MISSILES AND MATERIALS

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WHAT IS A MISSILE?

Missile is a projectile, guided and controlled from the launch to the terminal stage, with or without propulsion, and delivers the warhead for inflicting lethal destruction / damage to the designated target.

WHAT IS A MISSILE SYSTEM?

- The total Missile System is even more extensive in terms of Technology, Development Effort and Cost compared to Missile.
- A Missile System is structured as troop, battery, squadron or regiment.

- A System may comprise of many of the following systems (most often Vehicle-borne, Mobile):
  - Launcher system
  - Target Surveillance, and Tracking Radars System
  - Command, Control, Communications and Intelligence (C3I) System
  - Missile Replenishment System
  - Power Supply System
  - Survey Vehicle
  - Radar Repair and Vehicle Repair Vehicle
  - Fuel and Oxidiser Carriers
  - Missile Automatic Health Check System
- Due to this, a Missile System is treated as system of systems.

CLASSIFICATION OF MISSILES

- Broadly classified on the basis of their features such as type of Target; Range; mode of Launching; method for Flight Control, Propulsion or Guidance, type of Warhead
- Popularly terms such as Strategic, Tactical, Cruise or Ballistic are also used.

TARGET

- Anti-tank
- Anti-personnel / soft vehicle
- Anti-aircraft / Anti-helicopter
- Anti-ship
- Anti-satellite
- Anti-missile
- Anti-radar
- Anti-airfields / Fuel Dumps / Harbour / Industrial Centres / Command Control Centres

LAUNCH PLATFORMS

- Surface-to-surface missiles (SSM)
- Surface-to-air missiles (SAM)
- Air-to-air missiles (AAM)
- Air-to-surface missiles (ASM)
- Shoulder-fired / tripod launched (Man Portable)
- Land – mobile (wheeled vehicle or tracked vehicle)
- Aircraft / helicopter-borne
- Ship / submarine-launched
- Silo-based

