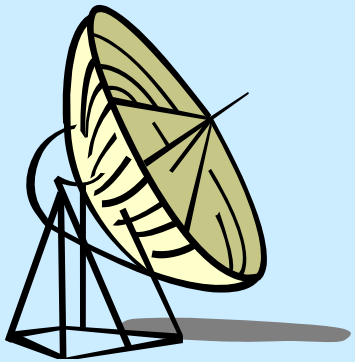
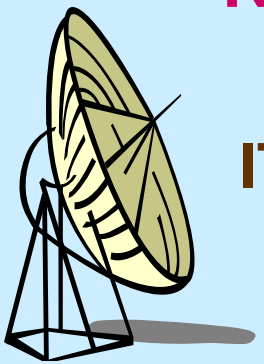
INTRODUCTION TO RADAR



RADAR

WHAT IS RADAR?

RADAR (RADIO DETECTION AND RANGING) IS A WAY TO DETECT AND STUDY FAR OFF TARGETS BY TRANSMITTING A RADIO PULSE IN THE DIRECTION OF THE TARGET AND OBSERVING THE REFLECTION OF THE WAVE.

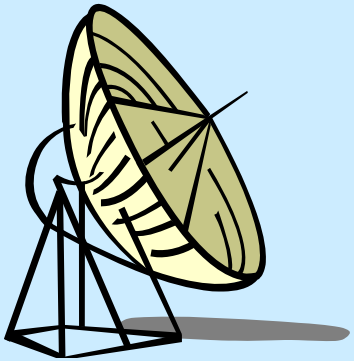


IT'S BASICALLY RADIO ECHO .

RADAR DEVELOPMENT

1885-1888 **BASIC CONCEPT OF RADAR WAS DEMONSTRATED BY HEINRICH. HERTZ VERIFIED THE MAXWELL PREDICTIONS ON ELCTROMAGNETICS.**

USED APPARATUS SIMILAR TO PULSE RADAR.



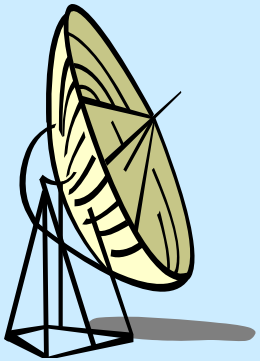
SHOWED THAT RADIO WAVE CAN BE REFLECTED FROM METAL OBJECTS AND REFRACTED BY A PRISM.

HERTZ DID NOT PERSUE HIS WORK.

RADAR DEVELOPMENT

1900 CHRISTION HULSMAYER, ASSEMBLED WHAT IS KNOWN AS MONOSTATIC PULSE RADAR. HIS RADAR DETECTED SHIPS BUT NO ONE SHOWED INTEREST IN BUYING IT.

1920 SG MARCONI OBSERVED RADIO DETECTION OF TARGETS AND STRONGLY URGED ITS USE.



A HOYT OF US NAVAL RESEARCH LABORATORY, OBSERVED A FLUCTUATING SIGNAL WHEN A SHIP PASSED BETWEEN TRANSMITTER AND RECEIVER LOCATED ON OPPOSITE SIDES OF RIVER.

RADAR DEVELOPMENT

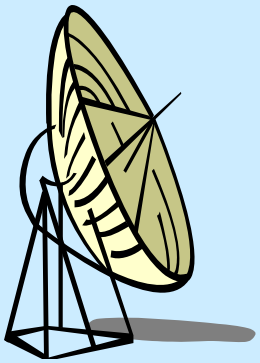
1930

APPEARANCE OF HEAVY MILITARY BOMBER THAT GAVE RISE TO OPERATIONAL MILITARY RADAR. AFTER WWI, BOMBER WAS CONVERTED FROM FABRIC TO METAL AIRCRAFT. SOUND LOCATERS, SPARK PLUG IGNITION NOISE DETECTION/ ABANDONED.

INFRA RED WAS TRIED BUT DID NOT HAVE RANGE.

BISTATIC CW RADAR WAS TRIED.

RADAR WAS REDISCOVERED & DEVELOPED SIMULTANEOUSLY IN US,



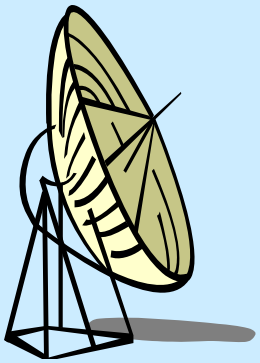
RADAR DEVELOPMENT

UK, GERMANY, SOVIET UNION, FRANCE, ITALY, JAPAN & NETHERLAND.

UNITED STATES:

1934 **SERIOUS EFFORTS STARTED TO DEVELOP RADAR.**

BY 1941, 132 RADARS WERE DELIVERED TO US NAVY & 79 WERE INSTALLED ON VARIOUS SHIPS.



DURING ATTACK ON PEARL HARBOUR ATTACK WAS DETECTED BUT COMMAND

& CONTROL SYSTEMS WAS NOT

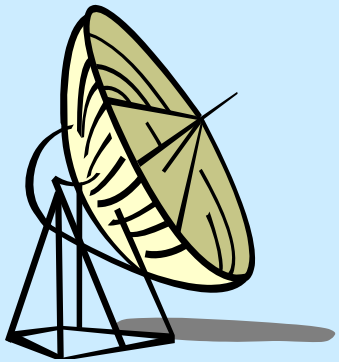
RADAR DEVELOPMENT

THERE TO MAKE USE OF THE INFORMATION.

UNITED KINGDOM:

1935 **FELT THE URGENCY OF RADAR DUE TO APPROACHING WAR. BY 1938,THEY PRODUCED THE CHAIN HOME RADAR.**

1940 **HIGH POWER MAGNETRON WAS DISCOVERED WHICH MADE IT POSSIBLE FOR RADAR TO OPERATE ON MICROWAVE FREQUENCIES.**



RADAR DEVELOPMENT

GERMANY:

1940 **HAD THREE MAJOR RADARS.**

(A) 125 MHZ FREYA, AIR SEARCH RADAR

(B) WURZBURG, FIRE CONTROL RADAR

(C) 500 MHZ SEETAKE SHIPBORNE RADAR

GERMANY WAS AHEAD OF BRITISH & AMERICAN FORCES IN RADAR TECHNOLOGY BUT COULD NOT TAKE ADVANTAGE OF THIS FACT.

RADAR DEVELOPMENT

U.S.S.R:

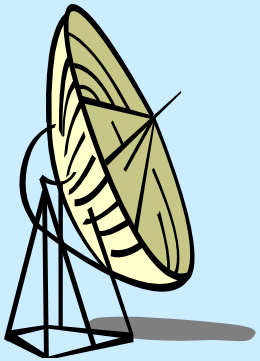
1930's **STARTRD THE DEVELOPMENT OF RADAR AND BY 1941 HAD DEPLOYED PRODUCTION & DEVELOPMENT RADARS.**

RADAR DEVELOPMENT

THE FIRST RADAR RUS -1 WAS BISTATIC. RUS-2 WAS MONOSTATIC, TRUCK MOUNTED.

ITALY:

1941 AFTER DEFEAT WHERE BRITISH RADARS WERE USED TO FIRE UPON ITALIAN SHIPS, THE PRODUCTION / DEVELOPMENT STARTED.



FIRST RADAR “OWL” WAS 200 MHZ, SHIPBOARD RADAR. WORK STOPPED IN 1943 WHEN ALLIED FORCES RAIDED ITALY.

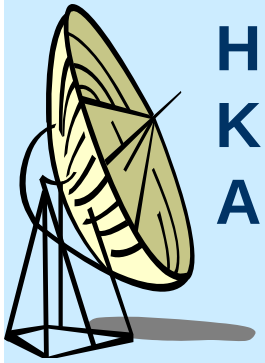
RADAR DEVELOPMENT

MICROWAVE MAGNETRON

MAJOR ADVANCE BY DEVELOPMENT OF MAGNETRON IN UNIVERSITY OF BIRMINGHAM. REDUCED THE SIZE OF ANTENNE AND OPENED UP HIGHER FREQUENCIES.SHIP BORN ANTENNAE COULD BE MADE.

