Federal Aviation Administration

55054003
EN ROUTE
RADAR ASSOCIATE
CONTROLLER TRAINING PART C:
ADVANCED CONCEPTS

Lesson 1: Fundamentals of ATC Surveillance Systems

Version: 1.0 2022.08

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LESSON PLAN DATA SHEET

Course Name	En Route Radar Associate Controller Training Part C: Advanced Concepts
Course Number	55054003
Lesson Title	Fundamentals of ATC Surveillance Systems
Duration	1 hour (includes lesson and ELT)
Version	1.0 2022.08
Reference(s)	JO 7110.65, Air Traffic Control; ETM 12-0-1, Fundamentals of Primary and Secondary Surveillance Radar; TI 6110.100, En Route Automation Modernization (ERAM) Air Traffic Manual (ATM): R-Position User Manual; Aeronautical Information Manual (AIM); SRT-047, Surveillance and Broadcast Services Description Document
Prerequisites	NONE
Handout(s)	NONE
Scenario	NONE
Exercise / Activity	NONE
Assessments	⊙ YES - Written
Materials and Equipment	⊙ Pencil and/or pen
Other Pertinent Information	⊙ **Ensure lesson materials are downloaded to the classroom computer** ⊙ This lesson is based on ERAM EAE410. ⊙ The lesson has been reviewed and reflects current orders and manuals as of April 2022.

LESSON ICON LEGEND

	Description
	The Activity icon indicates an exercise, lab, or hands-on activity.
	The Discussion Question icon signals a discussion question to be asked to the students.
	The Handout icon indicates a handout is to be distributed to the students.
	The Instructor Note icon is in hidden text and indicates text that is for the instructor only.
	The Multimedia icon indicates a video or audio clip is in the presentation.
	The Phraseology icon indicates that phraseology is in the content.
	The WBT icon indicates a component of web-based training.
	The Click icon indicates a PPT slide with click-based functionality to present additional information.
	The Definition icon indicates a published definition.

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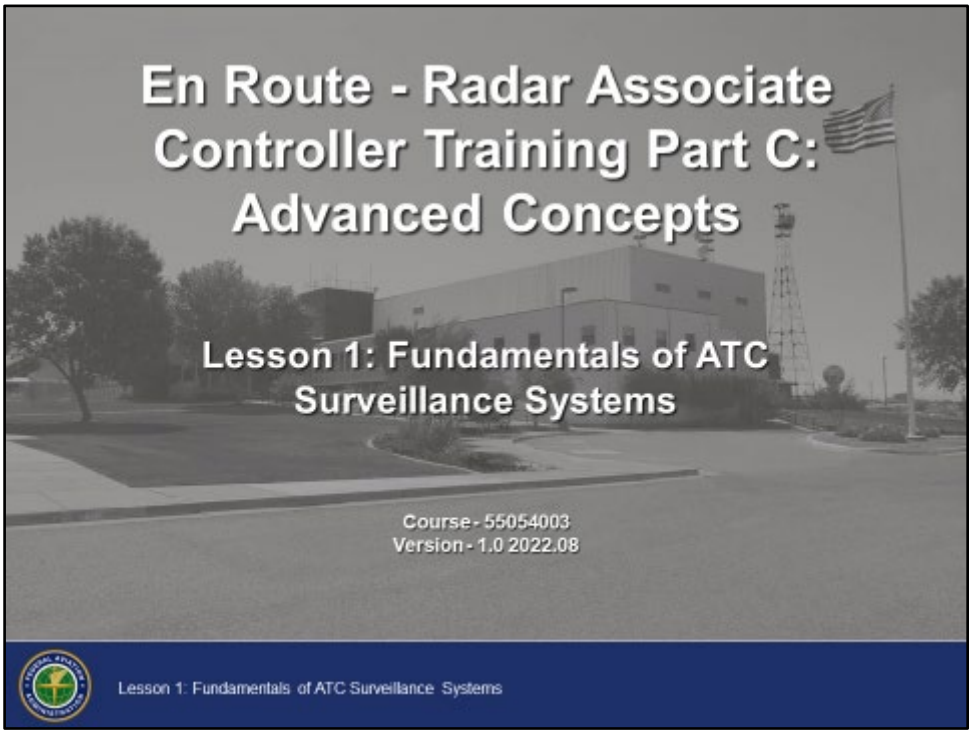
LESSON INTRODUCTION

Overview

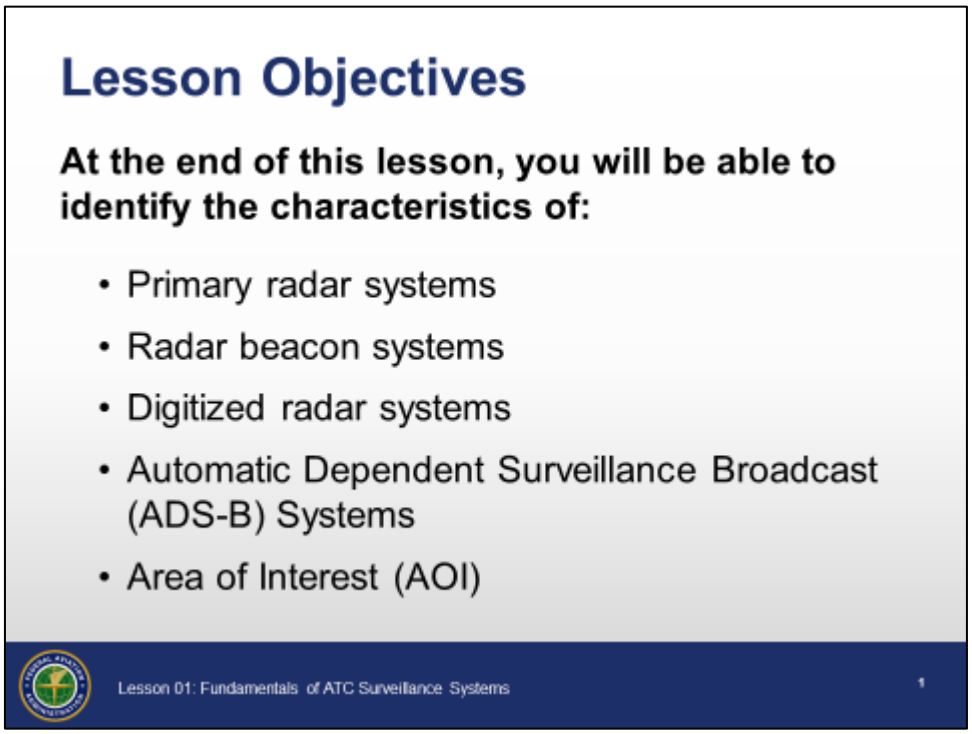
SRT - 047, pg. 1



A basic knowledge of primary, secondary and digitized radar, Automatic Dependent Surveillance-Broadcast (ADS-B), Surveillance and Broadcast Services System (SBSS) and Flight Planning Area of Interest (AOI) are necessary to perform your duties as a Radar Associate Controller.

LESSON INTRODUCTION *(CONT'D)*

Lesson Objectives



⊙ At the end of this lesson, you will be able to identify the characteristics of:

- Primary radar systems
- Radar beacon systems
- Digitized radar systems
- Automatic Dependent Surveillance Broadcast (ADS-B) systems
- Area of Interest (AOI)

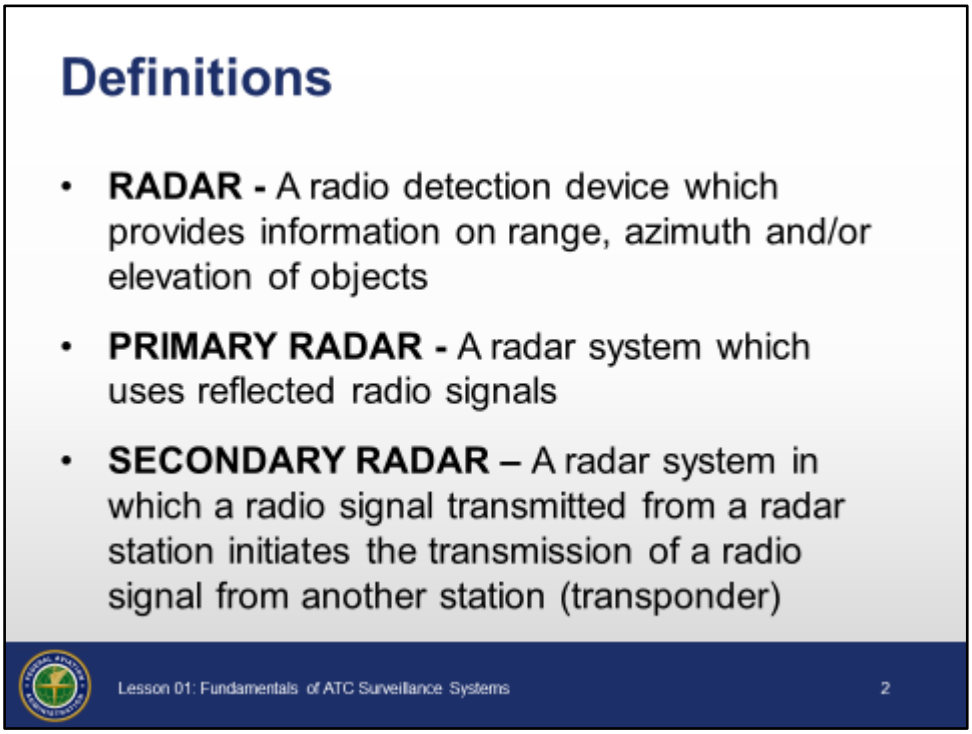
NOTE: There will be a graded end-of-lesson test upon completion of the lesson. The passing score is 70%. If you do not achieve a score of 70%, you will be provided study time and one retake of an alternate end-of-lesson test.

