TYPES OF RADAR SYSTEMS

ECE 514E-RADAR & SATELLITE SYSTEMS

Monday, September 14, 2026

OPPORTUNITIES IN RADAR ENGINEERING



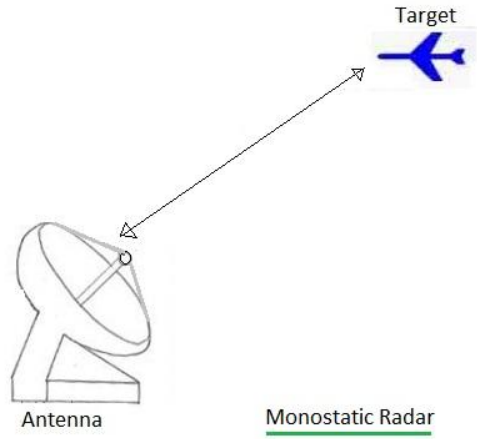
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GENERAL CLASSIFICATION OF RADAR SYSTEMS

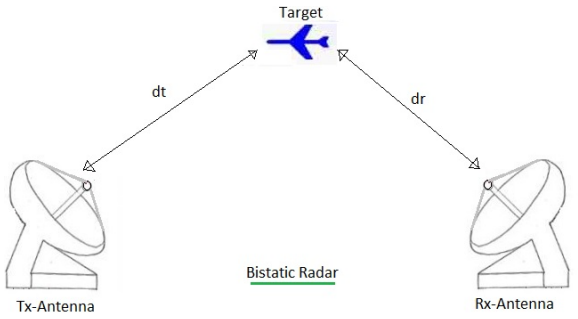
1. **Separation of Transmitter and Receiver** (Mono-static, Bi-static and Multi-static)
2. **Bearer/Location** (Ground-based, Naval, Air-borne and Space-based)
3. **Coordinate System** (2D and 3D)
4. **Transmission Waveform** (Pulsed and Continuous waveform)
5. **Target Response** (Primary and Secondary)
6. **Type of Processing** (Coherent, Non-Coherent, Phased Array)
7. **Operating Frequency** (UHF, L, S, C, X)

CLASSIFICATION BY LOCATION OF TRANSMITTER/RECEIVER

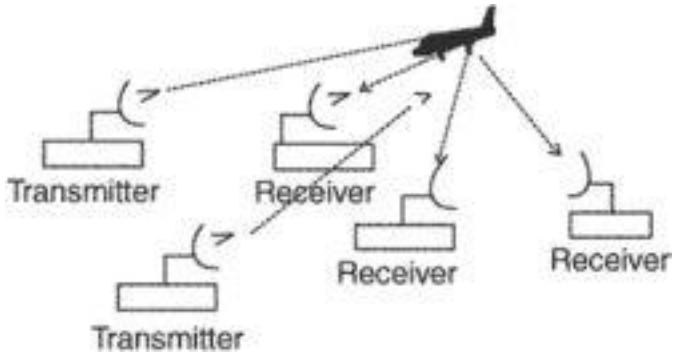
1. **Monostatic radar:** Both transmitter and receiver in the same location.