AFTER WORLD WAR II:

USE OF DOPPLER EFFECT IN MTI



HIGH POWER STABLE AMPLIFIERS LIKE KLYSTRON,TWT & SOLID STATE TRANSISTORS ALLOWED BETTER APPLICATIONS.

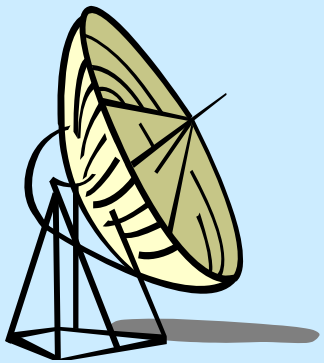
RADAR DEVELOPMENT

HIGHLY ACCURATE ANGLE TRACKING.

HIGH POWER SYNTHETIC APERTURE RADARS (SAR) PROVIDED HIGH RESOLUTIONS, MAP LIKE IMAGING.

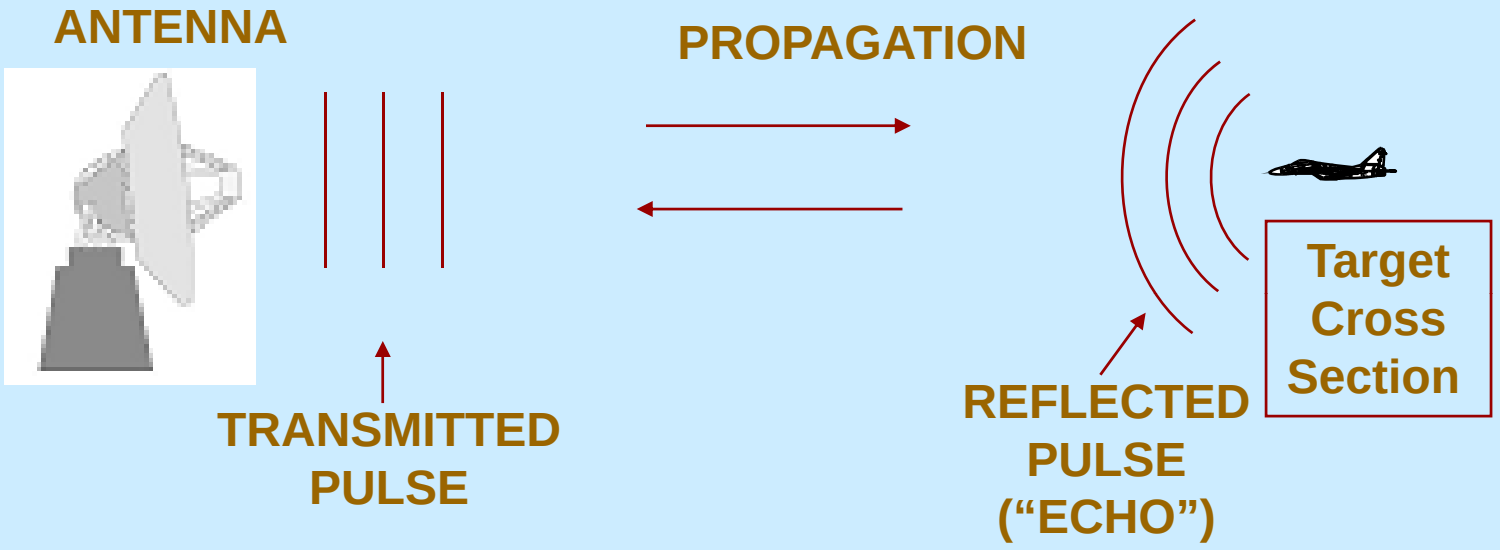
ELECTRONICALLY STEERED PHASE ARRAY RADARS,OFFERED RAPID BEAM STEERING.

DSP AND DDP (DIGITAL SIGNAL / DATA PROCESSING)

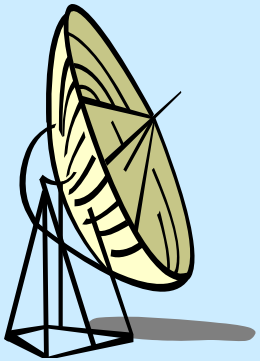


RADAR

RADIO DETECTION AND RANGING

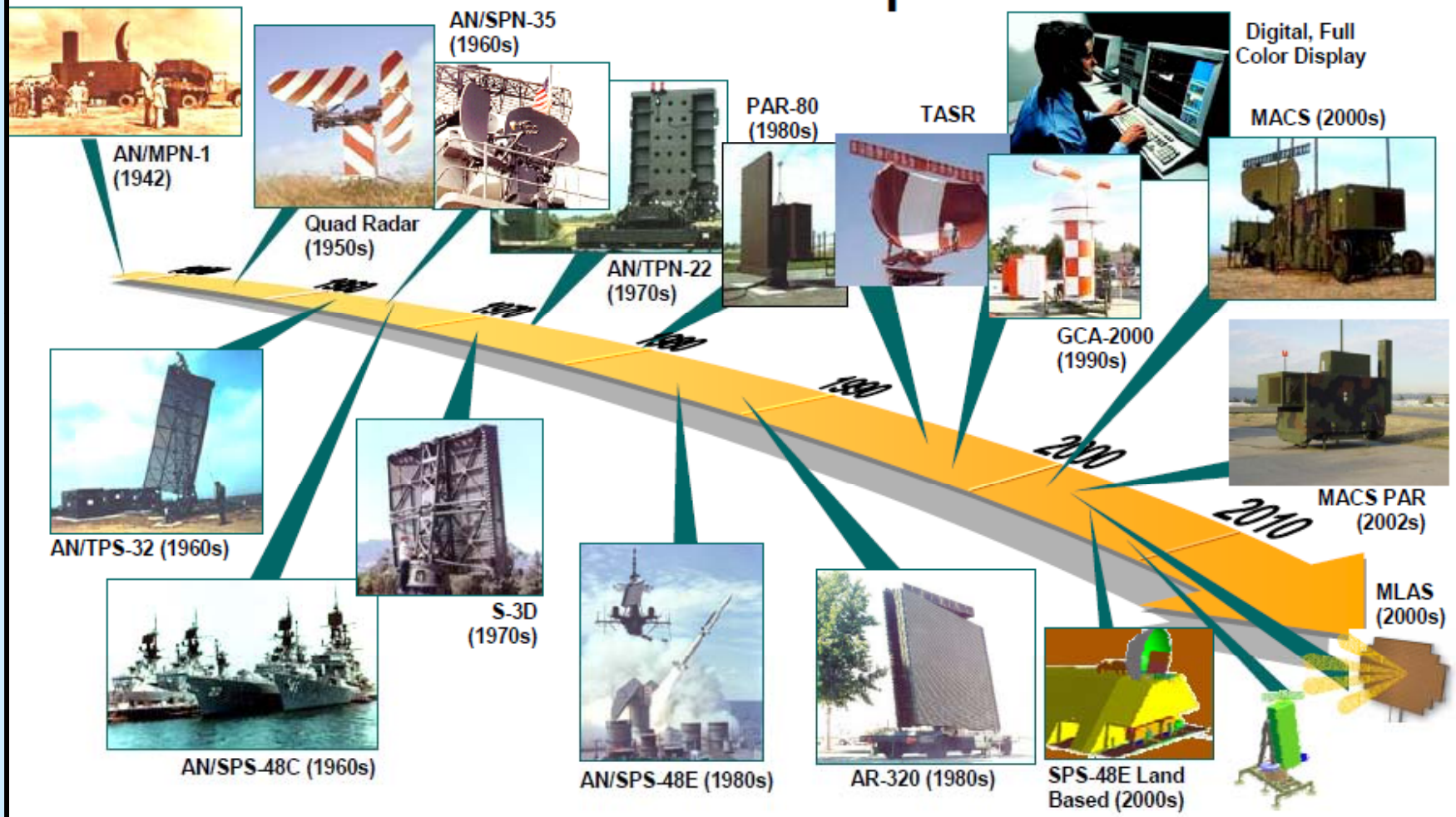


RADAR OBSERVABLES:

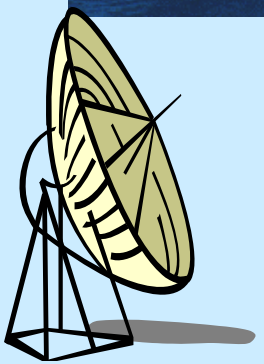


- **TARGET RANGE.**
- **TARGET ANGLES (AZIMUTH & ELEVATION).**
- **TARGET SIZE (RADAR CROSS SECTION).**
- **TARGET SPEED (DOPPLER).**
- **TARGET FEATURES (IMAGING).**

Radar development

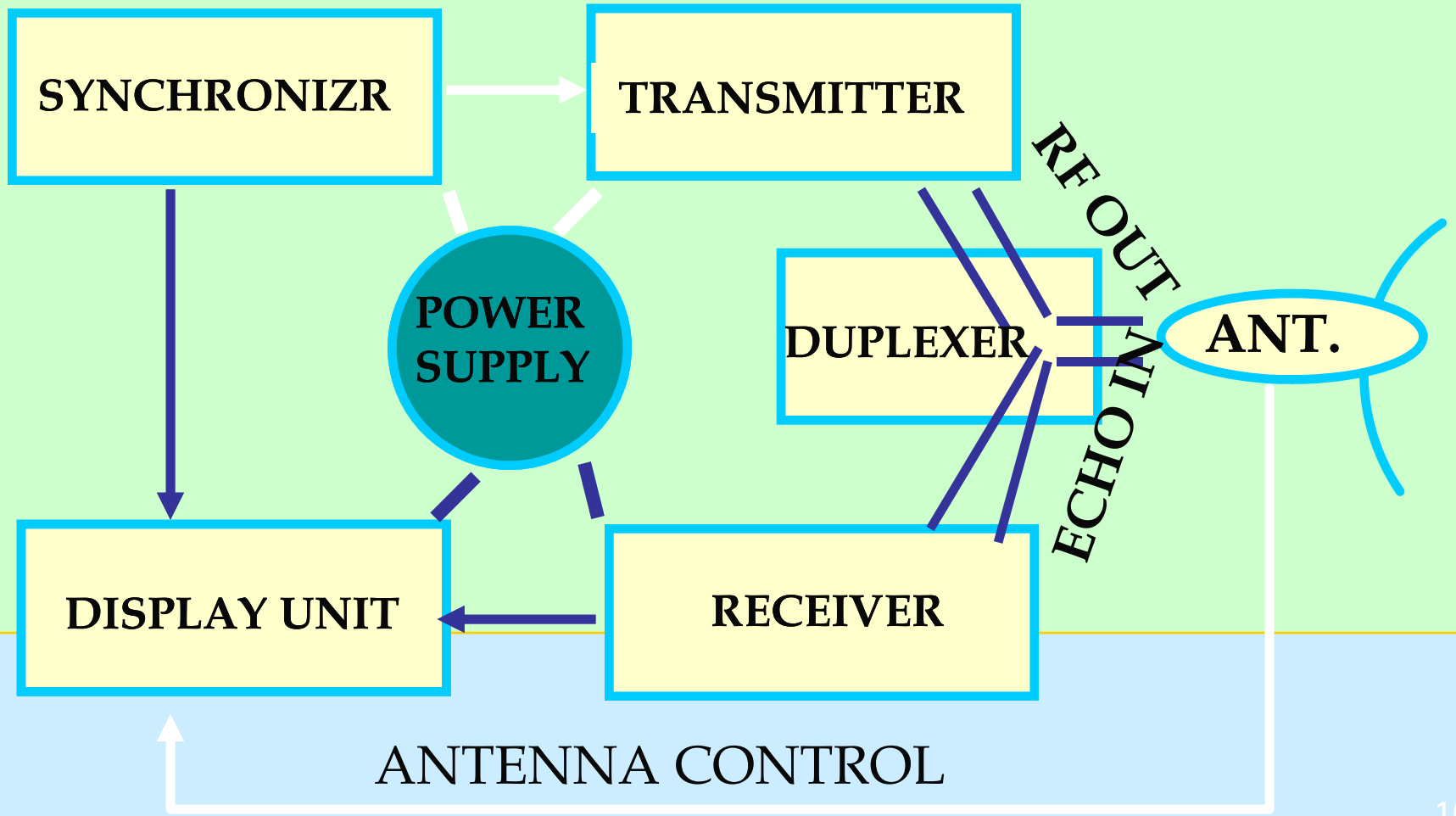


TWO BASIC RADAR TYPES

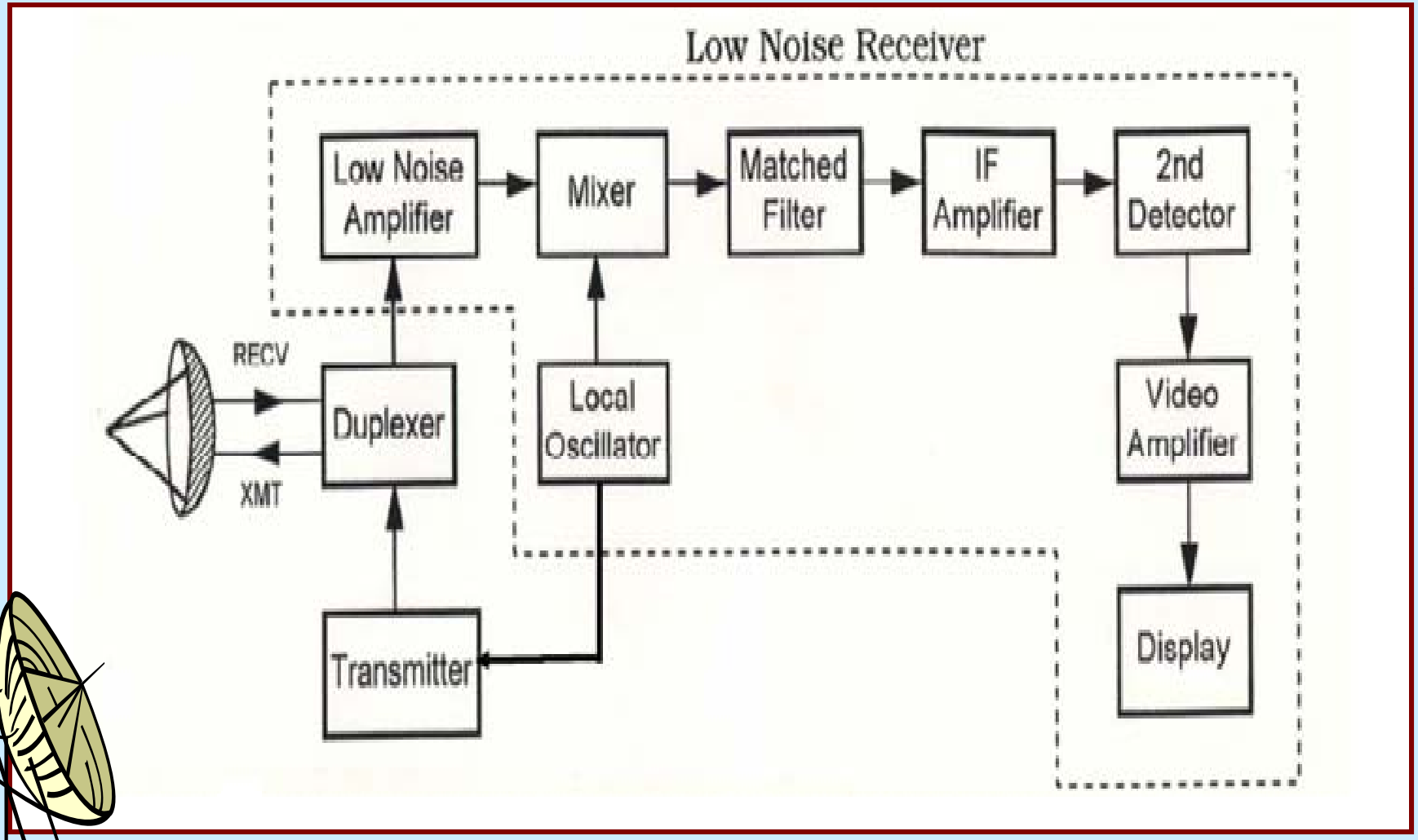


- PULSE TRANSMISSION
- CONTINUOUS WAVE

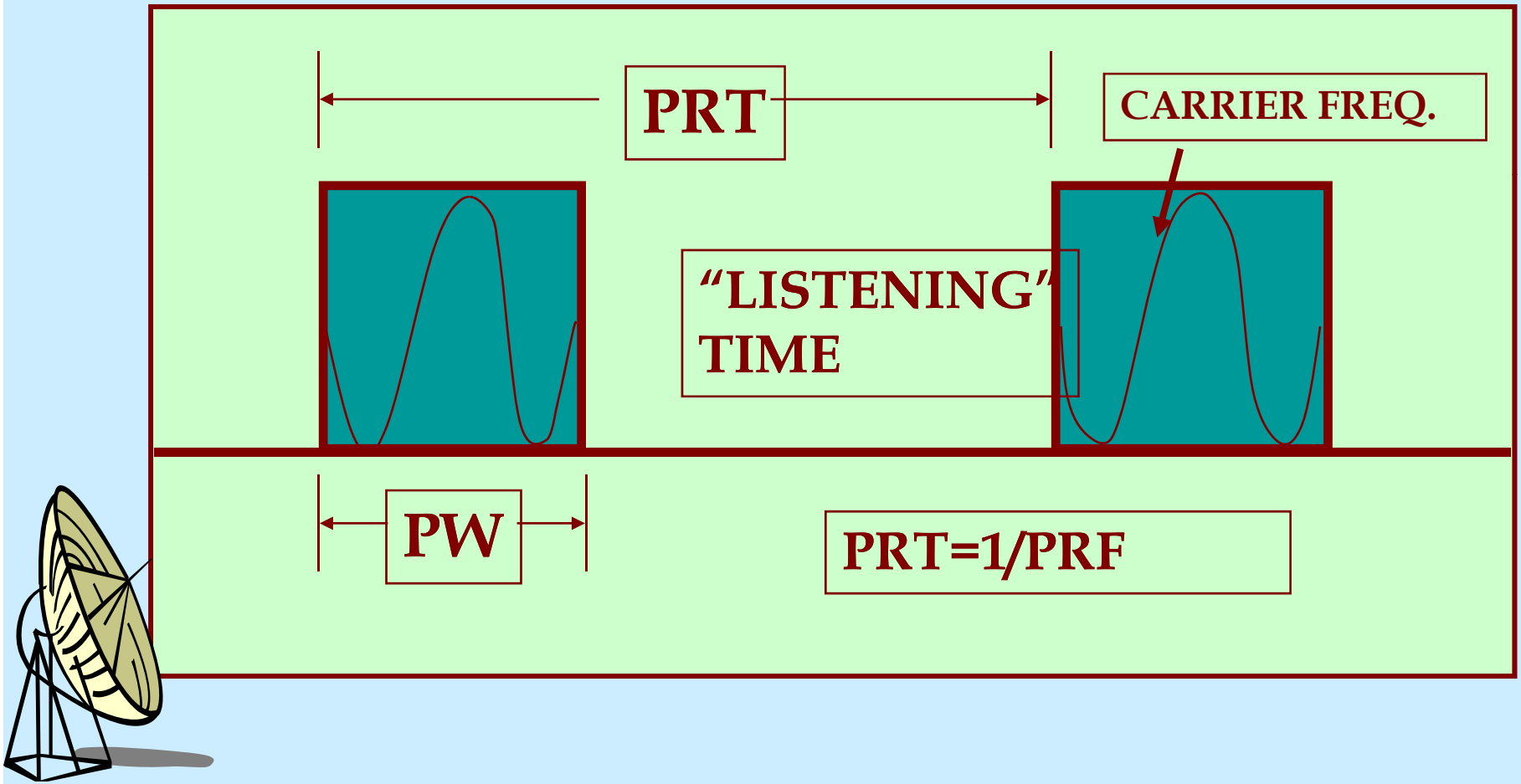
PULSE RADAR COMPONENTS



RADAR BLOCK DIAGRAM

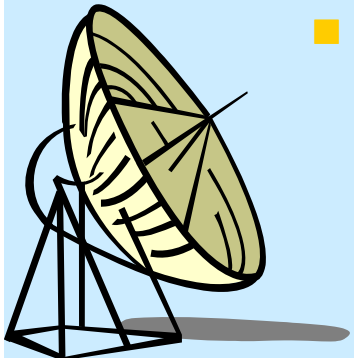


A TYPICAL RADAR PULSE DIAGRAM



PULSE TRANSMISSION

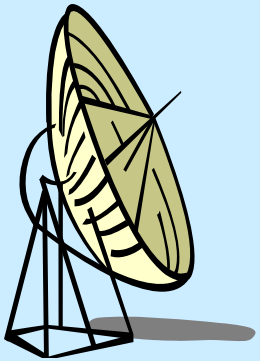
- PULSE WIDTH (PW)
- PULSE REPETITION TIME (PRT=1/PRF)