PRIMARY RADAR SYSTEMS

Definitions

JO 7110.65, PCG

ETM 12-0-1, p.5



RADAR - Radio Detection and Ranging. A radio detection device which provides information on range, azimuth and/or elevation of objects.

PRIMARY RADAR - A radar system which uses reflected radio signals.

SECONDARY RADAR - A radar system in which a radio signal transmitted from a radar station initiates the transmission of a radio signal from another station (transponder).

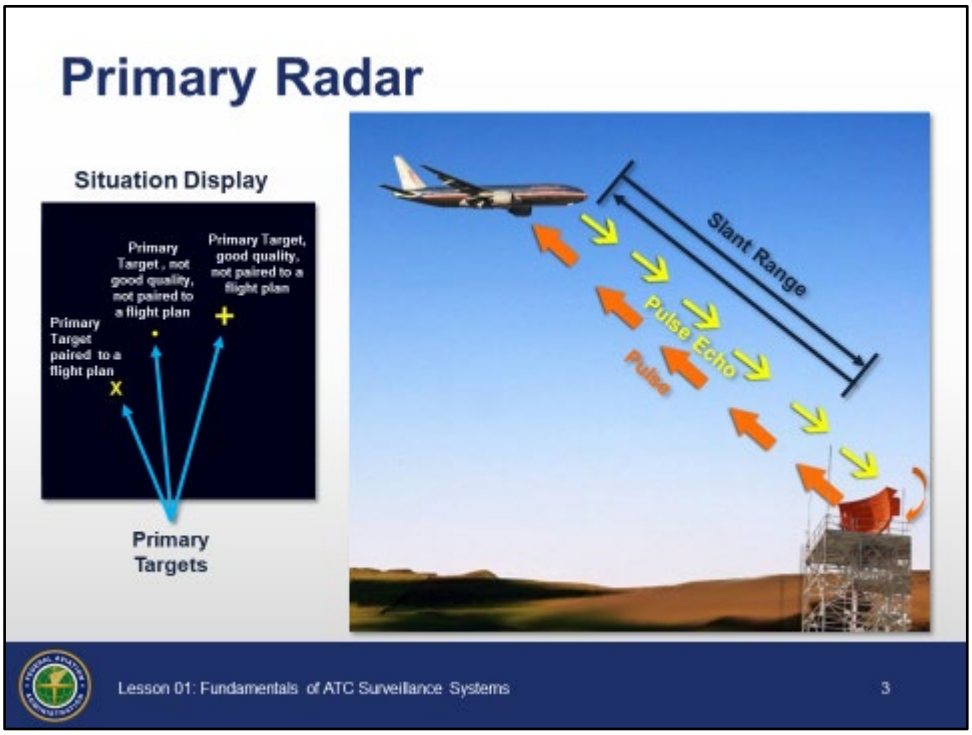
PRIMARY RADAR SYSTEMS *(CONT'D)*

Primary Radar

JO 7110.65, PCG

ETM 12-0-1, Glossary

TI 6110.100, sec. 2.7.1



- Primary radar relies on a signal bouncing off the aircraft and returning to the antenna
  - Antenna transmits a pulse signal
  - Aircraft reflects pulse echo
  - Antenna receives signal
  - Computer processes the signal
  - Aircraft position displayed on the Situation Display

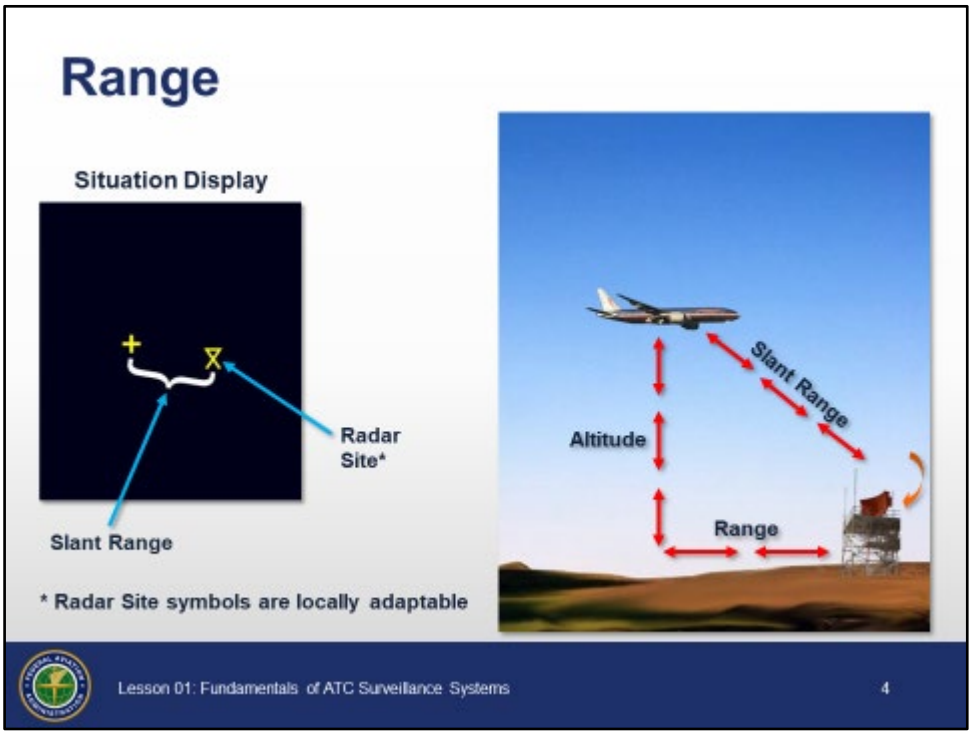
PRIMARY RADAR TARGET - An analog or digital target, exclusive of a secondary radar target, presented on a radar display.

- Situation Display - Primary targets
  - "X" indicates a primary target paired to a flight plan
  - A dot indicates a primary target with a weak or poor quality return that is not paired to a flight plan
  - "+" indicates a primary target with a strong or high quality return that is not paired to a flight plan

PRIMARY RADAR SYSTEMS *(CONT'D)*

Range

ETM 12-0-1, pp. 7, 8



RANGE - The distance from the antenna to a point on the ground directly below the aircraft.

SLANT RANGE - The straight line distance to the target. Radar range is determined by slant line range and not the normal geographical ranging.

- Range for primary and secondary radar targets is always slant range as it is measured from the radar antenna

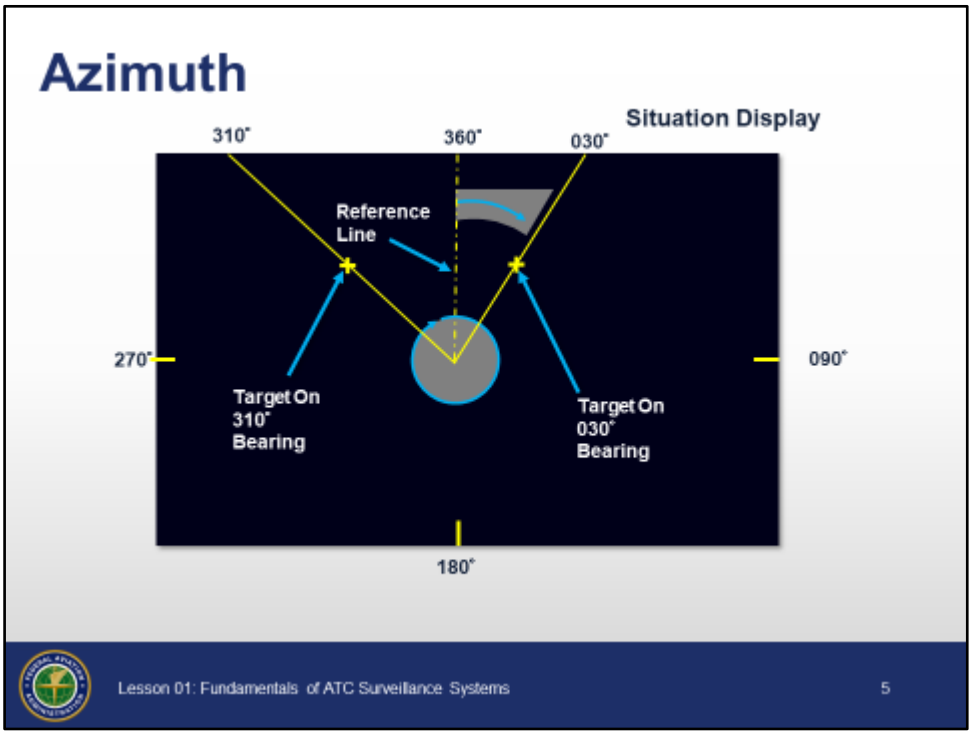
NOTE: Altitude updates are required to assure maximum accuracy in applying slant range correction formulas.