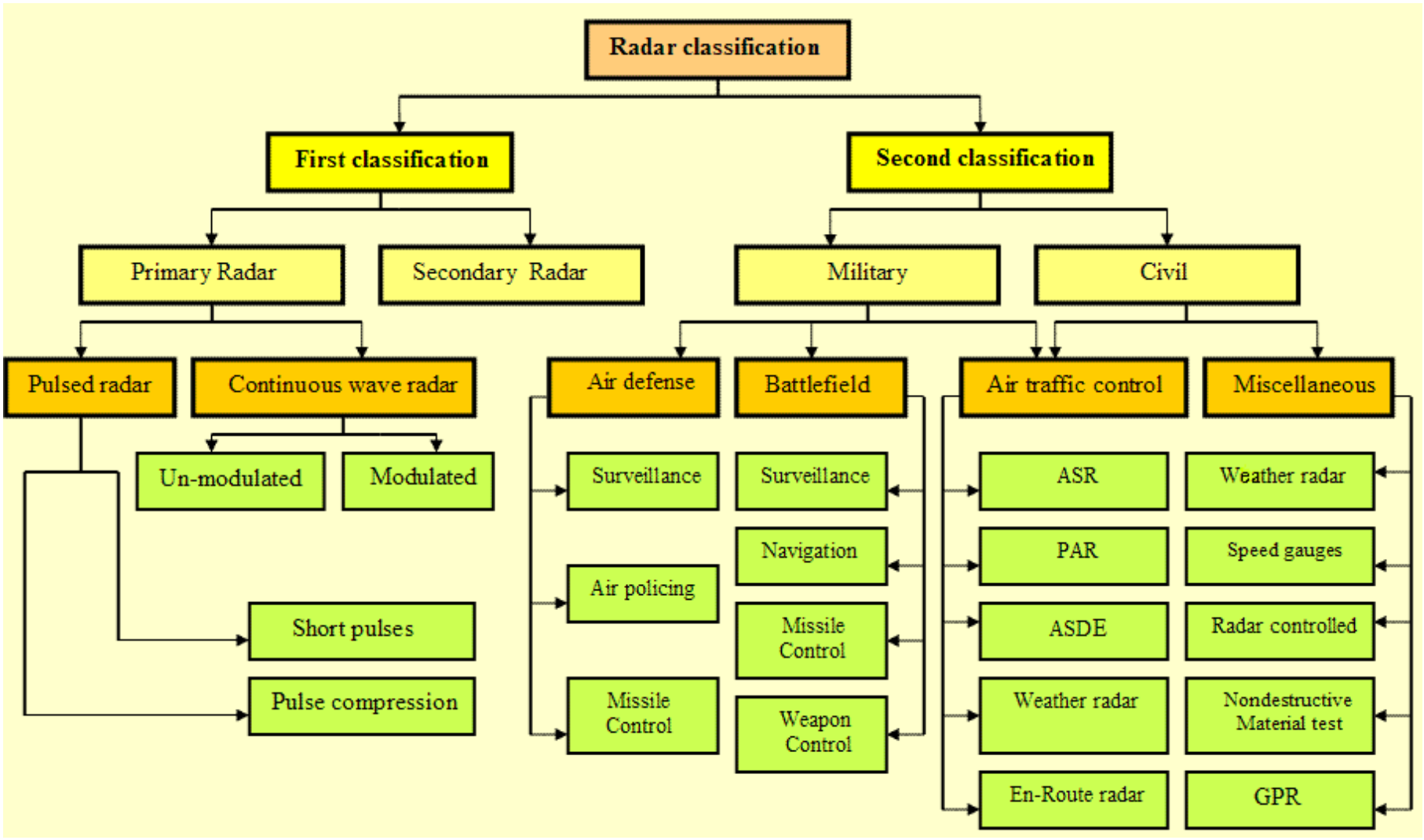
2. **Bistatic radar:** The transmitter and receiver are placed in different locations.



3. **Multistatic radar:** There is one transmitter and several receivers placed in different locations

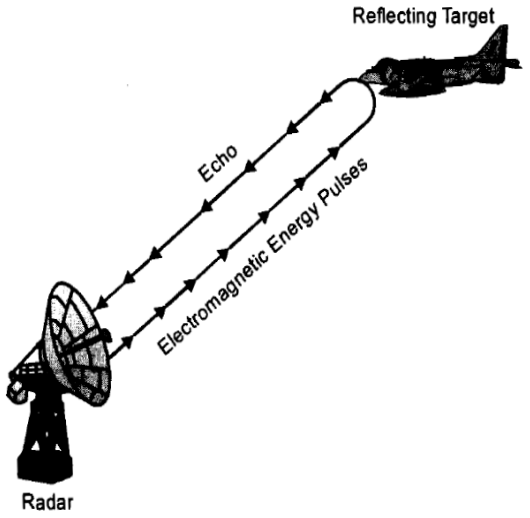


MILITARY/CIVIL CLASSIFICATION



PRIMARY RADAR

- This relies on the reflection of a portion of the incident energy (echo) by the target.
- The target does not willingly co-operate with the radar installation.
- Primary radar used to detect and track hostile aircraft and missiles.