- PRT IS TIME FROM BEGINNING OF ONE PULSE TO THE BEGINNING OF THE NEXT
- LENGTH OR DURATION OF A GIVEN PULSE
  - PRF IS FREQUENCY AT WHICH CONSECUTIVE PULSES ARE TRANSMITTED.



PULSE TRANSMISSION

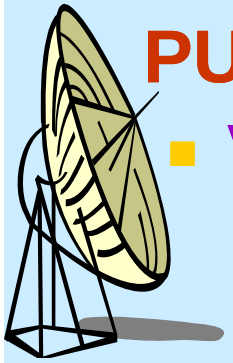
- PW CAN DETERMINE THE RADAR'S MINIMUM DETECTION RANGE;

- PW CAN DETERMINE THE RADAR'S MAXIMUM DETECTION RANGE (IF PEAK POWER IS CONSTANT).



RADAR WAVE MODULATION

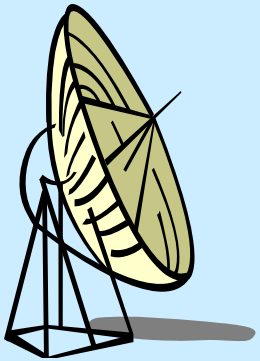
- **AMPLITUDE MODULATION**
  - VARY THE AMPLITUDE OF THE CARRIER SINE WAVE
- **FREQUENCY MODULATION**
  - VARY THE FREQUENCY OF THE CARRIER SINE WAVE
- **PULSE-AMPLITUDE MODULATION**
  - VARY THE AMPLITUDE OF THE PULSES