PRIMARY RADAR SYSTEMS *(CONT'D)*

Azimuth

JO 7110.65, par. 1-2-1

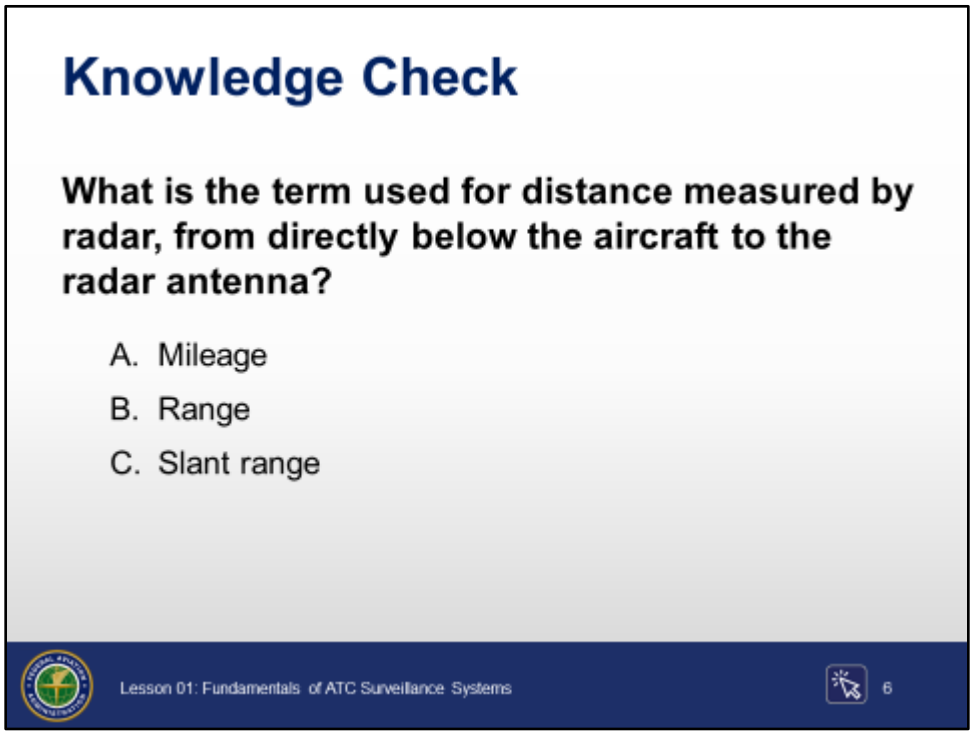
ETM 12-0-1 pp. 7-8



AZIMUTH - The direction of an object from the antenna based on a 360° circle measured clockwise from a reference line.

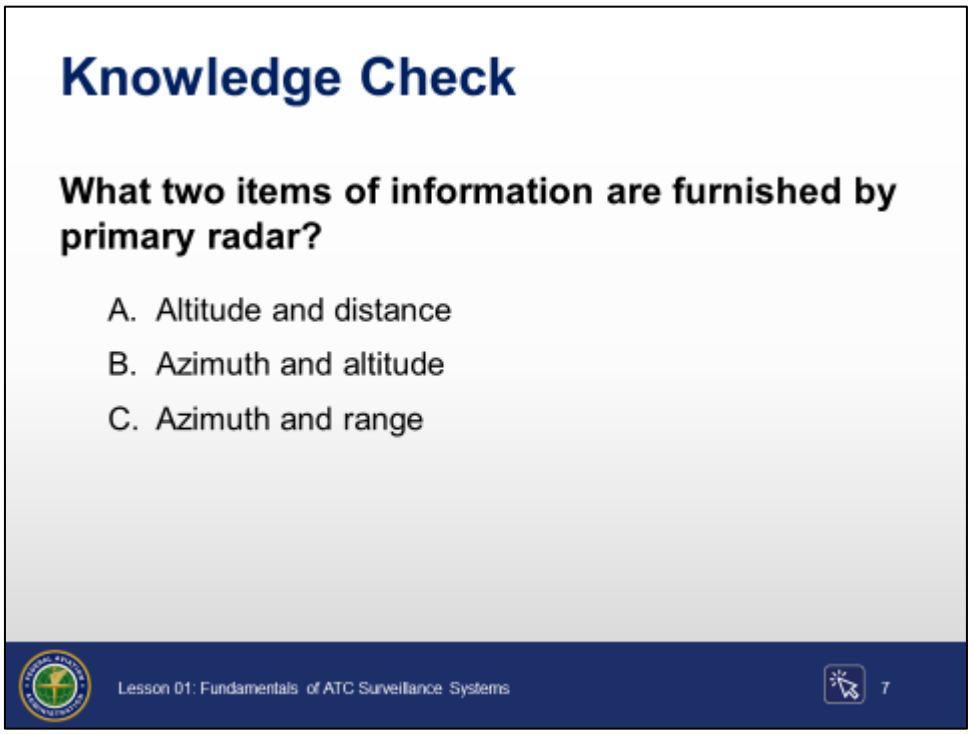
⊙ Azimuth must always be magnetic unless specifically stated otherwise

Knowledge Check



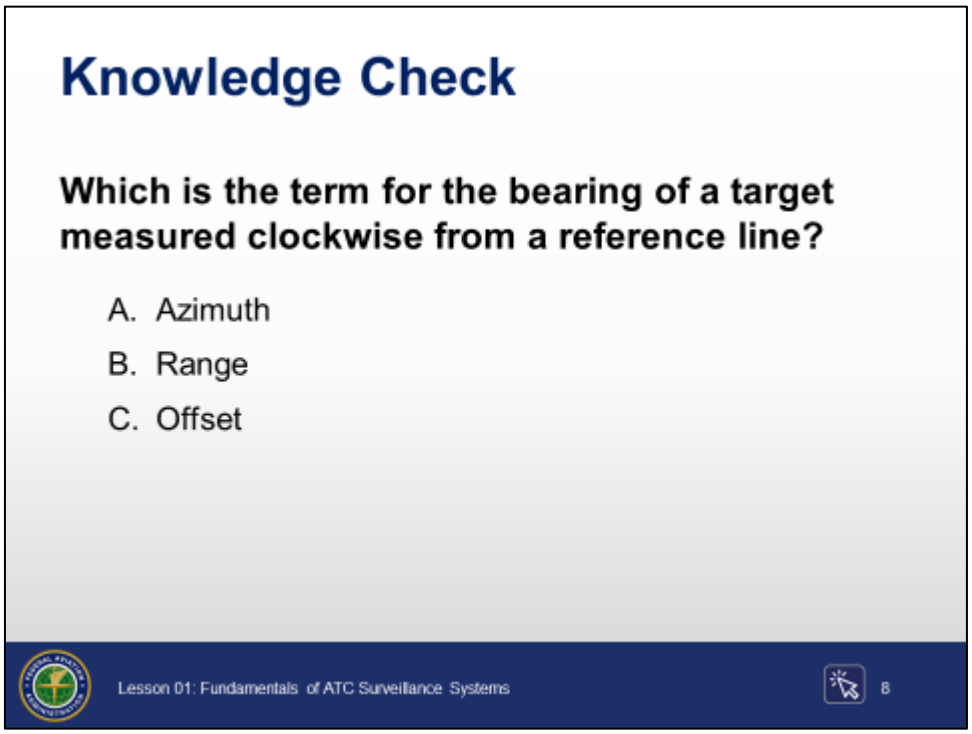
Question: What is the term used for distance measured by radar, from directly below the aircraft to the radar antenna?

Knowledge Check



Question: What two items of information are furnished by primary radar?

Knowledge Check



Question: Which is the term for the bearing of a target measured clockwise from a reference line?

