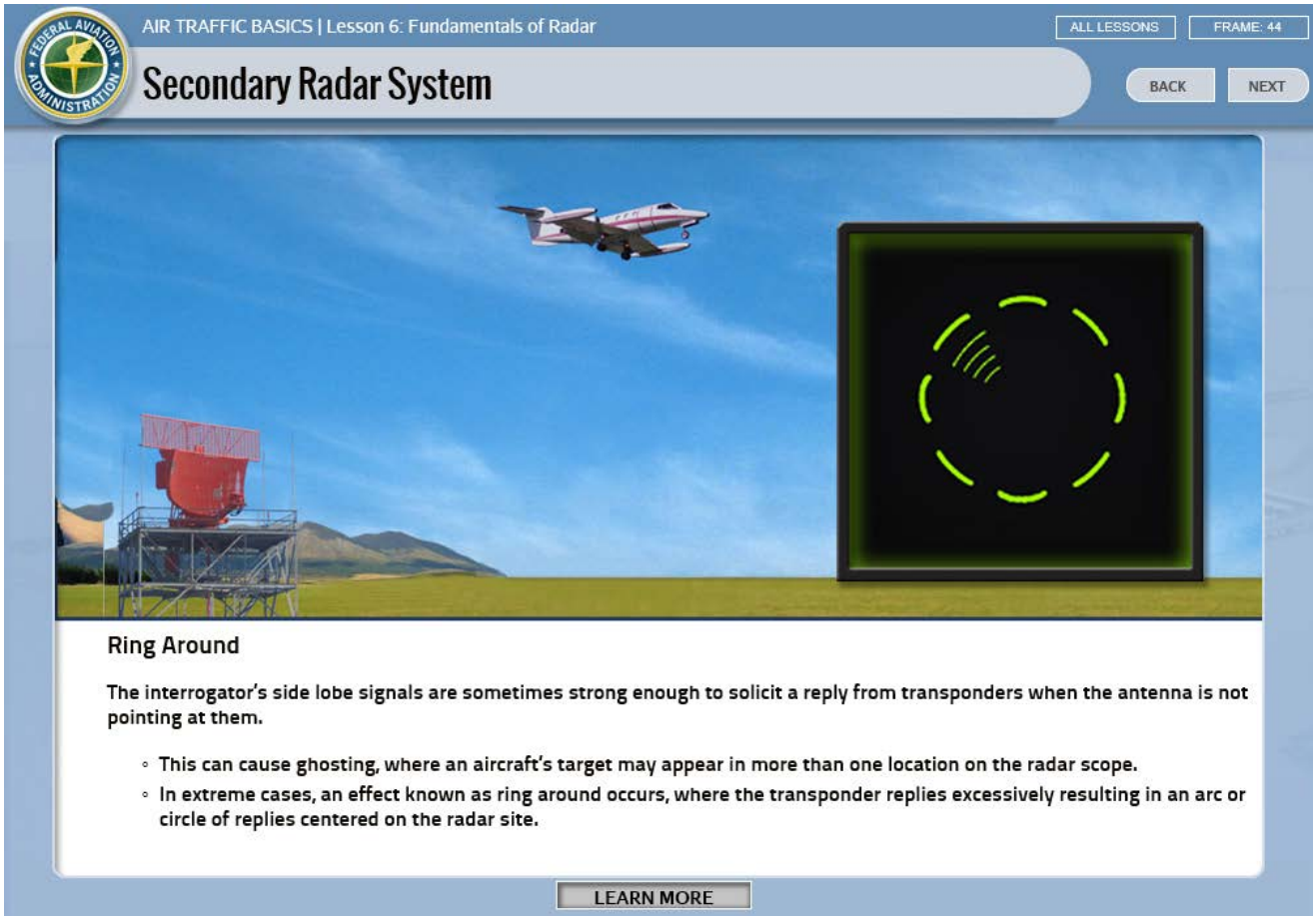
Secondary Radar System

BACK NEXT



Transponder Operating Near Obstructions

A transponder operating near obstructions or large objects may reflect a secondary radio signal off an obstruction, which the system interprets as a separate response.