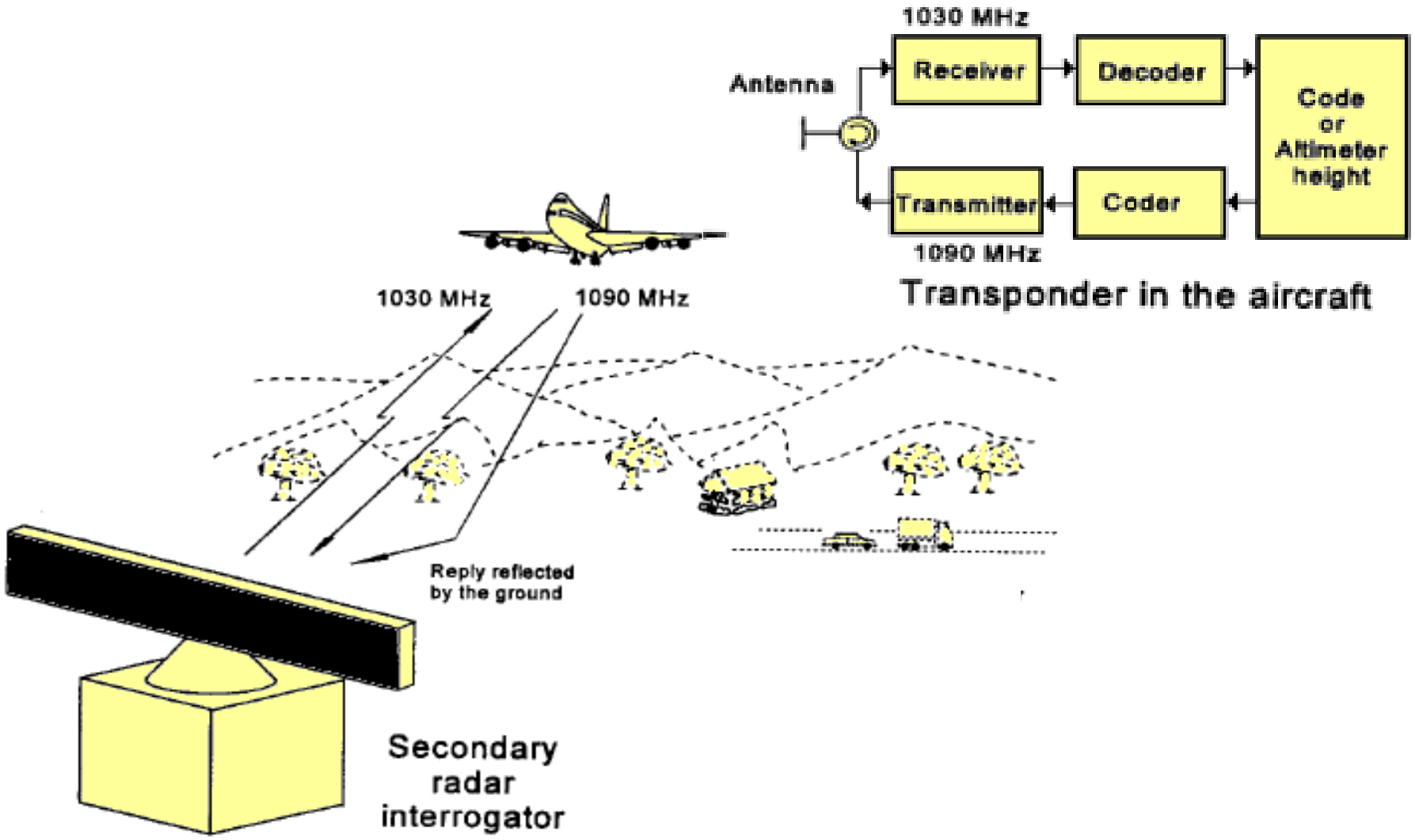
SECONDARY RADAR

1. When directing aircraft using radar in the second world war (1939 - 1945) a need arose to **differentiate between the Amy's own aircraft and enemy aircraft**.
2. This led to the development of radar repeaters which were carried on friendly aircraft and doubled the "blip" on the display.
3. This system was **called Identification Friend or Foe (IFF).** All the repeaters in the aircraft had to be tuned to the frequency of the radar that observed it and led to the development of separate systems, initially the IFF in the band **157 MHz to 187 MHz**.
4. Radar systems that require the object being observed **to cooperate by carrying a receiver - transmitter, transponder, or beacon are called secondary radar systems.**

SECONDARY RADAR (2)

- The secondary radar installation and the target help each other.
- The signal received at the radar installation is not a reflection of the incident energy but one from a transmitter, located in the target, which is switched on by the incident energy.
- An example of secondary radar is the identification equipment carried by all friendly ships and aircraft.

A SECONDARY RADAR INTERROGATOR AND ITS ENVIRONMENT



2. SECONDARY RADAR ICAO STANDARD

1. 1030 MHz is used for the interrogation path from ground to air path (Uplink) and 1090 MHz for the reply path from air to ground (Downlink).

2. The interrogator transmitter transmits two 0.8 µs pulses with a power between 21 dBW and 27 dBW

TEST YOUR KNOWLEDGE

(a) How much is 21dBW in Watts

(b) How much is 27 dBW in Watts?