RADAR WAVE MODULATION

- PULSE-FREQUENCY MODULATION VARY THE FREQUENCY AT WHICH THE PULSES OCCUR

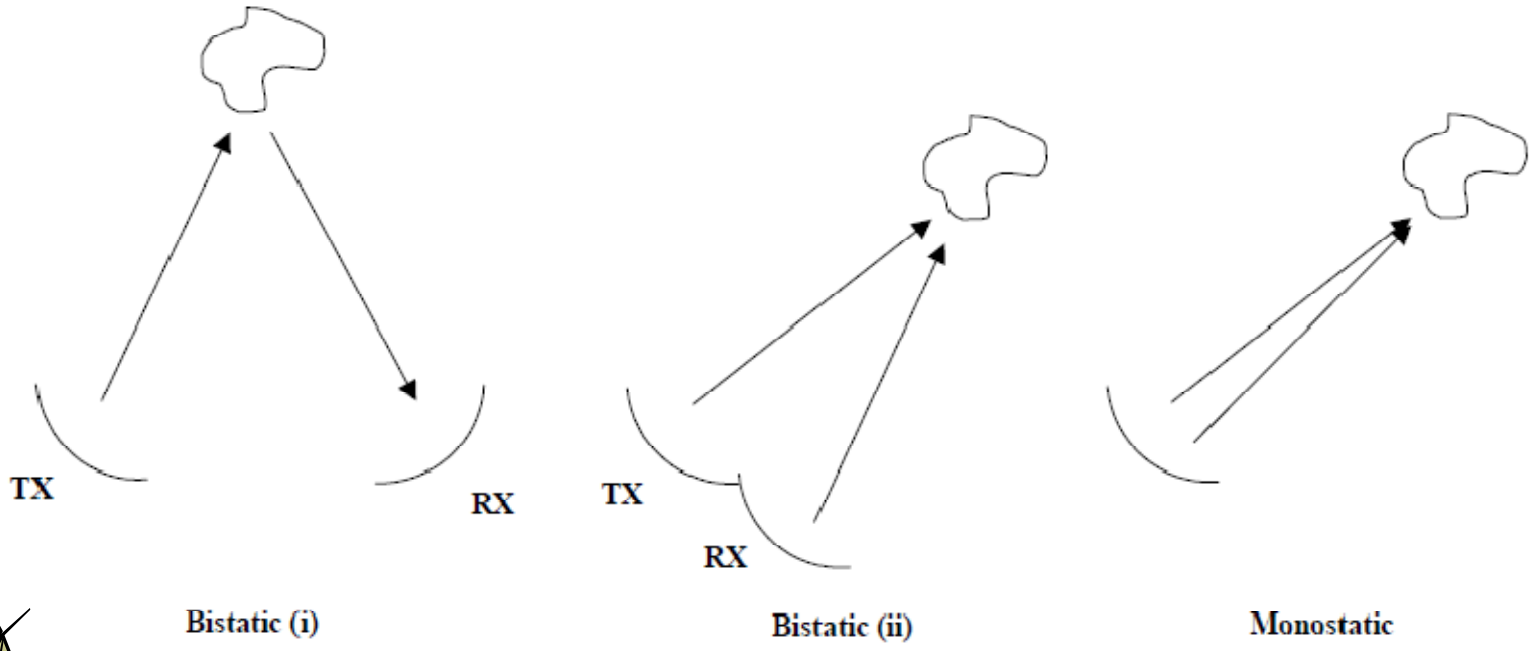
- FREQUENCY MODULATION CONTINUOUS WAVE IS SAME AS PULSE-FREQUENCY MODULATION BUT CONTINUOUS



TYPES OF RADAR

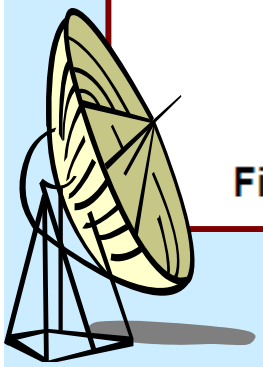
Types of radar

1. **Bistatic** — **separate transmit and receive antennas**
   Monostatic — same antenna for transmit and receive



Bistatic (i) Bistatic (ii) Monostatic

Figure 2 Monostatic and bistatic radar



TYPES OF RADAR

2. **CW radar** transmits continuous wave (CW)

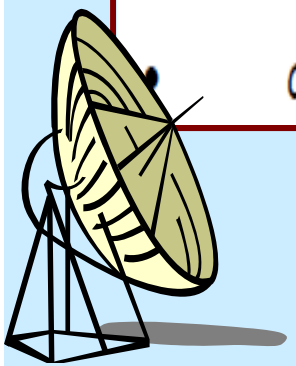
- can *detect* objects, measures *velocity* from Doppler shift, but cannot measure *range*

3. **FM-CW radar** frequency-modulated CW transmitted signal

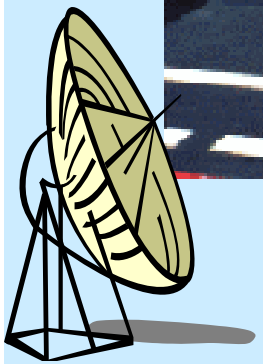
- *detects*, measures *range* and radial *velocity*

4. **Pulsed radar** includes MTI (moving target indicator) and Pulsed Doppler

- *detects*, measures *range* and *velocity*, but has blind speeds and ranges



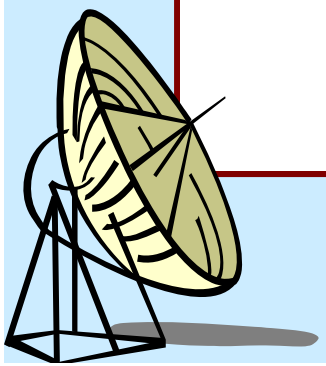
CONTINUOUS WAVE RADAR



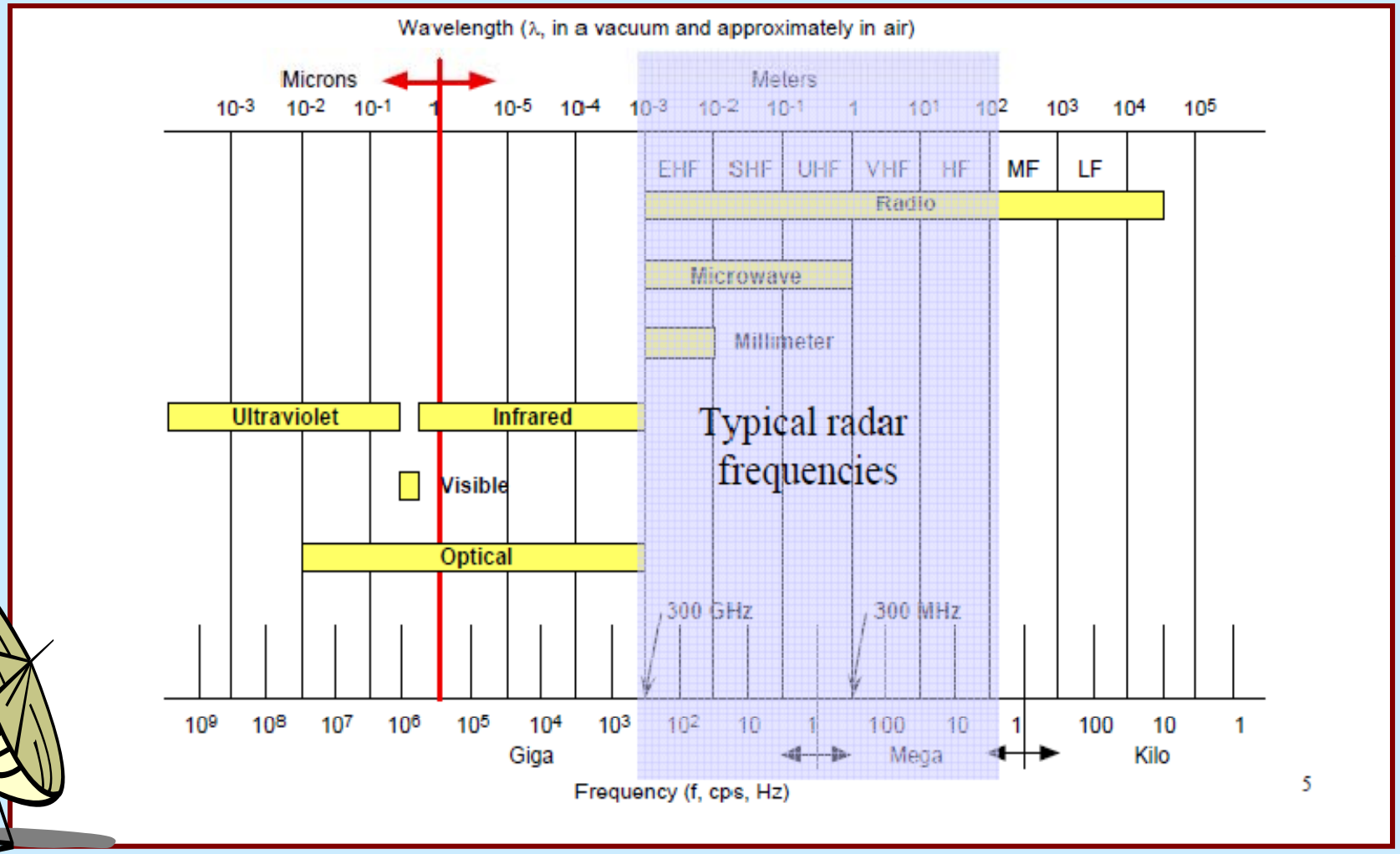
- EMPLOYS CONTINUAL RADAR TRANSMISSION
- SEPARATE TRANSMIT AND RECEIVE ANTENNAS
- RELIES ON THE "DOPPLER SHIFT"

