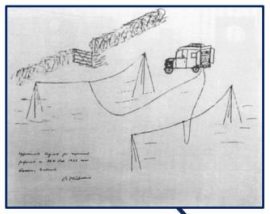
ECE 215
Objective 3.6
Stationary Target Range from a Monostatic Radar

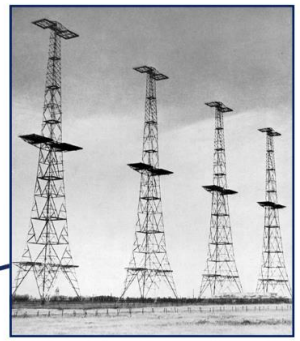
Material Contribution from MIT/LL Radar Short Couse

I can calculate the distance from a monostatic radar to a stationary target based on pulse timing, assuming a direct line-of-sight path.

World War II and Early Radar[1]



Daventry Experiment showed detection of aircraft possible using EM waves from BBC tower



Chain Home five-tower detection system built to monitor incoming aircraft

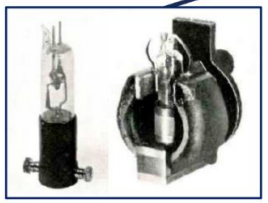
U.S. Navy coined RADAR as short for "Radio Detection and Ranging"

1935

1940

Prototype system built on Orford Ness

First detection on a flying boat from Orford Ness



Compact, high power transmitter designed by John Randall and Henry Boot

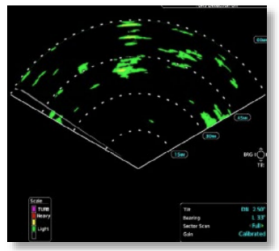
U.K. shared transmitter technology with U.S. and MIT Radiation Laboratory to advance radar

[1]Shown primarily from the perspective of the United Kingdom

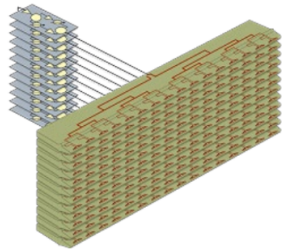
Radar After World War II

- Since World War II, radar development has remained very active
  - Detection of moving targets in complex scenes: *Pulse Doppler radar*
  - Improved localization of targets: *Monopulse radar*
  - Efficient surveillance and tracking: *Phased array radar*
  - Terrain imaging: *Synthetic aperture radar (SAR)*
- Extended to many non-defense applications
  - Weather mapping
  - Civil aviation
  - Automotive sensing
  - Astronomy

Pulse Doppler Radar

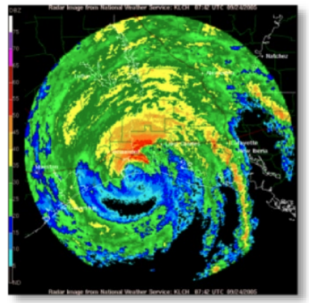


Phased Array Radar



Synthetic Aperture Radar

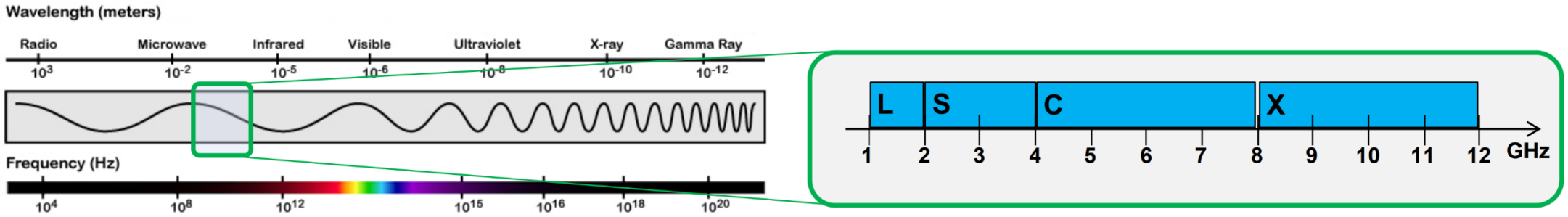
Weather Radar



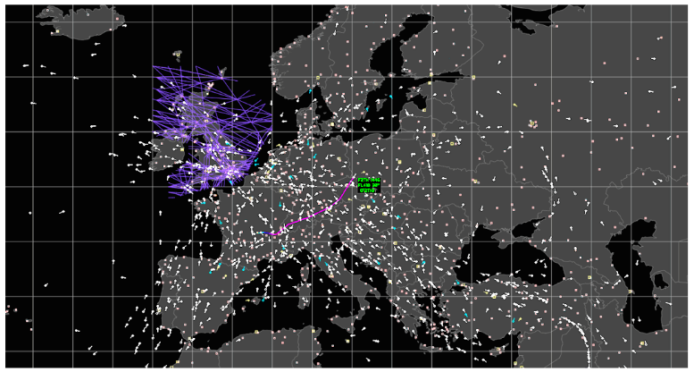
Radio Astronomy

What is Radar?