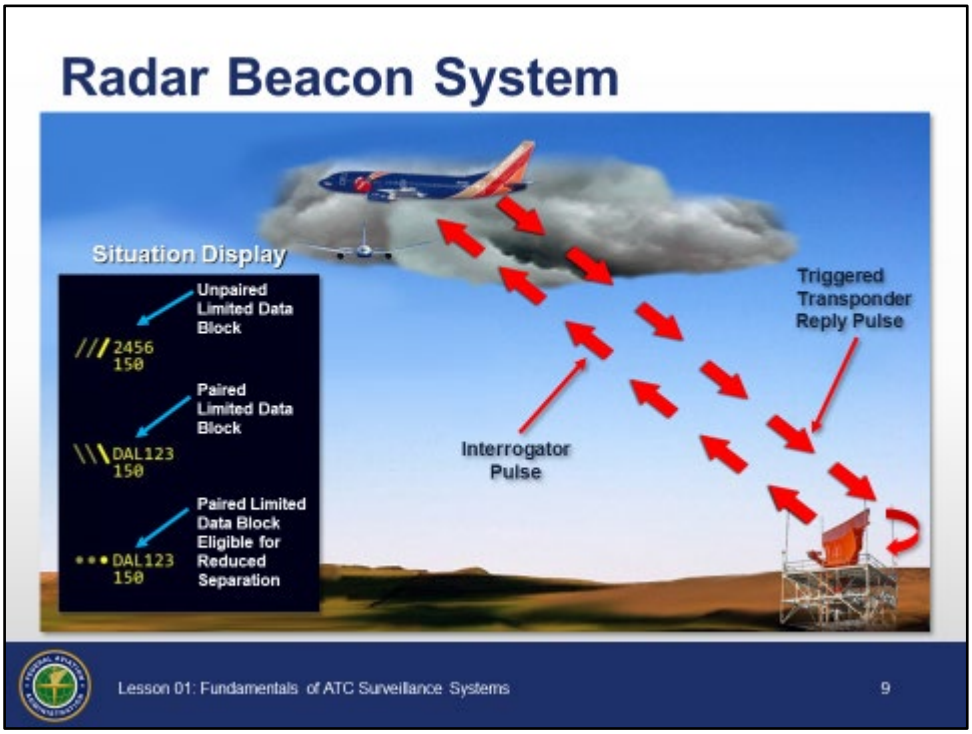
RADAR BEACON SYSTEM

Transponder Operation

JO 7110.65, PCG

ETM 12-0-1 pp. 35 through 37

AIM, par. 4-5-2

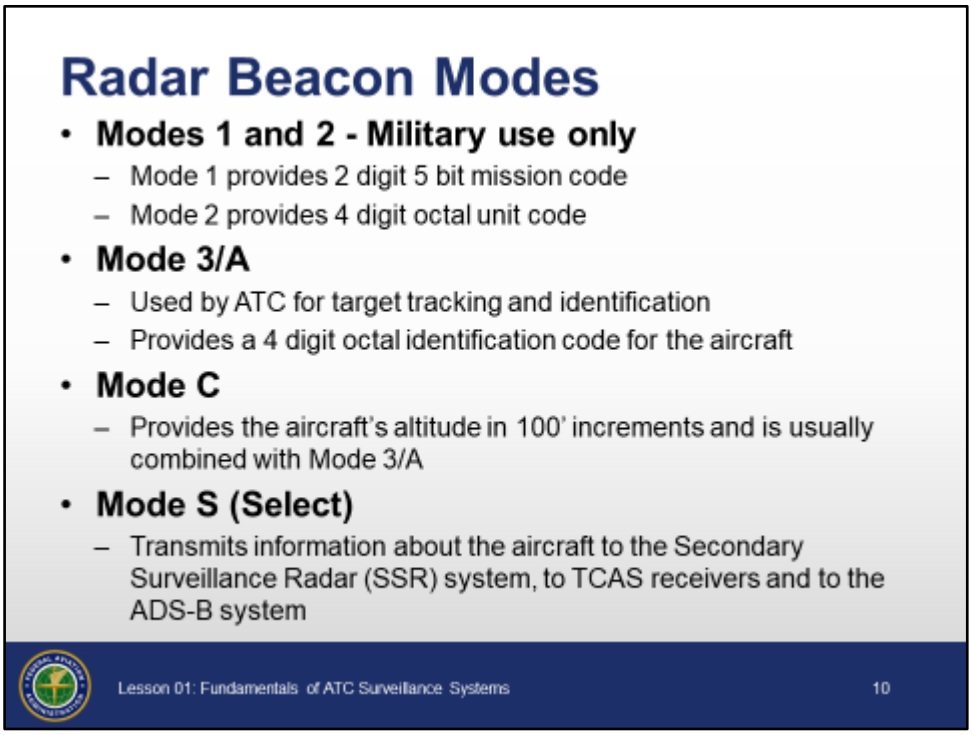


- A radar beacon system is also known as secondary radar
  - A signal (interrogator pulse) is transmitted from the interrogator on the radar antenna
  - The interrogator triggers the transponder on the aircraft to send a signal back to the antenna (reply pulse)
    - The reply pulse is the secondary radar return and reinforces or replaces the primary radar return
- The primary and secondary antennas are collocated
- Situation Display - secondary targets
  - "/" indicates a secondary target that is not paired to a flight plan
  - "\" indicates a secondary target that is paired to a flight plan
  - "●" indicates a secondary target that is eligible for reduced separation and is paired to a flight plan

RADAR BEACON SYSTEM *(CONT'D)*

Radar Beacon Modes

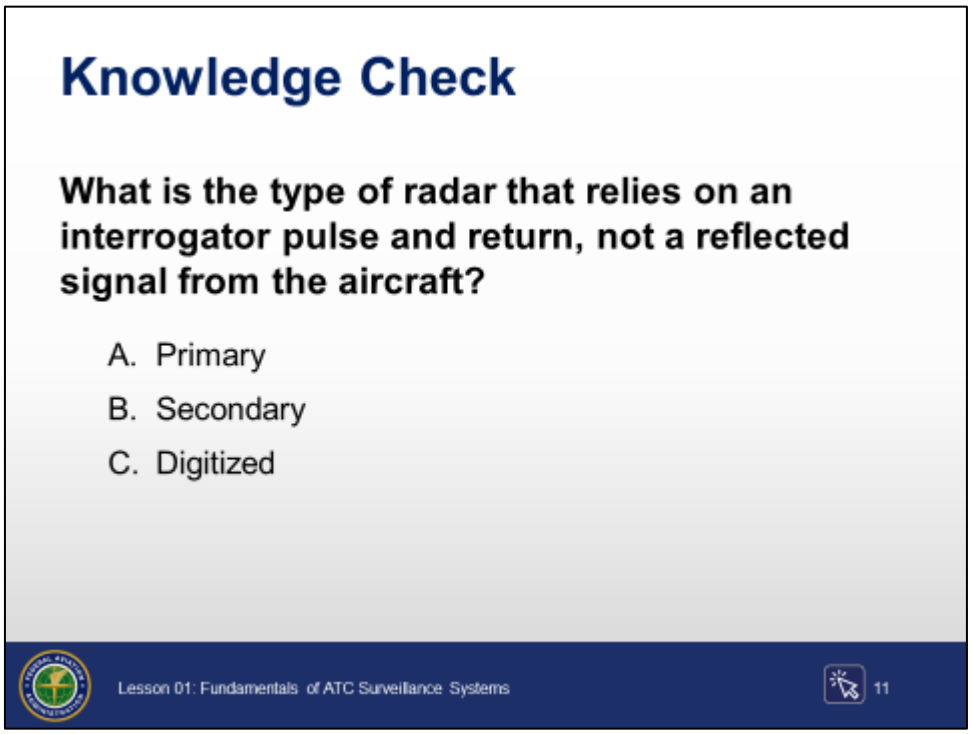
ETM 12-0-1 pp. 41 through 43, 52



- Modes 1 and 2 - Military use only
  - Mode 1 provides 2 digit 5 bit mission code
  - Mode 2 provides 4 digit octal unit code (set on ground for fighters, can be changed in flight by transport aircraft)
- Mode 3/A
  - Used by ATC for target tracking and identification
  - Provides a 4 digit octal identification code for the aircraft
- Mode C
  - Provides the aircraft's altitude in 100' increments and is usually combined with Mode 3/A
- Mode S (Select)
  - Transmits information about the aircraft to the Secondary Surveillance Radar (SSR) system, to TCAS receivers on board aircraft and to the ADS-B SSR system

RADAR BEACON SYSTEM *(CONT'D)*

Knowledge Check

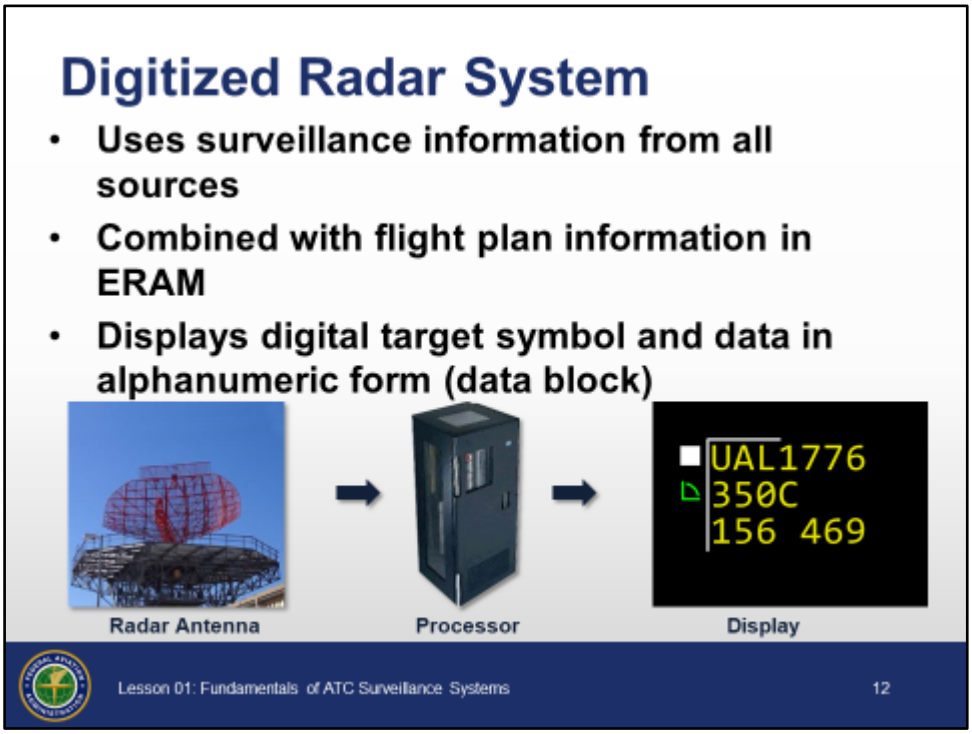


Question: What is the type of radar that relies on an interrogator pulse and return, not a reflected signal from the aircraft?