Ring around can also occur when an aircraft is operating close to the interrogator site: range can be determined, but azimuth cannot, resulting in multiple targets equidistant from the antenna.

Reference: ETM 12-0-1, p. 39

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

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Secondary Radar System

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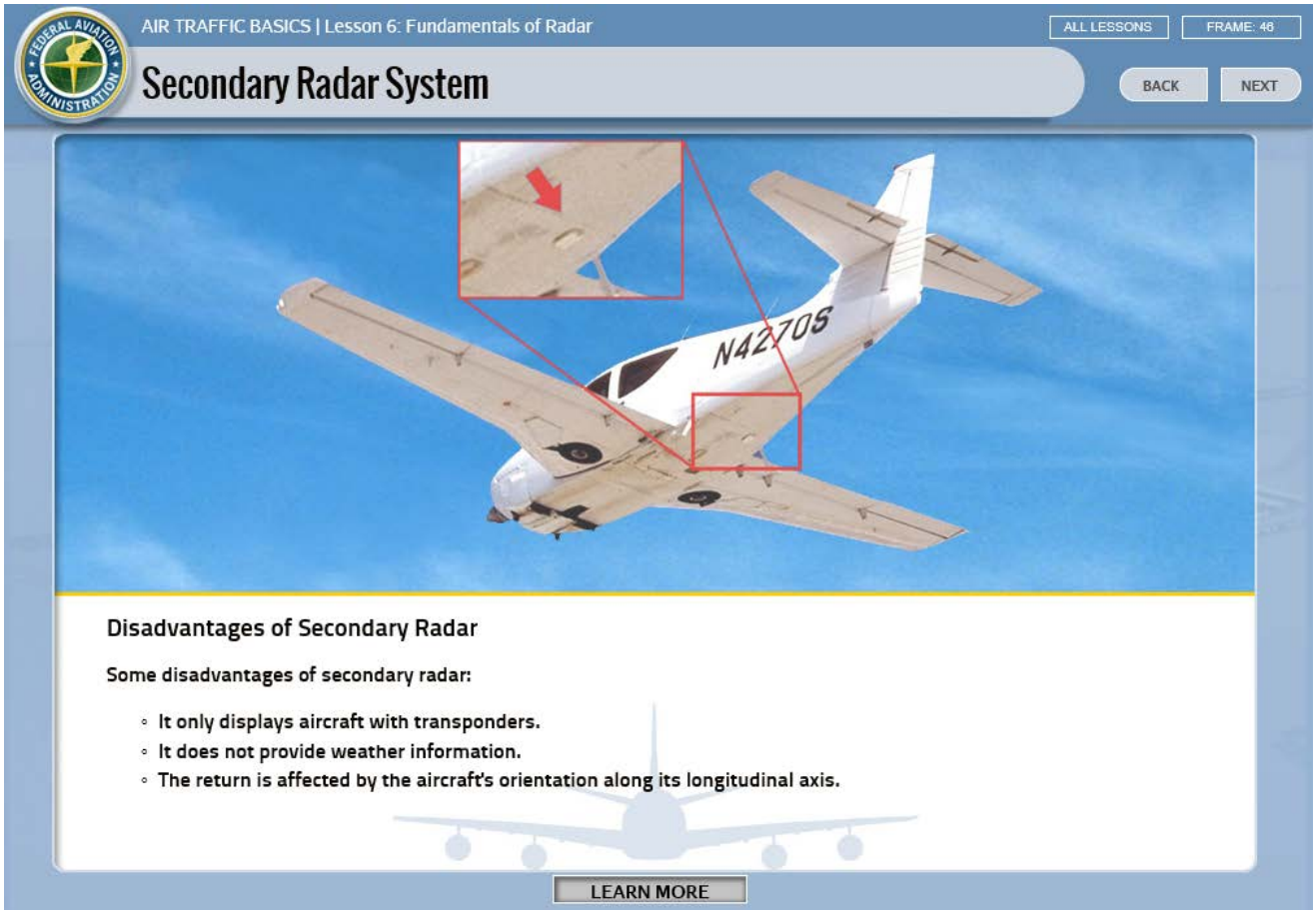
Advantages of Secondary Radar