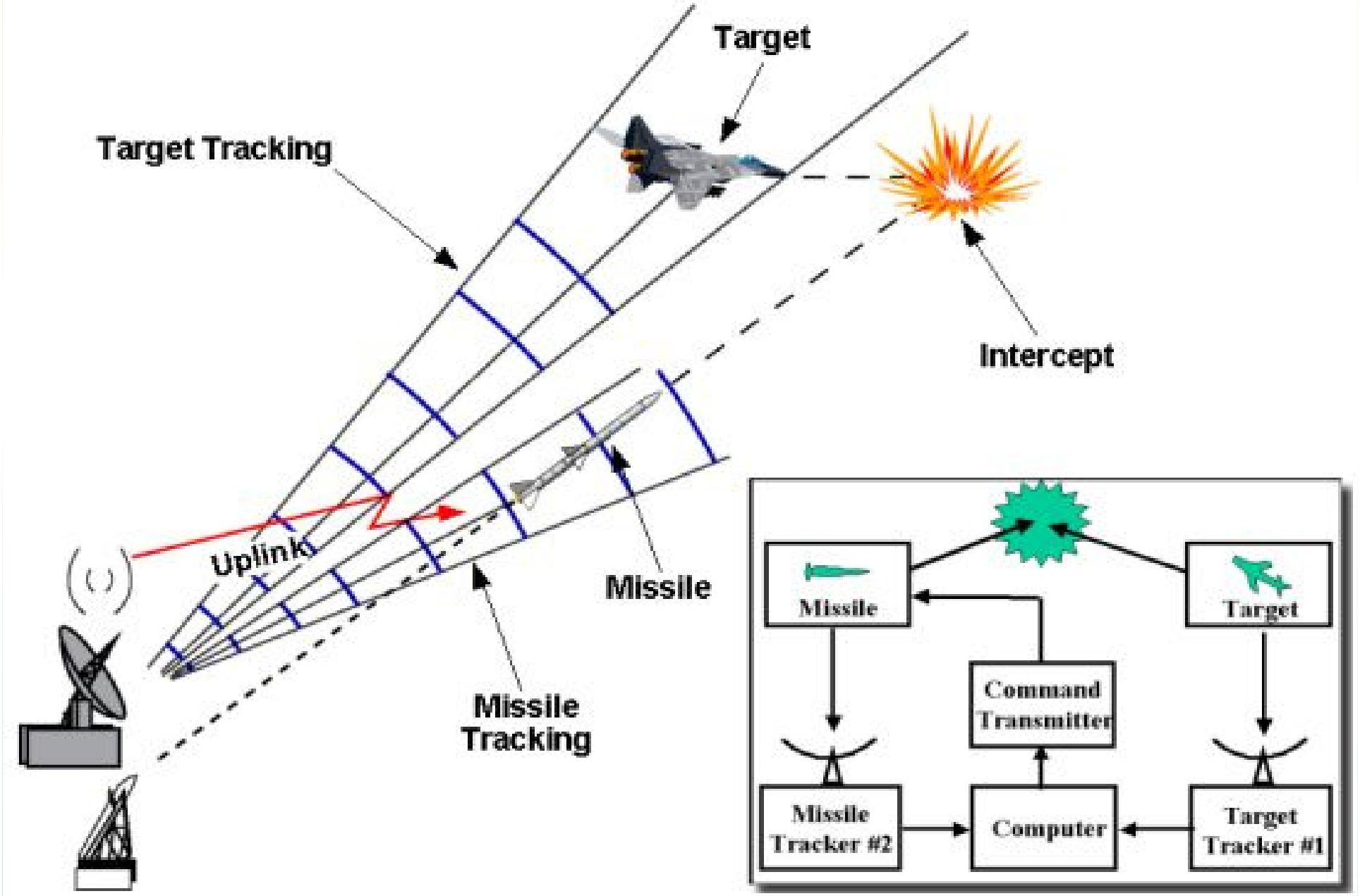
RANGE

- Theatre Weapons: Cruise as well as Ballistic missiles (upto 600 km)
- Medium-range: Cruise as well as ballistic missiles (MRBM) (2500 km)
- Intermediate-range ballistic missiles (IRBM) (5000 km), MIRVs, MaRVs
- Intercontinental or long-range ballistic missiles (ICBM) (12000 km), MIRVs, MaRVs