DIGITIZED RADAR SYSTEMS

Digitized Radar

ETM 12-0-1, p. 53



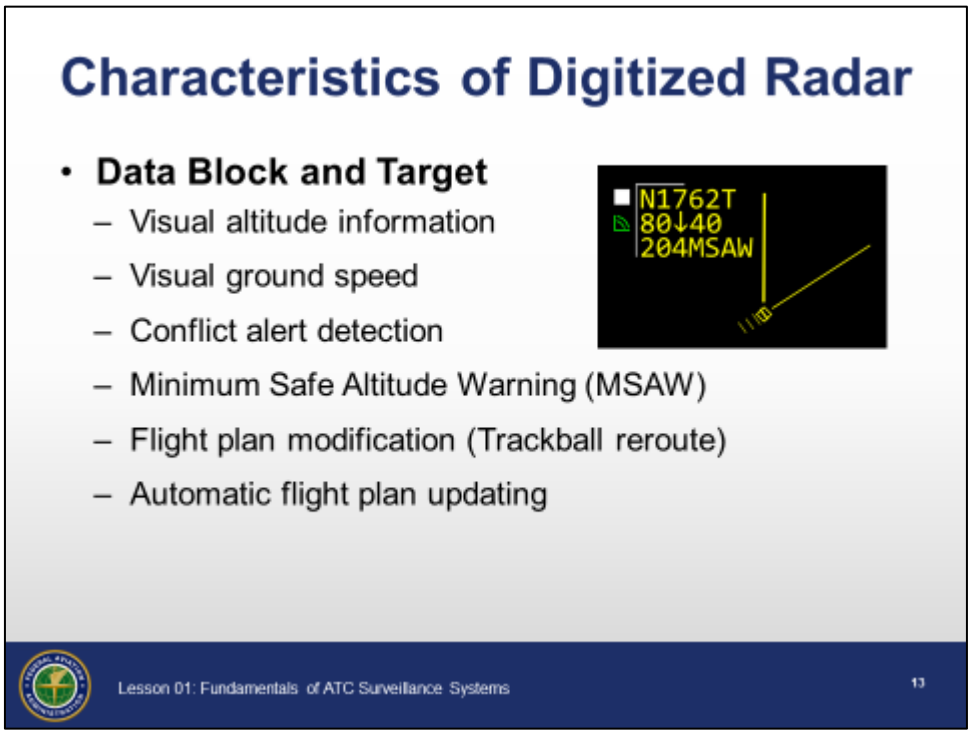
- Uses surveillance information from all sources
- Combined with flight plan information in ERAM
- Displays digital target symbol and data in alphanumeric form (data block)
  - A data block is displayed adjacent to the aircraft target on the Situation Display

DIGITIZED RADAR SYSTEMS *(CONT'D)*

Characteristics of Digitized Radar - Data Block and Target

ETM 12-0-1, p. 53

TI 6110.100, sec. 1.2.7



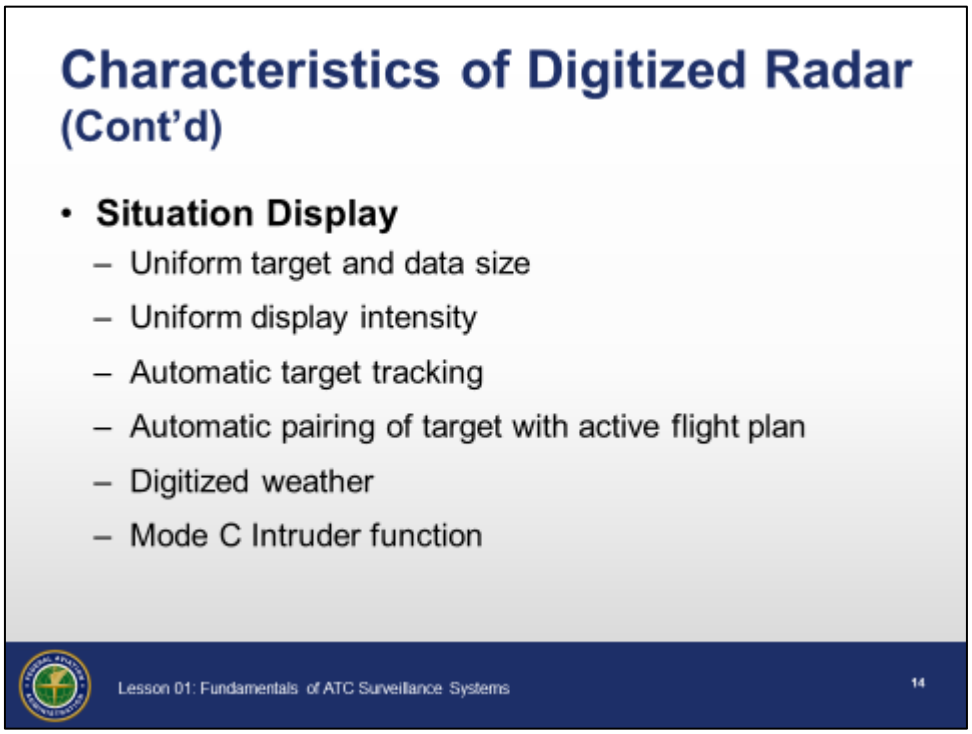
- Data block and target
  - Visual altitude information
    - Mode C altitude readout displayed in data block
  - Visual ground speed
    - Aircraft ground speed displayed in data block
  - Conflict alert detection
    - Data block of aircraft predicted to be in conflict will flash
  - Minimum Safe Altitude Warning (MSAW)
    - Warns ATC of aircraft in unsafe proximity to terrain
  - Flight plan modification (trackball reroute)
    - Allows reroute of flight plan using the trackball to select a point based on the Situation Display
  - Automatic flight plan updating
    - ERAM flight data processing will be updated based on aircraft's position

DIGITIZED RADAR SYSTEMS *(CONT'D)*

Characteristics of Digitized Radar - Situation Display

ETM 12-0-1, p. 53

TI 6110.100, sec. 1.2.7



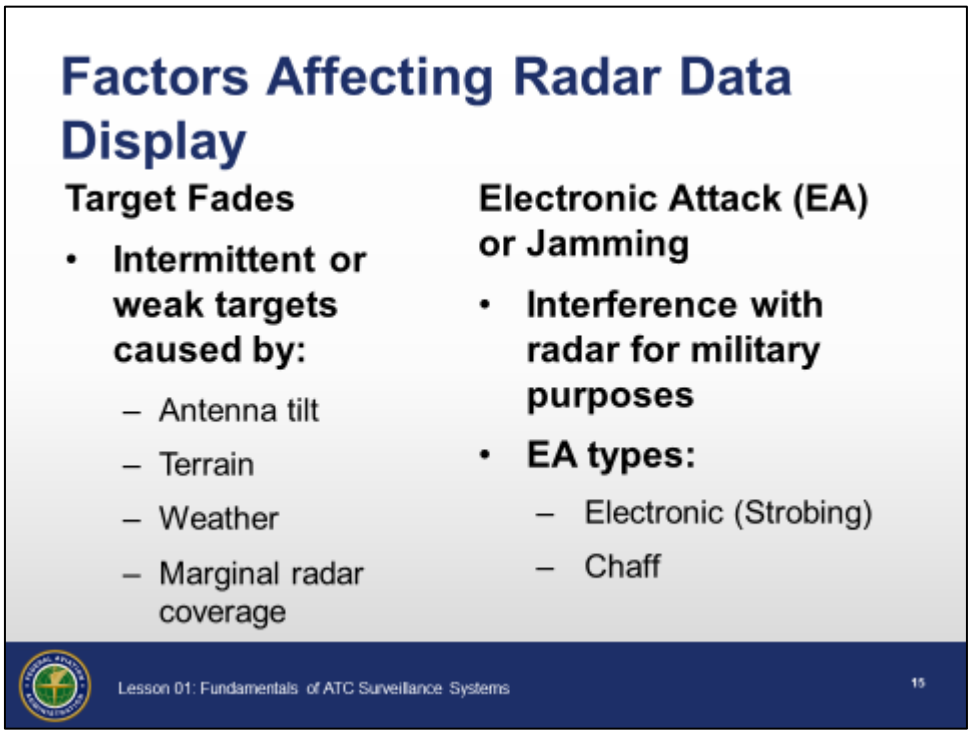
- ⊙ Situation Display
  - Uniform target and data size
    - Target and data block will remain the same size regardless of position from radar antenna
  - Uniform display intensity
    - Weak or strong target returns will show the same intensity
  - Automatic target tracking
    - ERAM updates target flight path information and keeps the paired data block with the target
  - Automatic pairing of target with an active flight plan
    - Target squawking a discrete beacon code will automatically pair with an active flight plan
  - Digitized weather
    - Display of digital weather radar
  - Mode C Intruder function
    - Displays and may alert to targets reporting mode C altitude that do not have an active flight plan