Some advantages of secondary radar:

- It is less vulnerable to blind spots (blind zone).
- It provides a longer range than primary radar.
- Radar responses are not degraded by weather or ground clutter.

ETM 12-0-1, p. 35



- The aircraft transponder antenna is normally located on the underside of the aircraft.
- The location of the transponder antenna may cause a difference in reception if an aircraft is in a turn at an angle where the antenna is **not** exposed.
- Reception may be blocked by the wings or fuselage.

AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar

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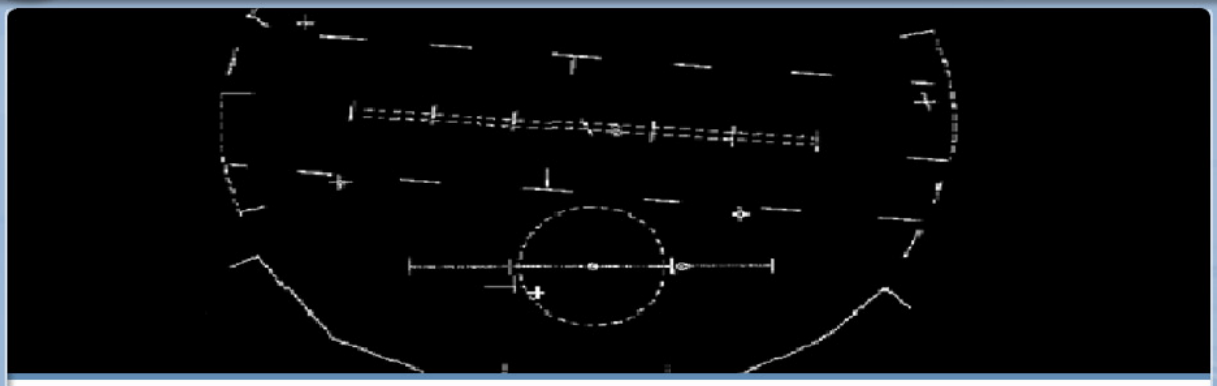
Features of Radar Display