- **Radio detection and ranging (RADAR)**
  - **Sensing objects from afar with radio-frequency (RF) electromagnetic energy**

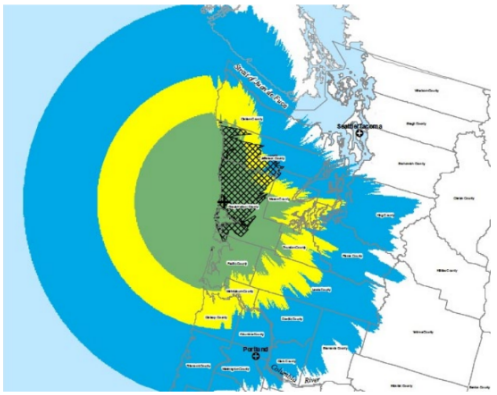


  - **Provides robust, extensive, remote, long-range situation awareness**



- **Observation of targets hundreds or thousands of miles away**

- **All weather, day/night operation**

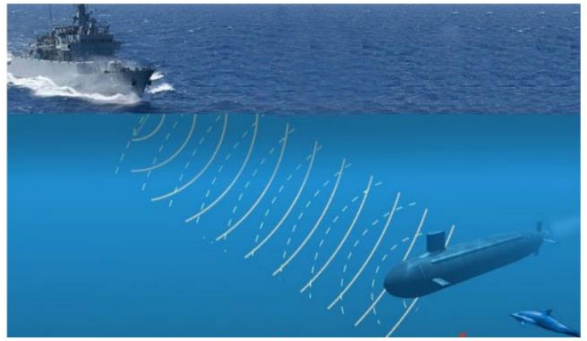


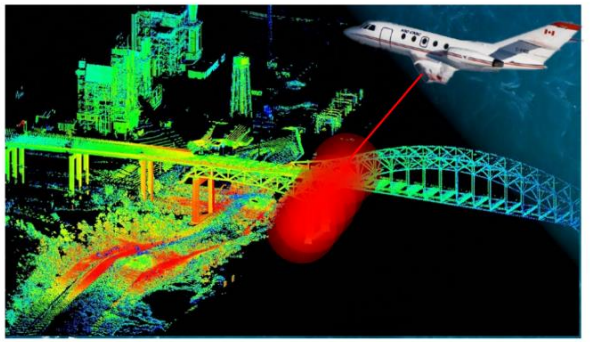
- **Wide area search coverage**

How Does Radar Work?

- Radar is active, not passive; emitting energy
  - Energy is transmitted outward like a flashlight beam illuminating objects in the dark
  - Reflections of the radar's own energy reveal targets
- Radar energy release and subsequent reflected returns are timed
  - Time elapsing during travel out to target and back as a reflection is proportional to range
- Similar concepts
  - Natural: Echolocation (sound-pressure reflections)

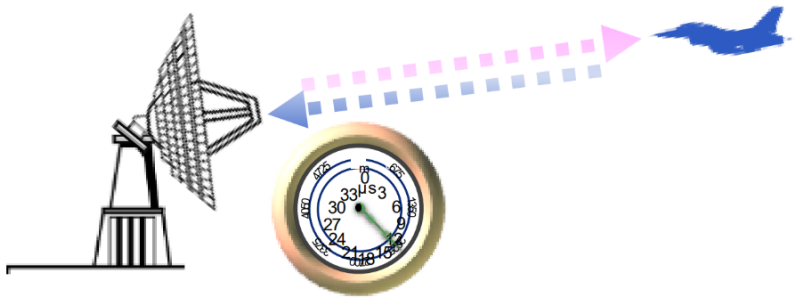
  - Man-made: SONAR (sound-pressure reflections), LIDAR (laser-light-pulse reflections)



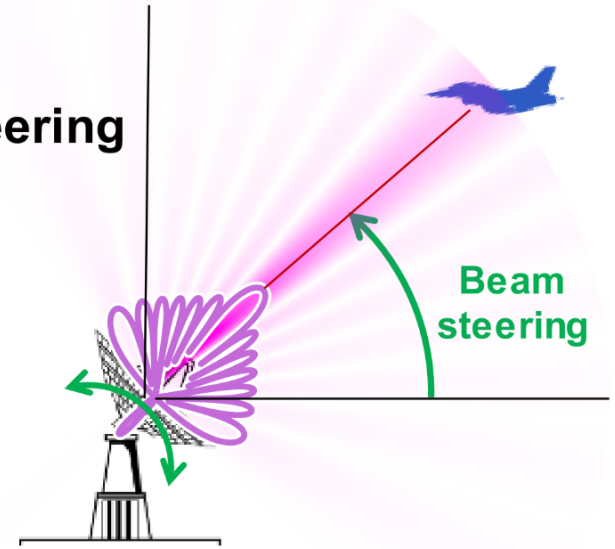


What Can Radars Measure?