DIGITIZED RADAR SYSTEMS *(CONT'D)*

Factors Affecting Radar Data Display

ETM 12-0-1, pp. 29-34

JO 7110.65, par. 5-1-3



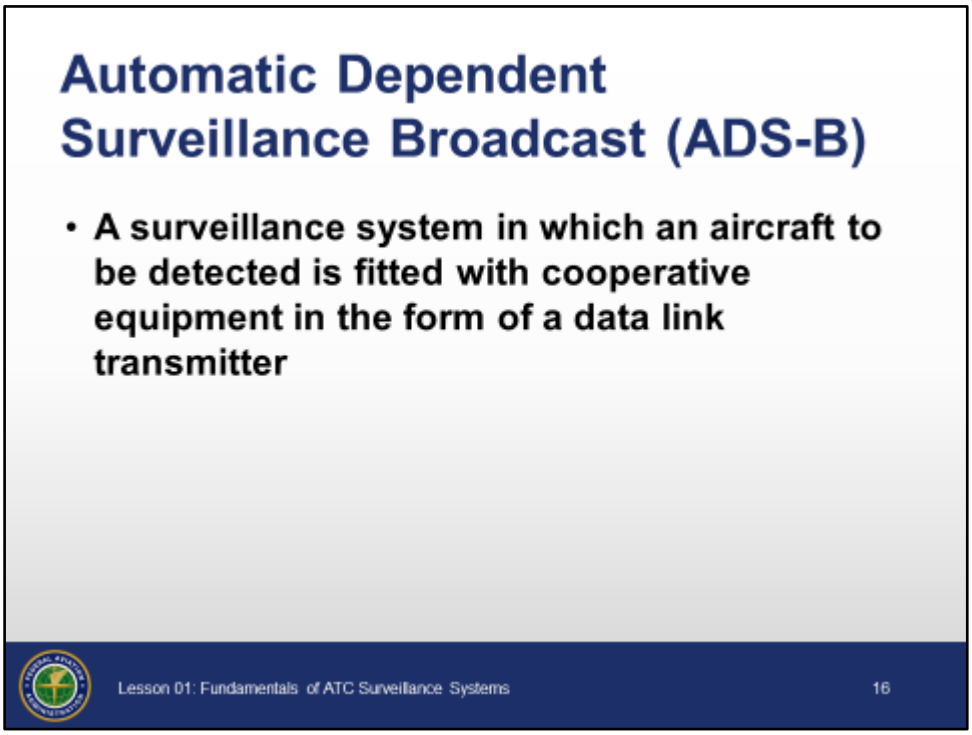
- Target fades are intermittent or weak targets caused by:
  - Antenna tilt
  - Terrain
  - Weather
  - Marginal radar coverage
- Electronic Attack (EA) or jamming activity
  - Interference with radar for military purposes
    - Electronic (Strobing)
      - May be corrected by calling the source and having them discontinue interference
    - Chaff
      - Thin metal or mylar strips released by aircraft to reflect radar signals
      - Not correctable, moves with the wind until it dissipates

AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B)

ADS-B

AC 90-114, par. 2-2

JO 7110.65, PCG



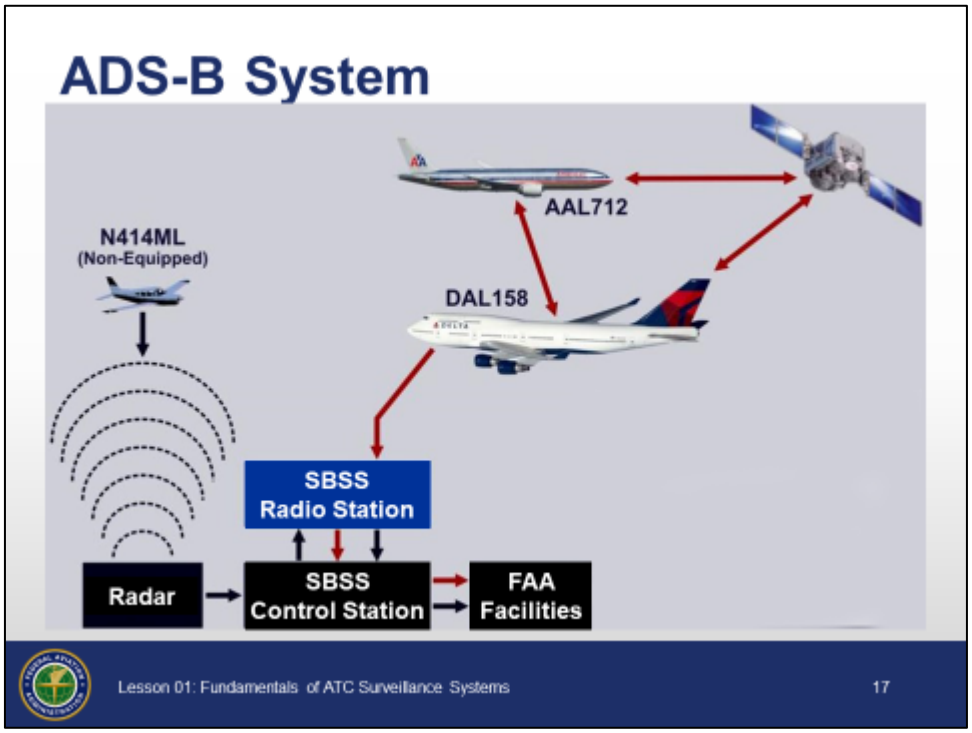
AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B) - A surveillance system in which an aircraft to be detected is fitted with cooperative equipment in the form of a data link transmitter.

- Periodically (at least once per second) transmits position, altitude, and other required information such as identity and velocity
  - No pilot or controller input is required
- Position and velocity vector are derived from the Global Positioning System (GPS)
- Transmitted information is received by ground or space-based receivers for processing and display at air traffic facilities and suitably equipped aircraft
- Transmitted information is available to anyone with the appropriate receiving equipment
- Augments primary and secondary radar to allow for ATC surveillance

AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B) *(CONT'D)*

ADS-B System

AC 90-114, par. 2-2



- The ADS-B system is composed of aircraft avionics and a ground based infrastructure
- On board avionics use GPS satellite signals to determine aircraft position
- The ADS-B transceiver in the aircraft broadcasts a position report (latitude/longitude), along with other information, such as:
  - Barometric pressure altitude
  - Beacon code
  - Call sign or Flight ID
  - ICAO aircraft address

NOTE: The call sign, Flight ID and ICAO aircraft address are not broadcast when the pilot has not filed a flight plan, has not requested ATC services, and is using an ADS-B Out equipment self-assigned temporary 24 bit address.

- ADS-B transmissions are received by:
  - Other ADS-B aircraft
  - A network of ground based radio stations

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AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B) *(CONT'D)*

ADS-B System (Cont'd)

AC 90-114, par. 2-2

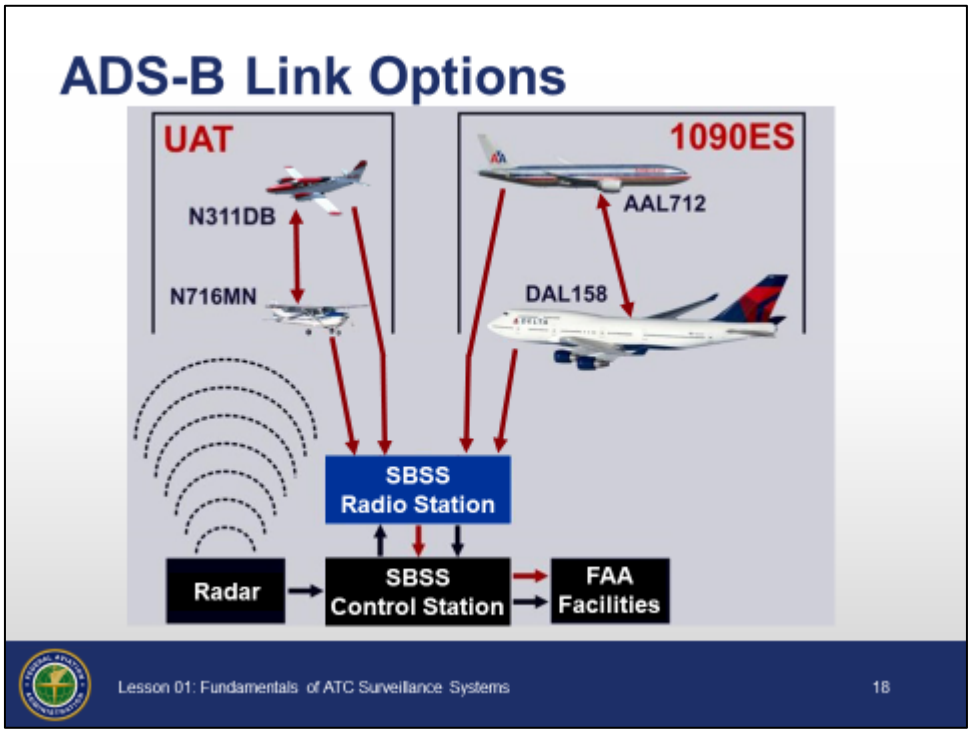
SRT - 047, pg. 1

- The ADS-B radio stations stream the reports over a wide area network to the control station that processes the information and forwards reports to FAA facilities
  - The ground system of radio stations, data centers, and wide area network are collectively known as Surveillance and Broadcast Services System (SBSS)
- Provides improved surveillance coverage in areas where primary or secondary radar does not provide adequate coverage

AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B) *(CONT'D)*

ADS-B Operating Frequencies

AC 90-114, par. 2.2

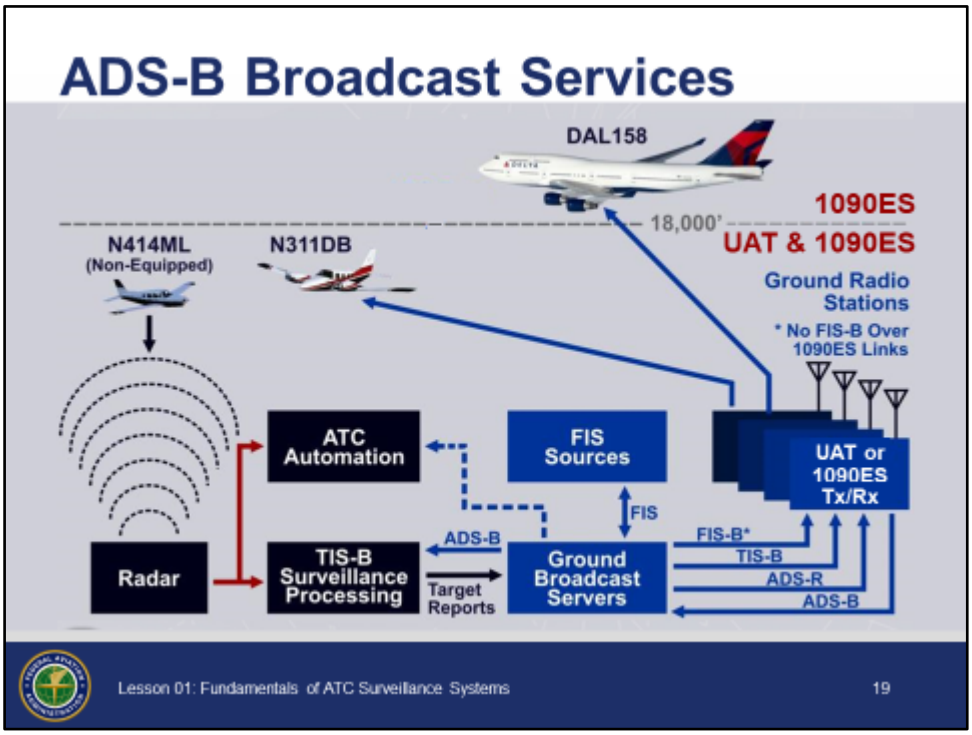


- ADS-B has two link options:
  - Universal Access Transceivers (UAT)
    - 978 MHZ
    - Used by general aviation
    - Used below 18,000'
  - 1090ES
    - 1090 MHZ
    - Used by most commercial and military aircraft
    - Required at or above FL180 (Class A), but usable at all altitudes
- ADS-B avionics have the ability to transmit and receive information
  - Some aircraft are equipped with transmit only capability
  - Other aircraft have both transmit and receive capability

AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST (ADS-B) *(CONT'D)*

ADS-B Broadcast Services

AC 90-114, par. 2-3

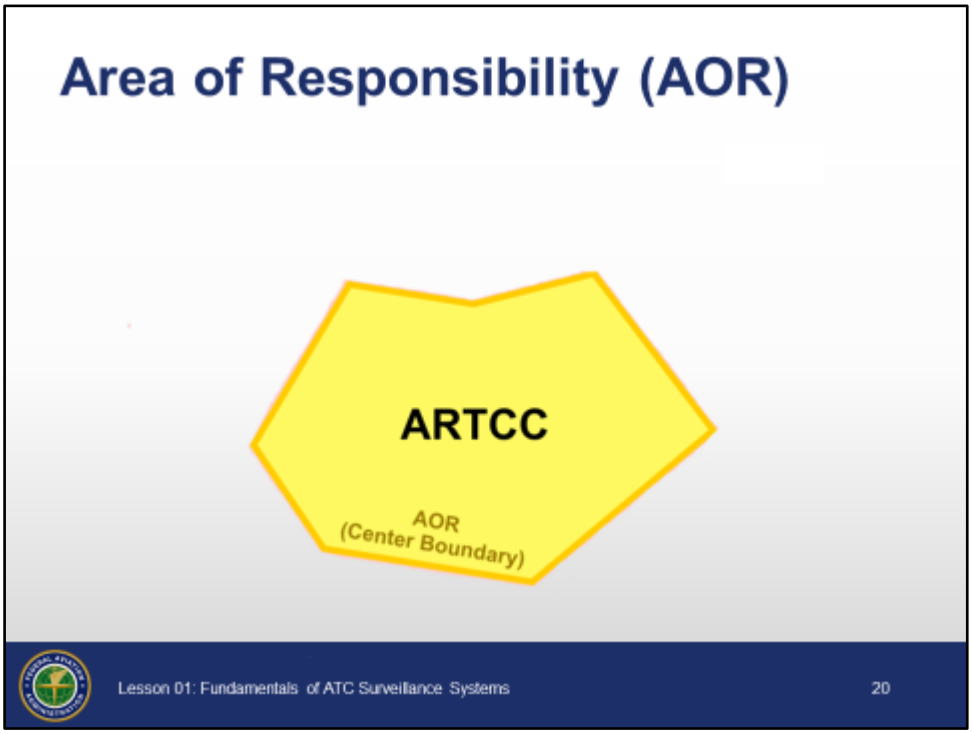


- ADS-B Broadcast Services includes:
  - Automatic Dependent Surveillance Rebroadcast (ADS-R)
    - Information from each frequency, 1090 MHz and 978 MHz, is translated, reformatted, and rebroadcast to enable aircraft receiving on the other frequency to process and use the other's information
  - Traffic Information Services - Broadcast (TIS-B)
    - Broadcasts transponder-based traffic information derived from ATC surveillance systems
  - Flight Information Services-Broadcast (FIS-B)
    - Operates on UAT only
    - Provides ADS-B-IN-equipped aircraft with a suite of advisory-only aeronautical and weather information products to enhance the user's situational awareness

AREA OF INTEREST (AOI)

Area of Responsibility

TI 6110.100, sec. 1.2.1

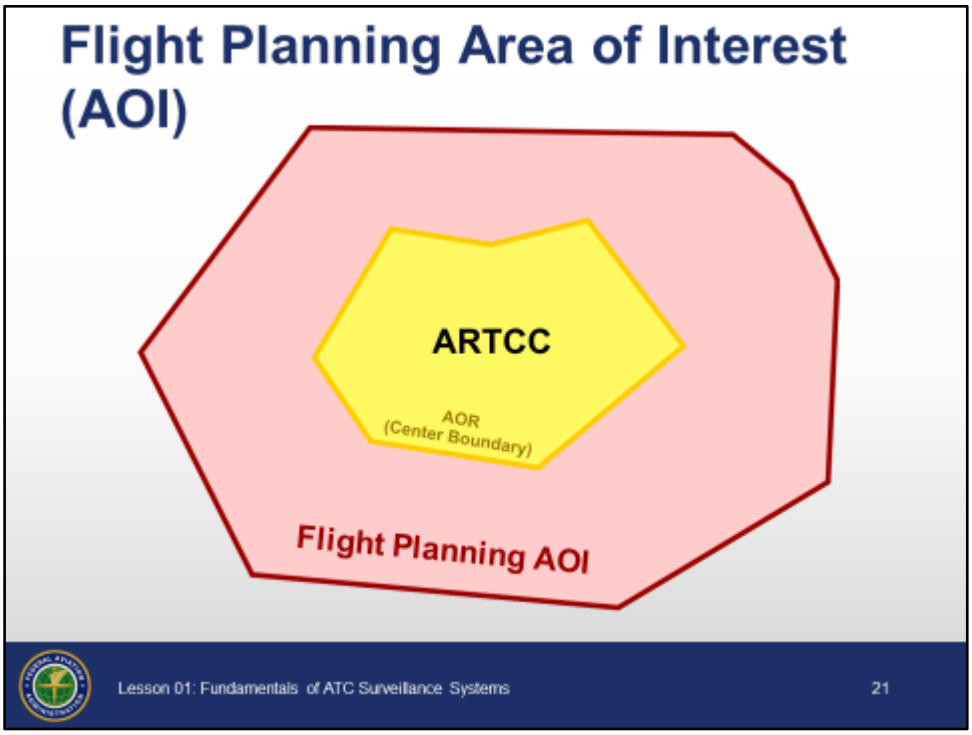


- The Center boundary is also referred to as the Area of Responsibility (AOR)

AREA OF INTEREST (AOI) *(CONT'D)*

Flight Planning Area of Interest (AOI)

TI 6110.100, sec. 1.2.1

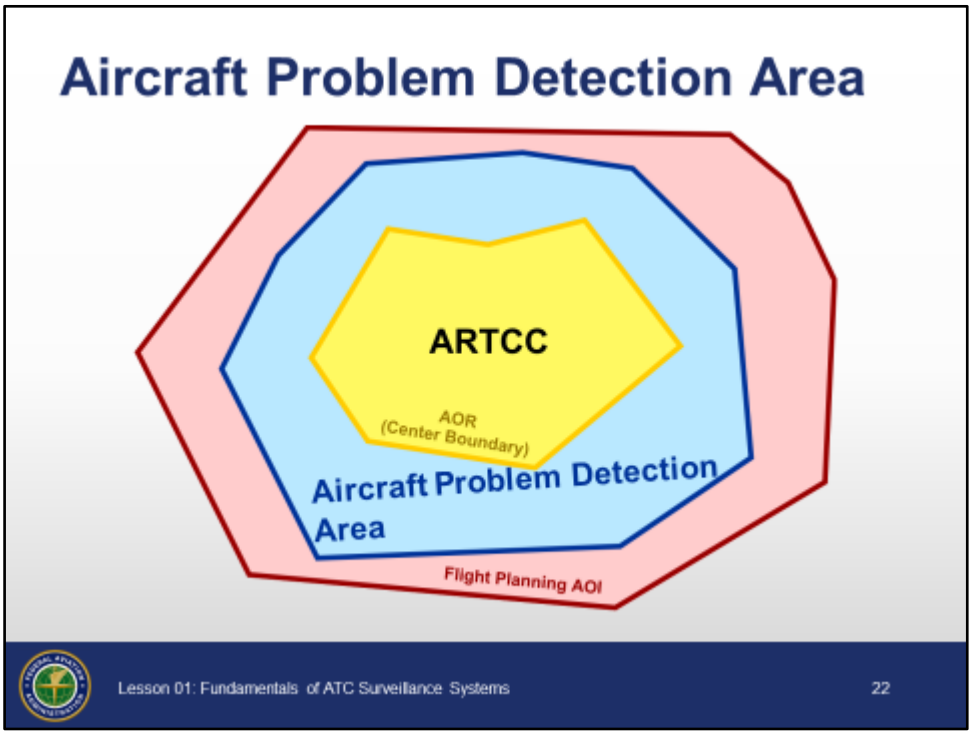


- An adapted area outside the center boundary within which flight plan data is available from other ERAM facilities is called the Flight Planning Area of Interest (AOI)