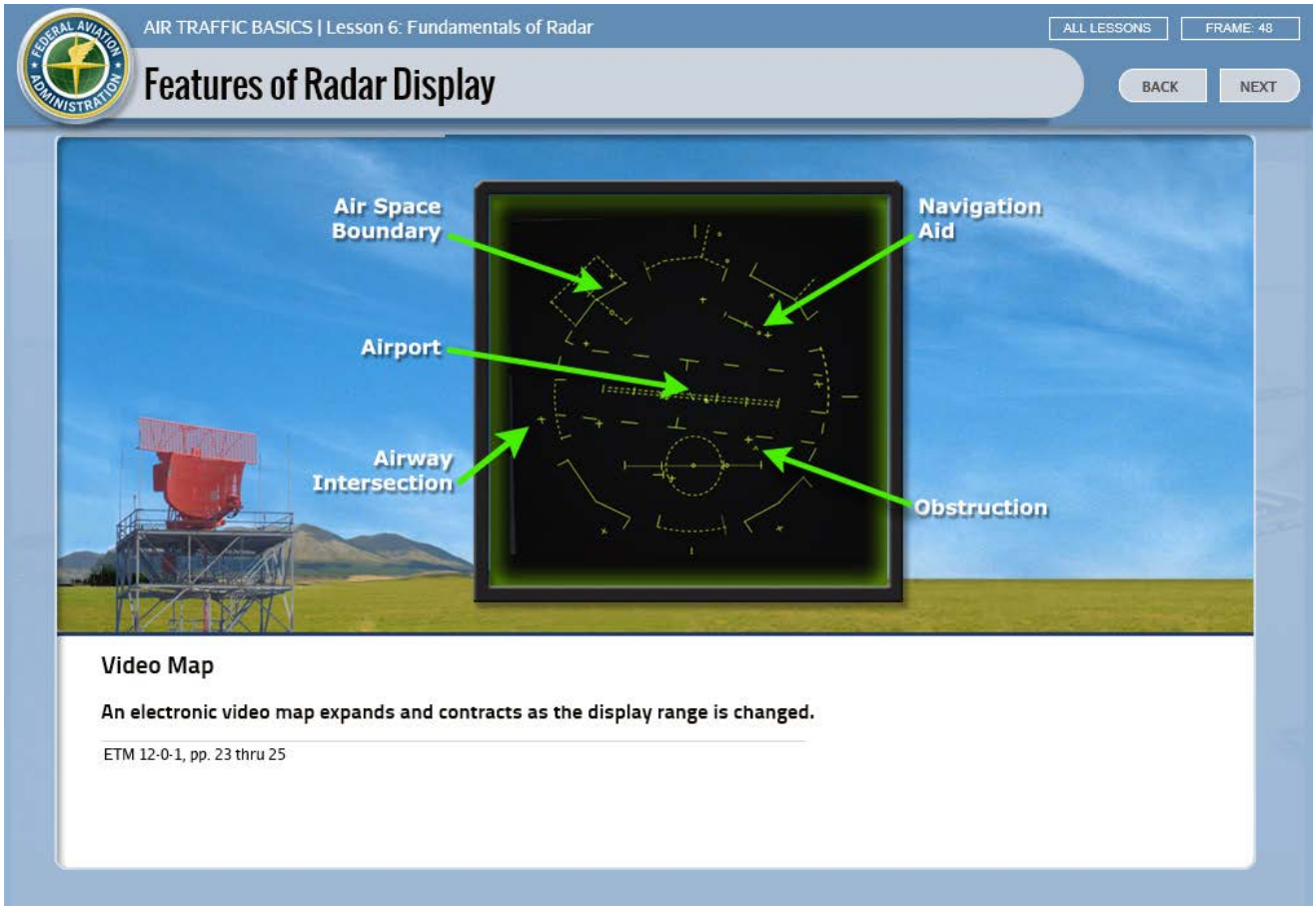
BACK NEXT



Video Map Definition

A video map is an electronically displayed map on the radar display that may depict data such as airports, heliports, runway centerline extensions, NAVAIDs and fixes, reporting points, airway/route centerlines, boundaries, handoff points, special use tracks, obstructions, prominent geographic features, range marks, minimum vectoring altitudes.