RADAR FUNCTIONS

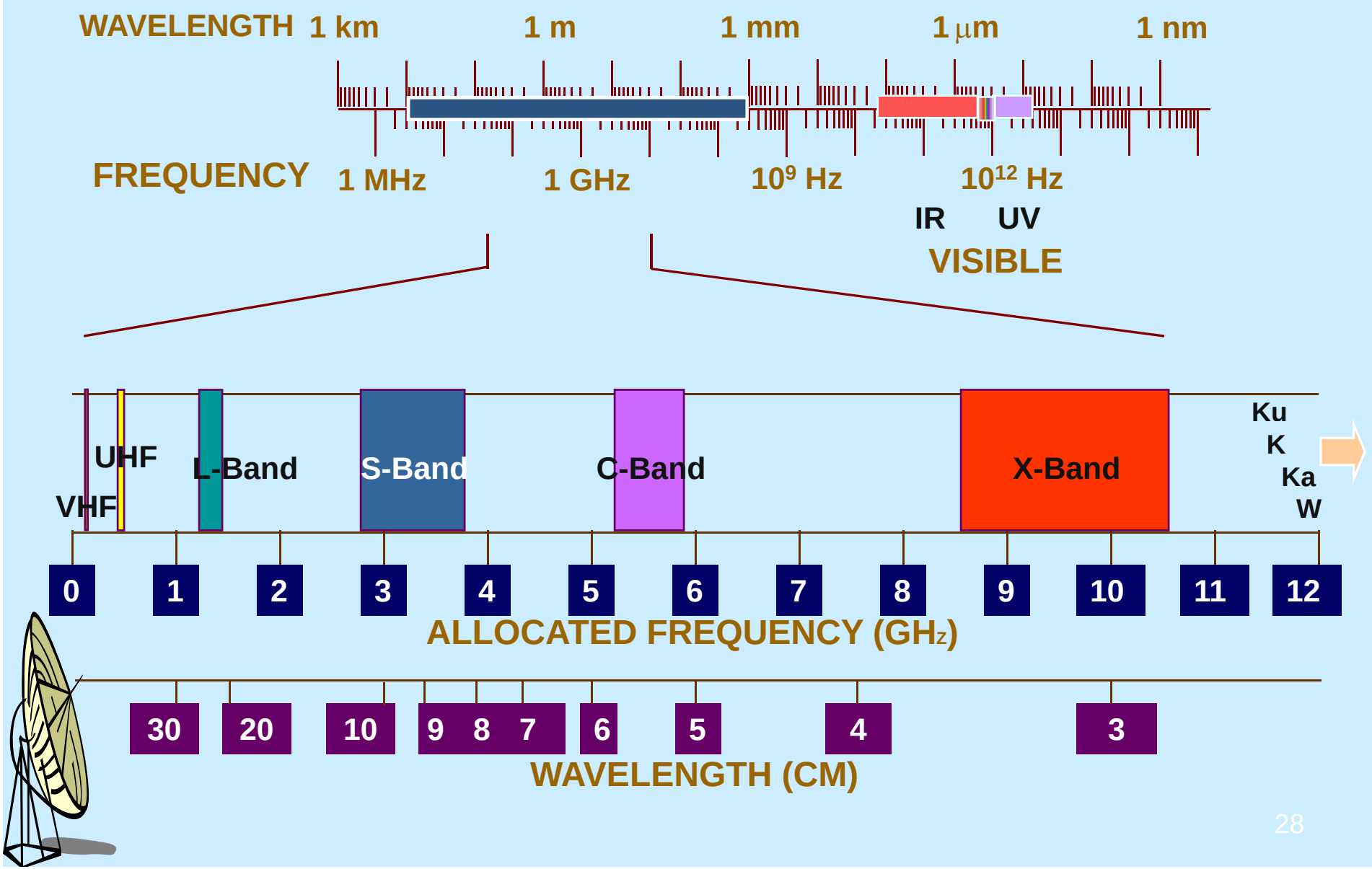
- Normal radar functions:
    1. range (from pulse delay)
    2. velocity (from Doppler frequency shift)
    3. angular direction (from antenna pointing)
- Signature analysis and inverse scattering:
    4. target size (from magnitude of return)
    5. target shape and components (return as a function of direction)
    6. moving parts (modulation of the return)
    7. material composition
- The complexity (cost & size) of the radar increases with the extent of the functions that the radar performs.



ELECTROMAGNETIC SPECTRUM

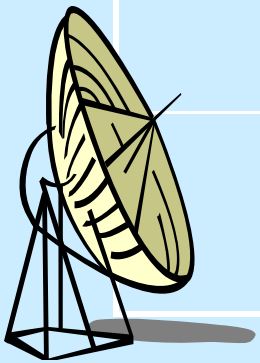


RADAR FREQUENCY BANDS



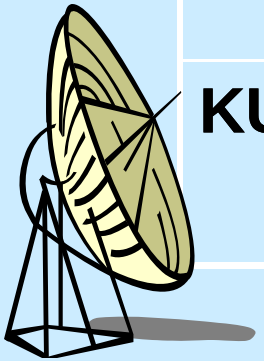
RADAR FREQUENCIES

BAND	NOMINAL FREQUENCY RANGE	SPECIFIC FREQUENCY RANGE AS PER I.T.U
HF	3-30 MHZ	
VHF	30-300 MHZ	138 – 144 & 216 – 225 MHZ
UHF	300-1000 MHZ	420 – 450 & 850 – 942 MHZ
	1-2 GHZ	1.215 – 1.40 GHZ



RADAR FREQUENCIES

BAND	NOMINAL FREQUENCY RANGE	SPECIFIC FREQUENCY RANGE AS PER I.T.U.
S	2-4 GHZ	2.3 - 2.5 & 2.7 – 3.7 GHZ
C	4-8 GHZ	5.25 – 5.925 GHZ
X	8-12 GHZ	8.5 – 10.680 GHZ
KU	12-18 GHZ	13.4 – 14.0 GHZ & 15.7 – 17.7 GHZ

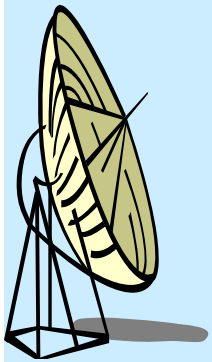


RADAR FREQUENCIES

BAND	NOMINAL FREQUENCY RANGE	SPECIFIC FREQUENCY RANGE AS PER I.T.U.
K	18 – 27 GHZ	24.05 – 24.25 GHZ
KA	27 – 40 GHZ	33.4 – 36.0 GHZ
V	40 – 75 GHZ	59 – 64 GHZ
W	75 – 110 GHZ	76 – 81 & 92 – 100 GHZ

RADAR FREQUENCIES

BAND	NOMINAL FREQUENCY RANGE	SPECIFIC FREQUENCY RANGE AS PER I.T.U.
MM	110 – 300 GHZ	126 – 142 GHZ 144 – 149 GHZ 231 – 235 GHZ 238 – 248 GHZ



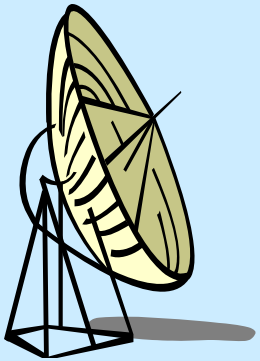
I.T.U. – INTERNATIONAL TELE COMMUNICATION UNION

APPLICATIONS OF RADAR

MILITARY — **AIR DEFENCE**

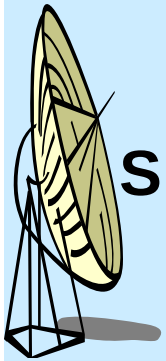
REMOTE SENSING

- **WEATHER**
- **PLANETARY OBSERVATIONS**
- **SHORT RANGE BELOW GROUND PROBING**
- **MAPPING OF SEA**
- **AIR ROUTE SURVIALLENCE RADAR**
- **TERMINAL DOPPLER WEATHER RADAR**
- **ATC RADAR BEACON SYSTEM**