AREA OF INTEREST (AOI) *(CONT'D)*

Aircraft Problem Detection Area

TI 6110.100, sec. 1.2.1

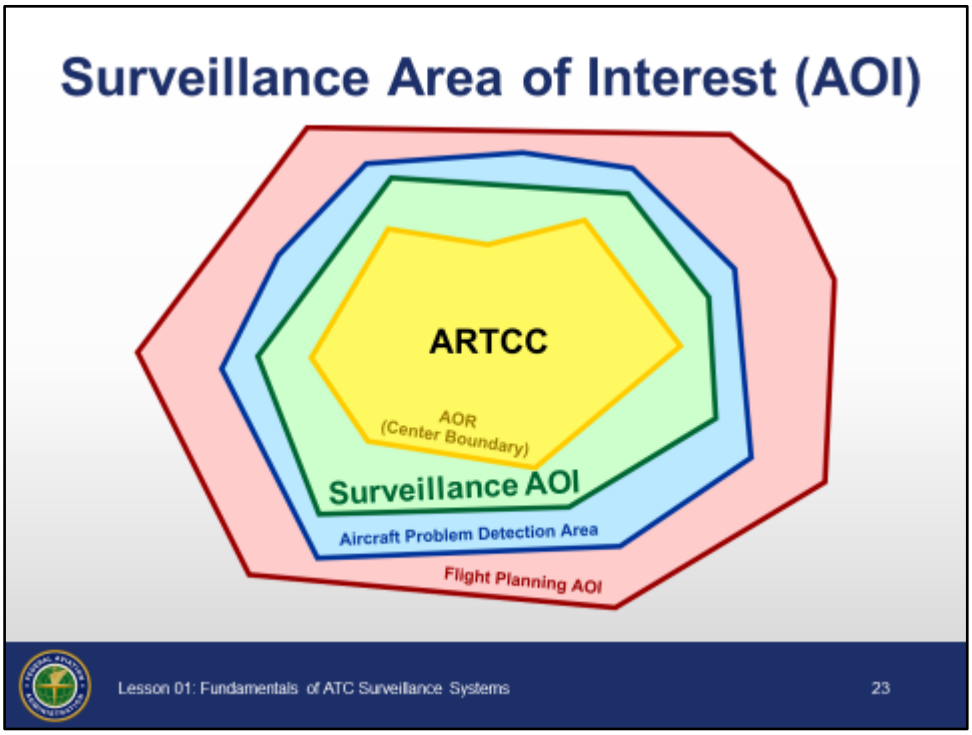


- The area inside of the AOI in which the controller will receive conflict probe alerts is called the Aircraft Problem Detection Area

AREA OF INTEREST (AOI) *(CONT'D)*

Surveillance Area of Interest

TI 6110.100, sec. 1.2.1

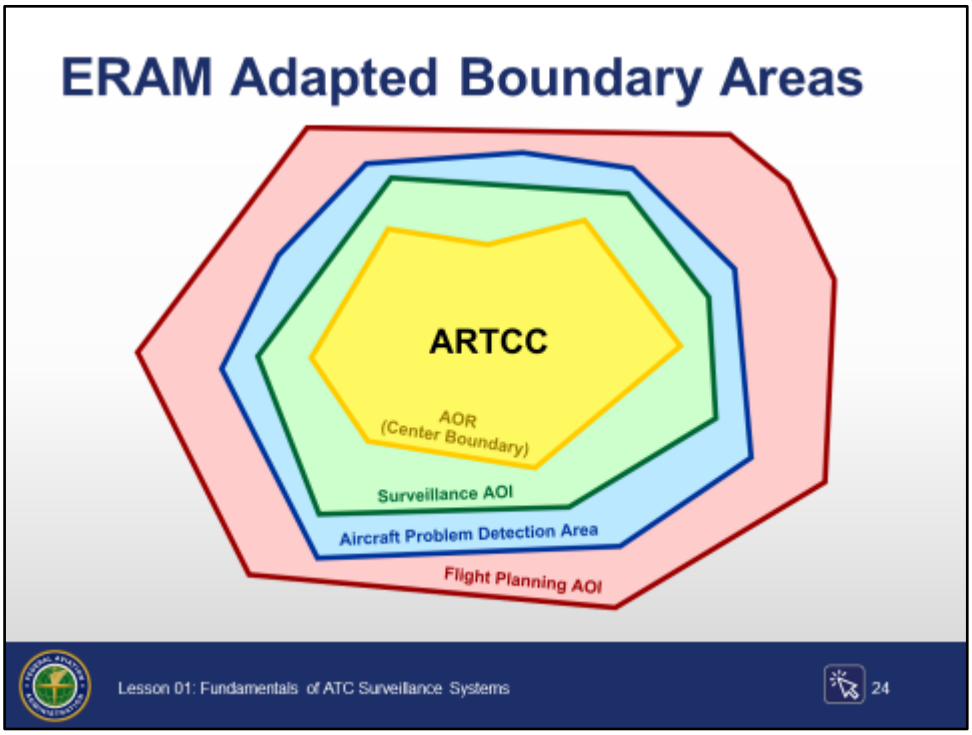


- Defines the area where the controller will see targets, safety alerts, and data blocks. Information from the Aircraft Problem Detection Area and the Flight Planning AOI will also be seen in this area

AREA OF INTEREST (AOI) *(CONT'D)*

ERAM Adapted Areas

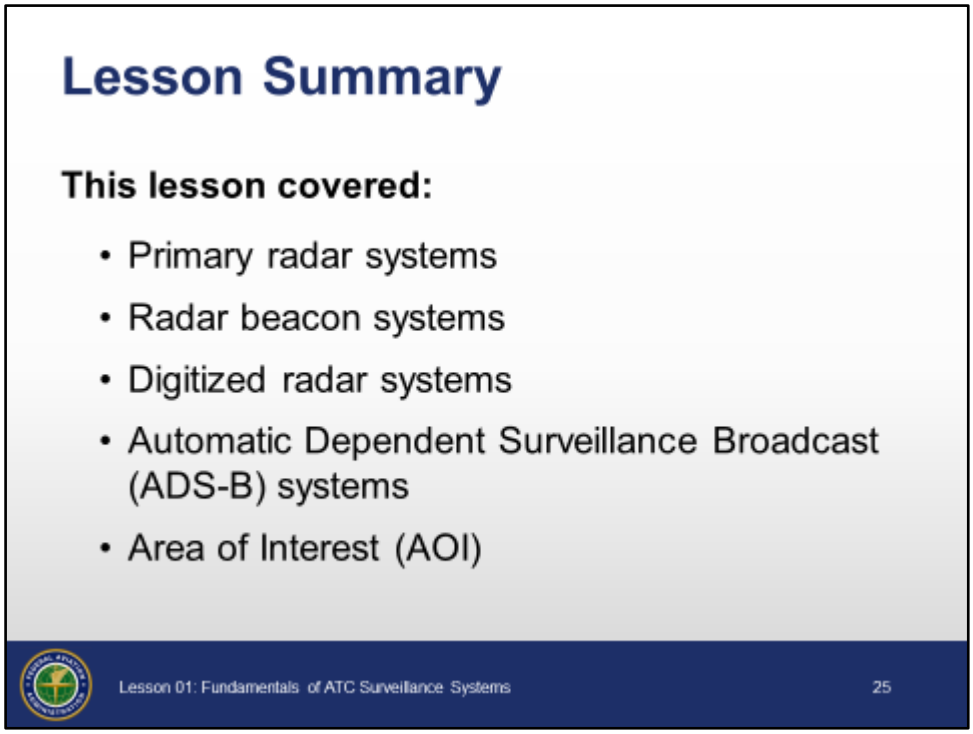
TI 6110.100, sec. 1.2.1



- Flight Planning Area of Interest (AOI) - The area outside the center boundary where flight plan data is available from other ERAM facilities
- Aircraft Problem Detection Area - The area inside the Flight Planning AOI that will receive Conflict Probe alerts, also includes information from the Flight Planning AOI
- Surveillance AOI - The area where controllers will see target, safety alerts, and data blocks. This area includes information from the Aircraft Problem Detection Area and the Flight Planning AOI.

CONCLUSION

Lesson Summary



This lesson covered:

- Primary radar systems
  - Primary radar
  - Range
  - Azimuth
- Radar beacon systems
  - Transponder operation
  - Radar beacon modes
- Digitized radar systems
  - Characteristics of digitized radar
  - Factors affecting radar data display

Continue on next page

CONCLUSION *(CONT'D)*

Lesson Summary (Cont'd)

- Automatic Dependent Surveillance Broadcast (ADS-B)
  - ADS-B system
  - ADS-B operating frequencies
  - ADS-B broadcast services
- Area of Interest (AOI)
  - Area of Responsibility
  - Flight Plan AOI
  - Aircraft Problem Detection Area
  - Surveillance AOI