JO 7110.65, Pilot/Controller Glossary


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
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Features of Radar Display
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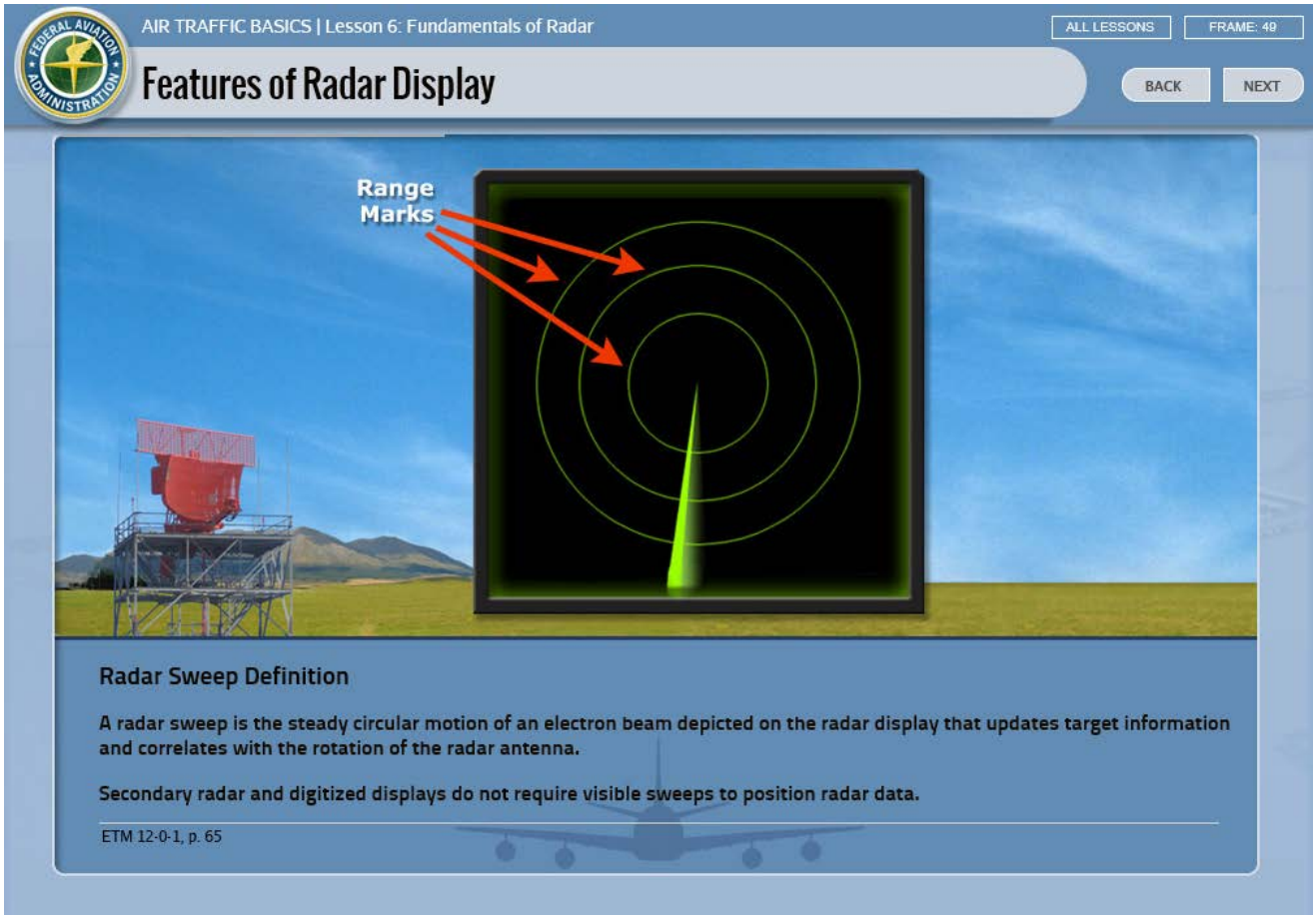
Air Space Boundary
Navigation Aid
Airport
Airway Intersection
Obstruction
Video Map
An electronic video map expands and contracts as the display range is changed.
ETM 12-0-1, pp. 23 thru 25