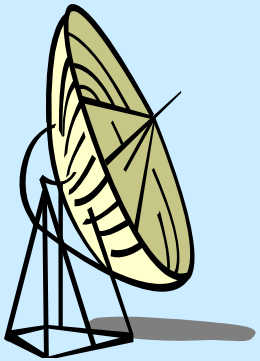
APPLICATIONS OF RADAR

LAW & HIGHWAY SAFETY	**DOPPLER RADAR FOR SPEED LIMITS.**
AIRCRAFT SAFETY & NAVIGATION	**WEATHER AVOIDANCE RADAR** **TERRAIN AVOIDANCE / TERRAIN FOLLOWING RADAR** **RADIO ALTIMETER**
SHIP SAFETY	**FOR COLLISION AVOIDANCE IN LOW VISIBILITY.**



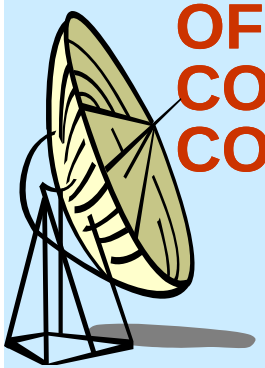
APPLICATIONS OF RADAR

SPACE	FOR RENDEZEVOUS & DOCKING
	FOR LANDING ON MOON
	GD BASED RADARS FOR TRACKING
OTHERS	MEASUREMENT OF SPEED / DISTANCE
	OIL & GAS EXPLORATIONS, ENTOMOLOGY.



TYPES AND USES OF RADAR

- SEARCH RADARS SCAN A LARGE AREA WITH PULSES OF SHORT RADIO WAVES
- TRACKING RADARS USE THE SAME PRINCIPLE BUT SCAN A SMALLER AREA MORE OFTEN
- NAVIGATIONAL RADARS ARE LIKE SEARCH RADARS, BUT USE SHORT WAVES THAT REFLECT OFF HARD SURFACES. THEY ARE USED ON COMMERCIAL SHIPS AND LONG-DISTANCE COMMERCIAL AIRCRAFT

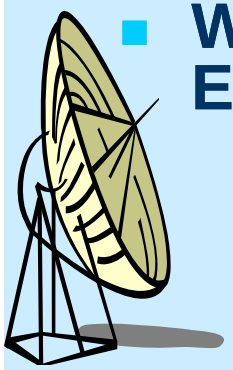


TYPES AND USES OF RADAR

- MAPPING RADAR SCANS A LARGE REGION FOR REMOTE SENSING AND GEOGRAPHY APPLICATIONS.

- AIR TRAFFIC CONTROL USES RADAR TO REFLECT ECHOES OF AIRCRAFT.

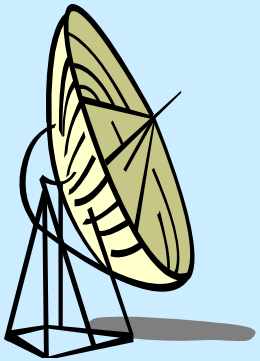
- WEATHER RADAR USES RADAR TO REFLECT ECHOES OF CLOUDS.



TYPES AND USES OF RADAR

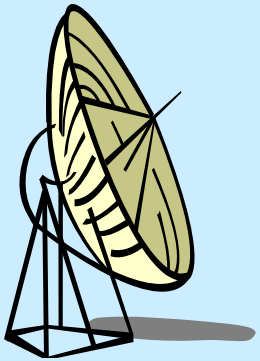
- WEATHER RADARS USE RADIO WAVES WITH HORIZONTAL, DUAL (HORIZONTAL AND VERTICAL), OR CIRCULAR POLARIZATION.

- SOME WEATHER RADARS USE THE DOPPLER EFFECT TO MEASURE WIND SPEEDS.



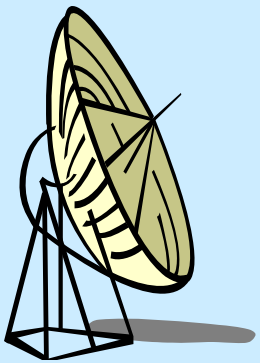
INCOHERENT SCATTER RADAR- A RADAR APPLICATION

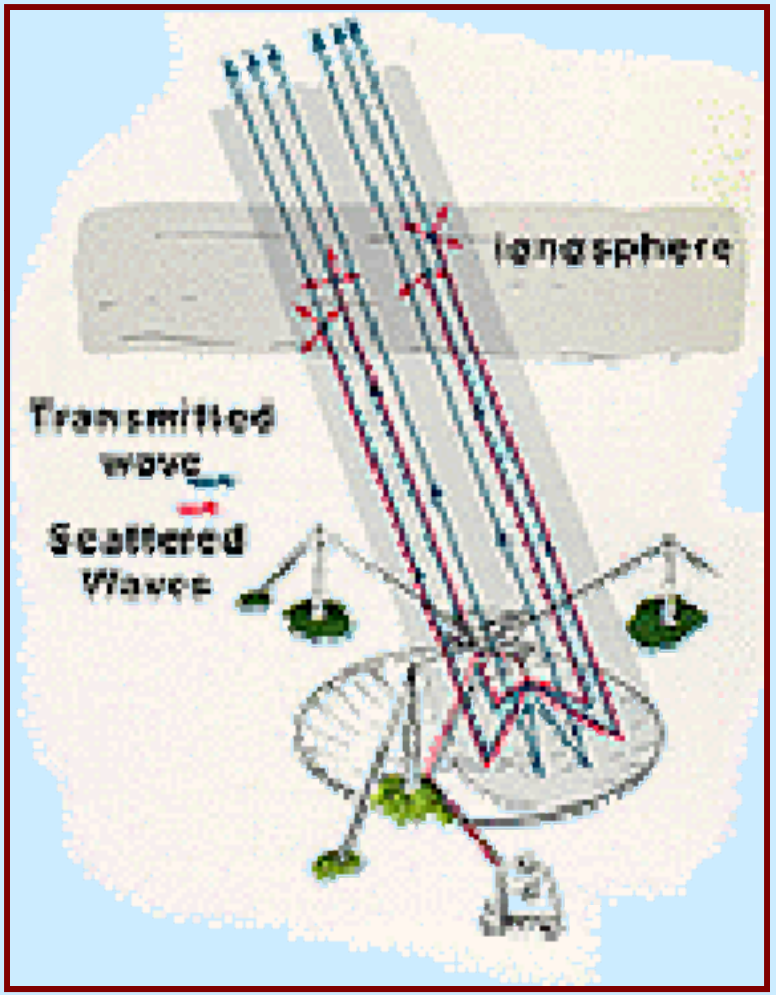
- USED TO STUDY THE EARTH'S IONOSPHERE AND ITS INTERACTIONS WITH THE UPPER ATMOSPHERE, THE MAGNETOSPHERE, AND THE SOLAR WIND.



INCOHERENT SCATTER ECHO

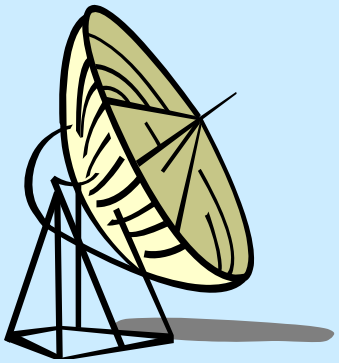
- ELECTRONS IN IONOSPHERE ARE RADAR TARGETS.
- THESE ELECTRONS CAN SCATTER RADIO WAVES.





RADAR CAN MEASURE PRESSURE

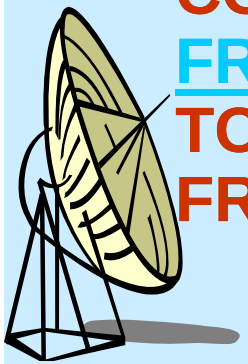
- THE STRENGTH OF THE ECHO RECEIVED FROM THE IONOSPHERE MEASURES THE NUMBER OF ELECTRONS ABLE TO SCATTER RADIO WAVES OR WHAT WE CALL ELECTRON PRESSURE.