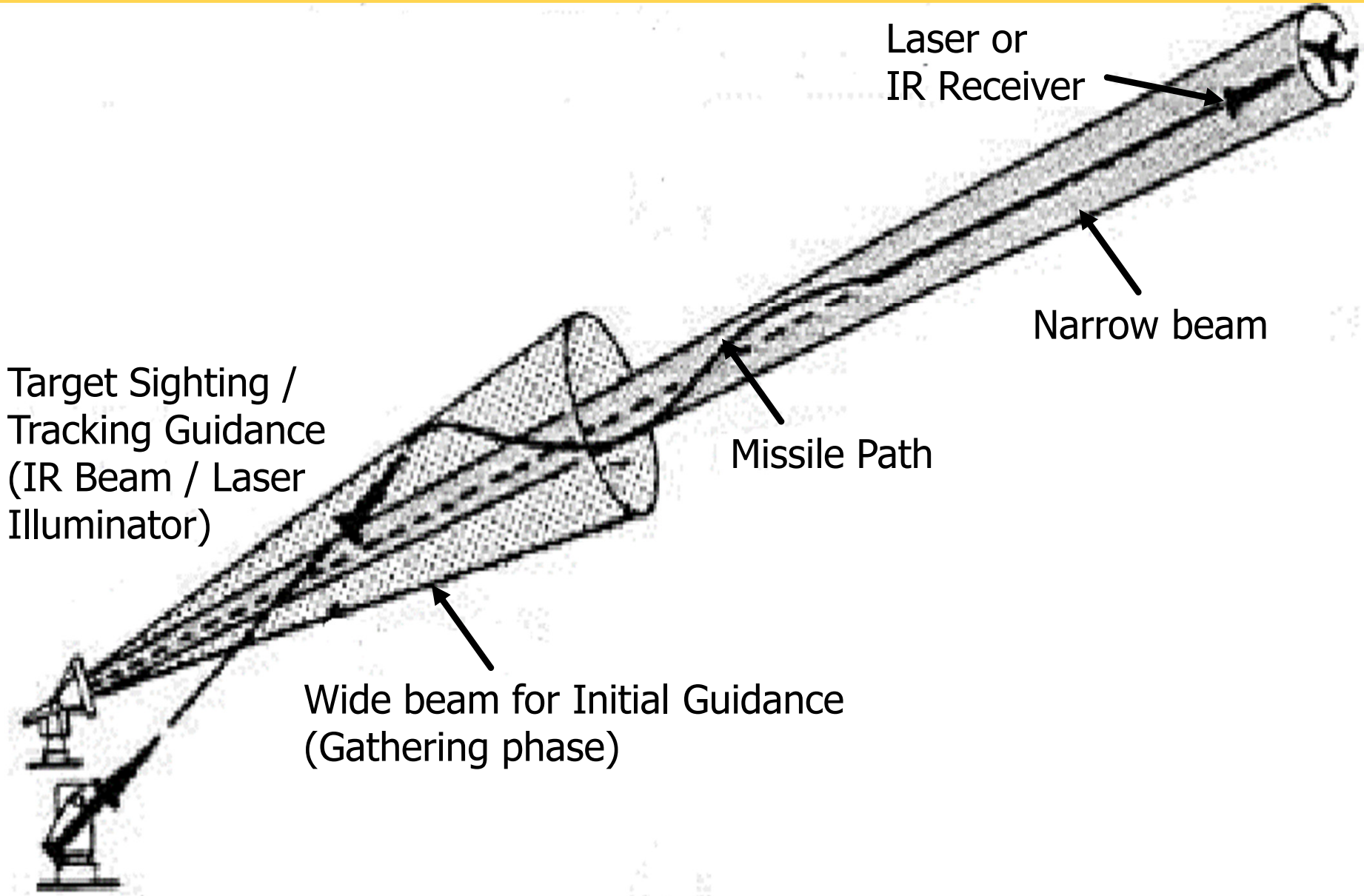
GUIDANCE

- Line of Sight Guidance
  - Command Guidance
  - Beam rider Guidance
- Homing Guidance
  - Active Homing
  - Semi-Active Homing
  - Passive Homing
- Inertial Navigation Guidance
- Combination of the above