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
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Features of Radar Display
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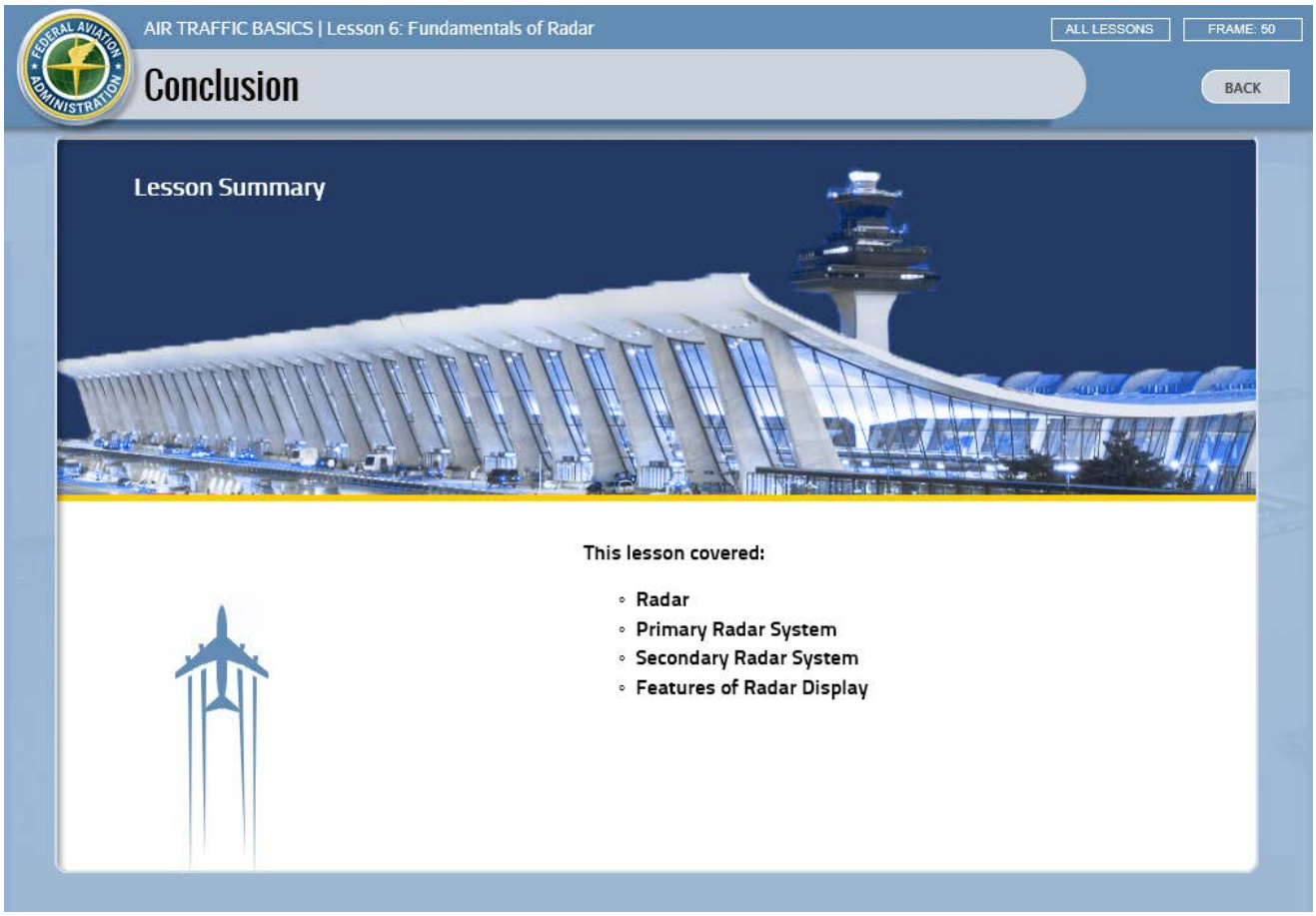
Range Marks
Radar Sweep Definition
A radar sweep is the steady circular motion of an electron beam depicted on the radar display that updates target information and correlates with the rotation of the radar antenna.
Secondary radar and digitized displays do not require visible sweeps to position radar data.
ETM 12-0-1, p. 65


AIR TRAFFIC BASICS | Lesson 6: Fundamentals of Radar
ALL LESSONS
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Conclusion
BACK
Lesson Summary
This lesson covered:
Radar
Primary Radar System
Secondary Radar System
Features of Radar Display