RADAR FREQUENCY BANDS & APPLICATIONS

BAND	ORIGIN	RANGE	WAVE LENGTH	APPLICATION
HF	High Frequency'	3-30 MHz	10 – 100M	**Coastal radar systems, Over-the-horizon (OTH) radars;**
P (VHF)	'**P**' for '**P**revious' (**V**ery **H**igh **F**requency)	30 – 300MHz	1 – 10M	**Applied retrospectively to early radar systems**
UHF	**Ultra High Frequency**	**300 – 1,000 MHz**	**0.3 – 1 M**	**Very long range (e.g. ballistic missile early warning), Ground penetrating, Foliage penetrating**
L	**'L' for 'long'**	**1 – 2.0 GHz**	**15 – 30 cm**	**Long-range air traffic control and surveillance**
S	**'S' for 'short'**	**2 – 4 GHz**	**7.5 – 15 cm**	**Terminal air traffic control, Long-range weather, Marine radar**
C	**Compromise between X and S bands; Hence** C	**4 – 8 GHz**		**Weather radar**
X	**Frequency was kept secret during World War 2, hence 'X'**	**8 – 12 GHz**	**8 – 12 GHz**	**Missile guidance, Marine radar, Weather, Medium-resolution mapping and ground surveillance.**

3. MILITARY RADAR TYPES

Military radars are divided into three Categories, i.e

(a) Air Defense Radar

(b) Battlefield Radar

(c) Air Traffic Control Radar



3.1 AIR DEFENSE RADARS (1)

1. Air defense radars can detect air targets and determine their position, course, and speed in a relatively large area.

2. The maximum range of air defense radar can exceed 500 Kms, and the bearing coverage is a complete 360 degree circle.



3.1 AIR DEFENSE RADARS (2)

Functions of Air Defense Radars are:

a) To serve as **Early Warning systems** because they can detect approaching enemy aircraft or missiles at great distances.

b) To police the National Airspace.

c) To **Guide combat Air Patrol Aircraft** to a position suitable to intercept an enemy aircraft.

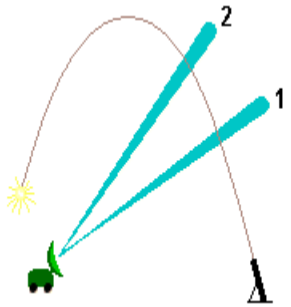
d) to **defend against aircraft and cruise missiles**, and more recently against short-range ballistic missiles



BATTLEFIELD RADARS

Battlefield radar are divided into three types:

1. **Surveillance:** to alert combat troops of hostile and unknown aircraft, cruise missiles and unmanned aerial vehicles
2. **Navigation:** for fixing a vessel´s position with sufficient accuracy to allow safe passage
3. **Weapon control:** by providing information used to guide missiles/ weapons to a hostile target



AIR TRAFFIC CONTROL RADARS



Air traffic control radar fall into five categories:

(a) Airport Surveillance Radar (ASR) used for the identification of aircrafts, determination of aircrafts approach sequence and for individual aircraft approach controls by Air Traffic Security operators.

(b) Precision Approach Radar (PAR) used to guide aircraft to safe landing under conditions approaching zero visibility.

(c) Surface Movement Radar (SMR) provides surveillance cover for the maneuvering area, which is defined as that used for the take off, landing and taxiing of aircraft, excluding aprons .

(d) weather radar for measurement of precipitation and the detection of hazardous weather conditions, e.g. Microburst Radar (MBR) is an airport ground based system that detects microburst windshear two to five minutes before a hazardous condition occurs.

(e) En-route radar displays radar data to controllers in the en route environment at a maximum range up to 450 km

CIVILIAN RADAR SYSTEMS

1. **Weather Radar:** used both for approach support and for feeding into the wider weather data concentration systems.
2. **Speed Gauges:** Specialized CW radars using the Doppler frequency for measurement of the speed.
3. **Radar Control:** Used to automatically control devices, e.g. Mercedes SL-Class registers traffic scenarios to a distance of up to 150 meters (500 feet) ahead and when necessary applies the brakes automatically.
4. **Non-Destructive Material Test:** used to penetrate material to detect material defects.
5. **Ground Penetrating Radar (GPR):** used to map geologic conditions that include depth to bedrock, depth to the water table, depth and thickness of soil and sediment strata on land and water aquifers, and the location of subsurface cavities and fractures in bedrock.