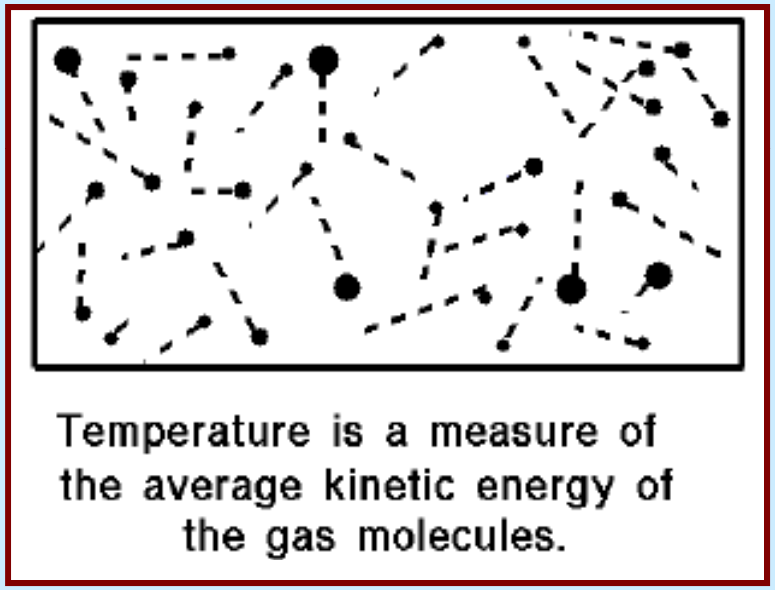


RADAR CAN MEASURE TEMPERATURE

- SOME ELECTRONS ARE MOVING DUE TO HEAT - IN THIS CASE THE ECHO IS SCATTERED.

- THE ECHO WILL CONTAIN A RANGE OF FREQUENCIES CLOSE TO THE TRANSMITTER FREQUENCY.

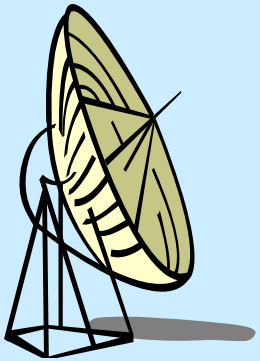




Temperature is a measure of the average kinetic energy of the gas molecules.

RADAR CAN MEASURE TEMPERATURE

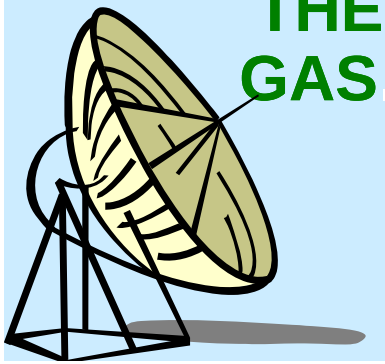
AS THE TEMPERATURE INCREASES, THE ELECTRONS MOVE FASTER SO RADAR CAN ACT LIKE A THERMOMETER AND MEASURE THE TEMPERATURE OF THE IONOSPHERE.



RADAR CAN MEASURE WIND SPEED

- WHEN AN ELECTRON IS REMOVED FROM AN ATOM, THE REMAINING CHARGED ATOM IS CALLED AN ION.

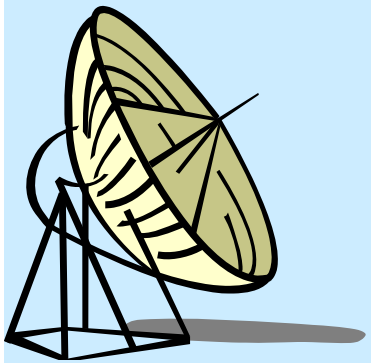
- THE ION GAS CAN HAVE A DIFFERENT TEMPERATURE FROM THE ELECTRON GAS.

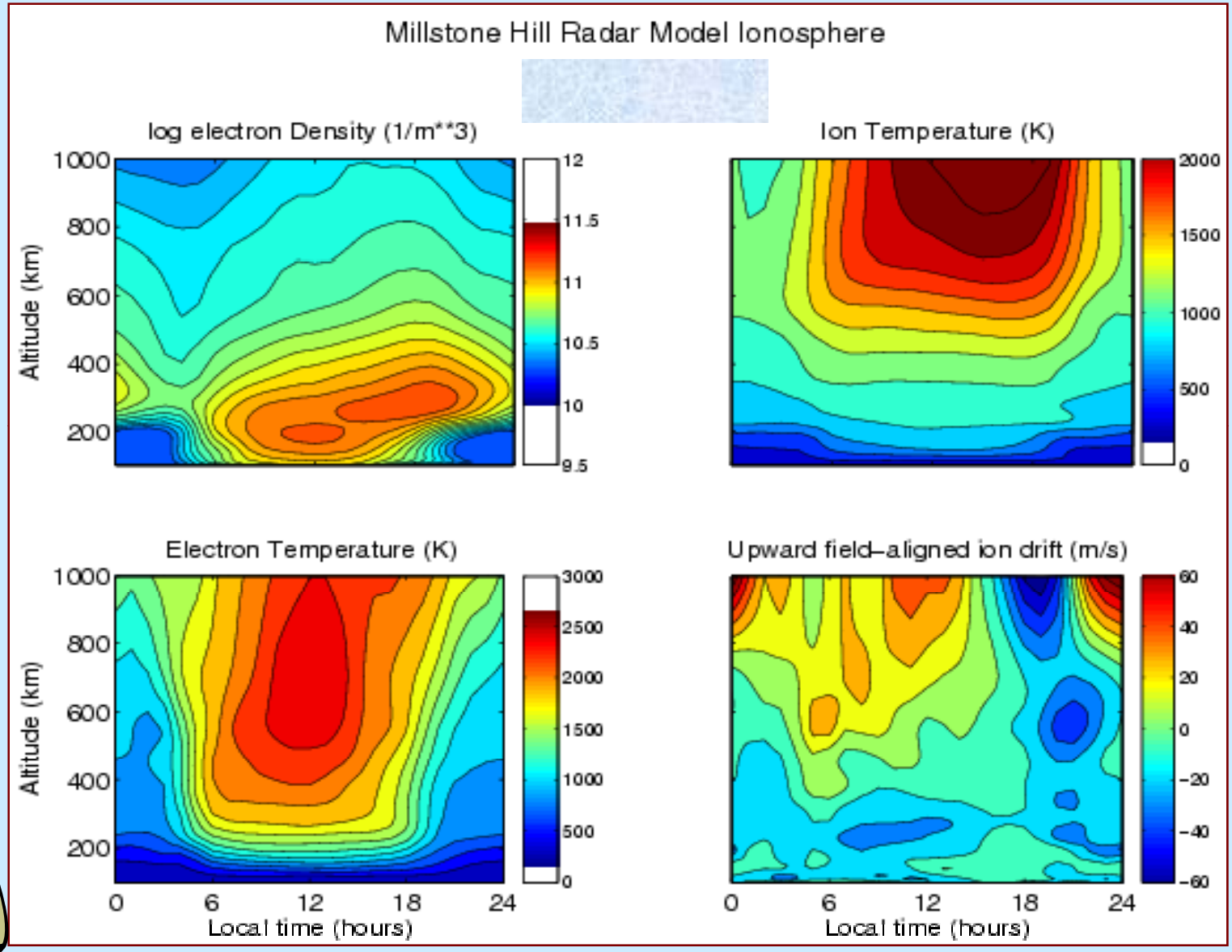


RADAR CAN MEASURE WIND SPEED

THE ELECTRON/ION MIXTURE IS KNOWN AS A PLASMA AND IS USUALLY IN MOTION (LIKE OUR WIND).

SO INCOHERENT SCATTER RADAR CAN ALSO MEASURE WIND SPEED.




Millstone Hill Radar Model Ionosphere
log electron Density (1/m**3)
Ion Temperature (K)
Electron Temperature (K)
Upward field–aligned ion drift (m/s)
Altitude (km)
Local time (hours)
1000
800
600
400
200
0
6
12
18
24
12
11.5
11
10.5
10
9.5
2000
1500
1000
500
0
3000
2500
2000
1500
1000
500
0
60
40
20
0
−20
−40
−60