- What can radars measure?
  - Range (by measuring time)



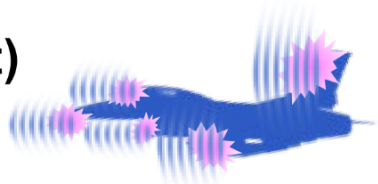
  - Angle (by steering beam)



  - Velocity (by observing Doppler frequency shift)

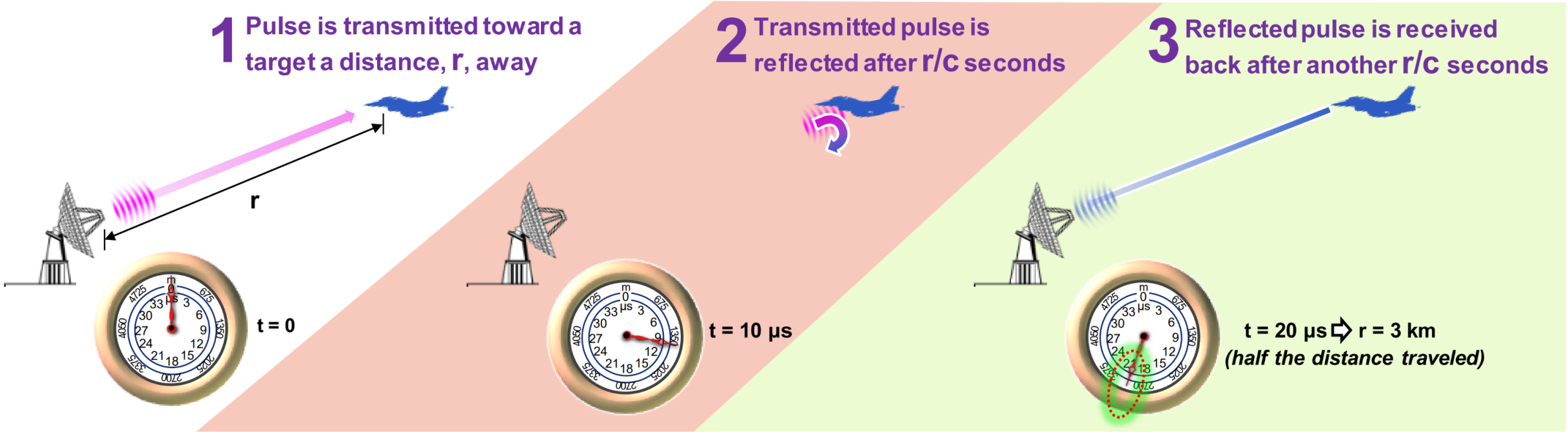
  - Size (by measuring the strength of the reflection)

  - Features (by measuring differences in reflections across distinct parts of a target)



Key Principle of Radar: Elapsed Time

- **TIME for a pulse to travel to a target and back is proportional to DISTANCE**



Since total distance traveled is the elapsed time multiplied by the speed of light

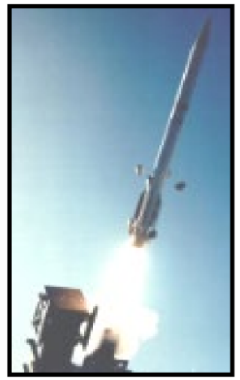
$$\text{Range} = \text{Time}_{\text{Roundtrip}} \frac{c}{2}$$

Speed of Light

Speed of electromagnetic energy through free space

$\sim 3 \times 10^8$ m/s

Radar Spectrum Bands and Their Uses



W-Band	40 – 100+ GHz
Ka-Band	27 – 40 GHz
K-Band	18 – 27 GHz
Ku-Band	12 – 18 GHz
X-Band	8 – 12 GHz
C-Band	4 – 8 GHz
S-Band	2 – 4 GHz
L-Band	1 – 2 GHz
UHF	300 MHz – 1 GHz
VHF	30 – 300 MHz
HF	3 – 30 MHz