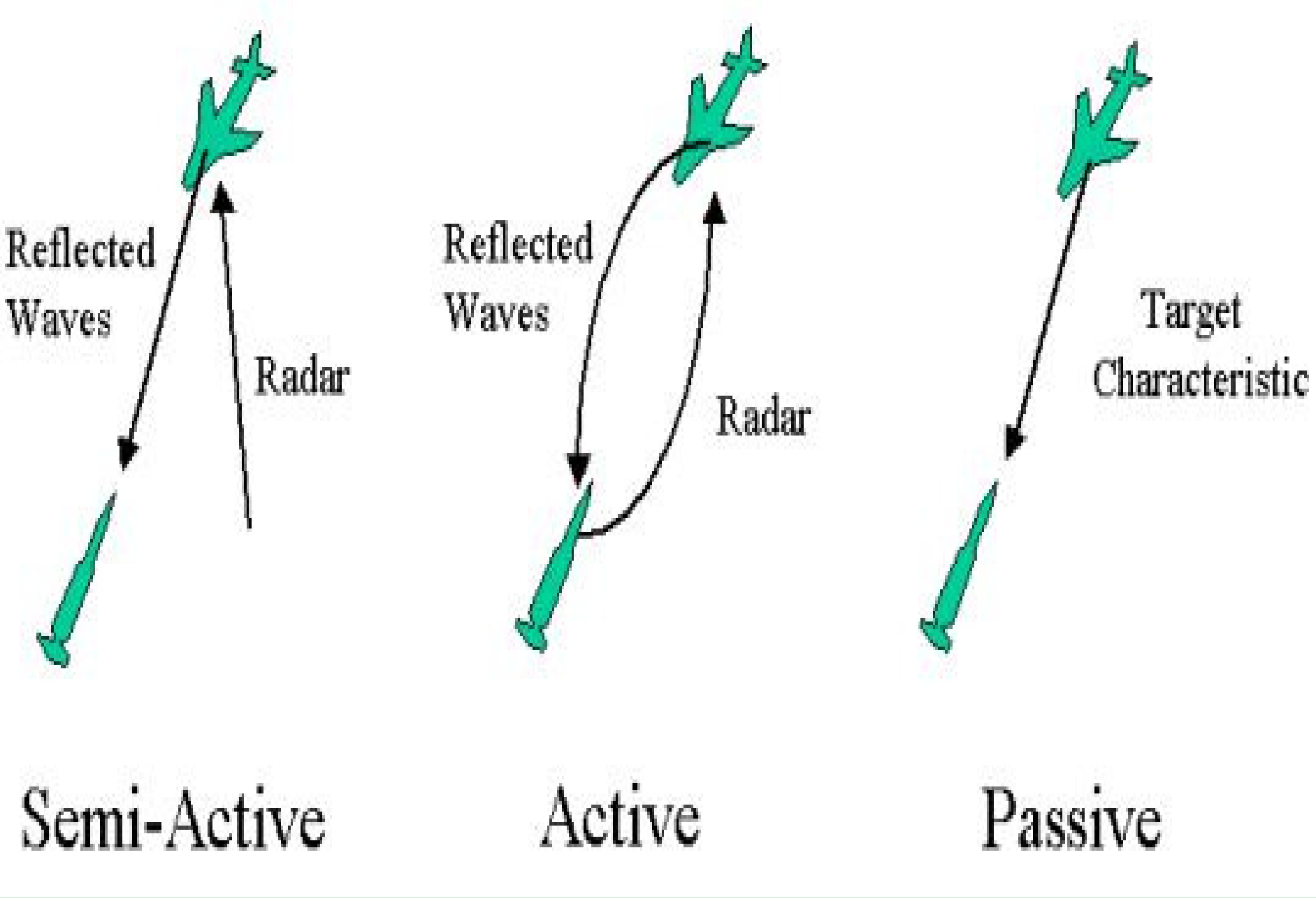
COMMAND GUIDANCE



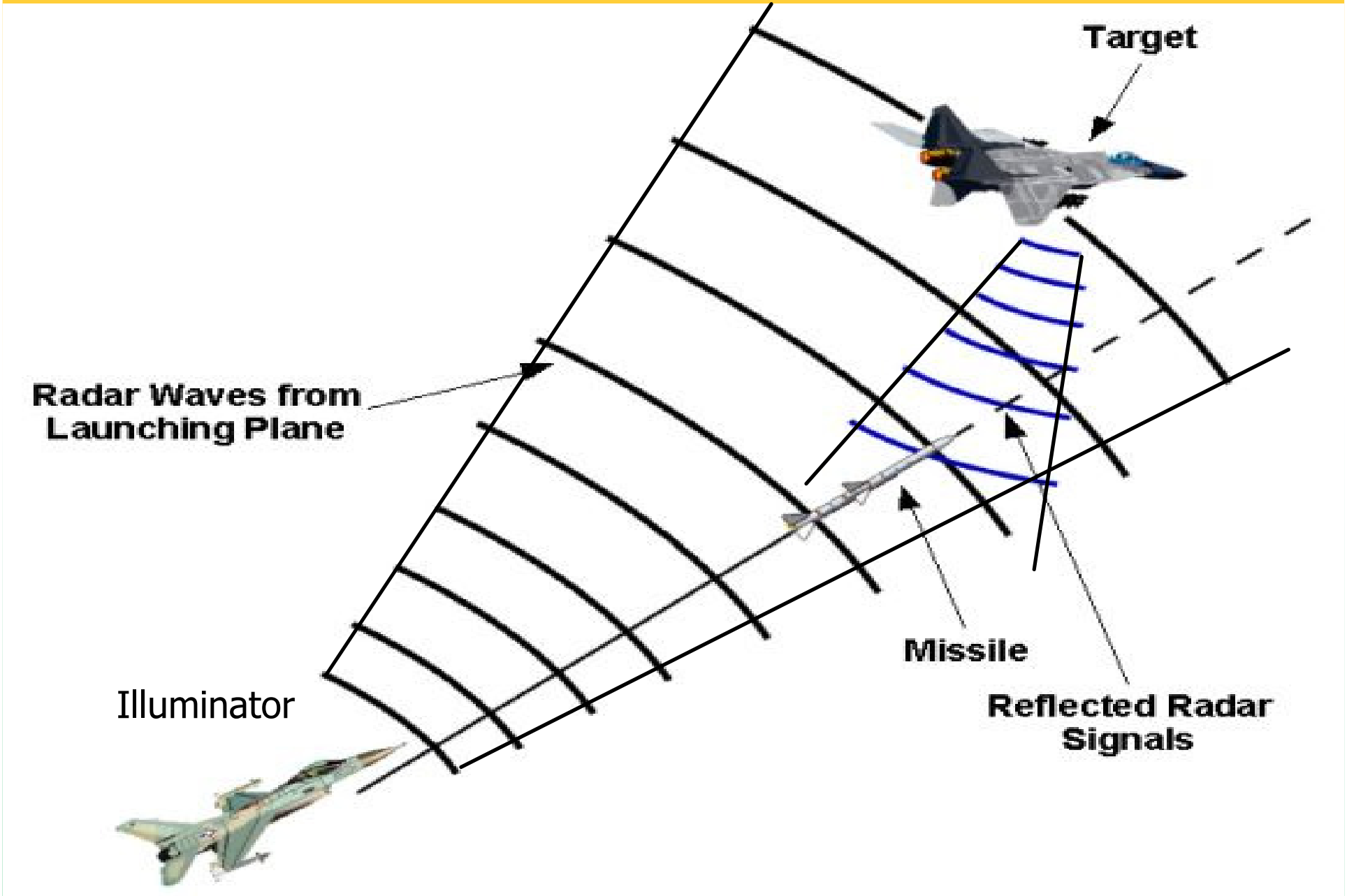
BEAM RIDER


Laser or
IR Receiver
Narrow beam
Target Sighting /
Tracking Guidance
(IR Beam / Laser
Illuminator)
Missile Path
Wide beam for Initial Guidance
(Gathering phase)

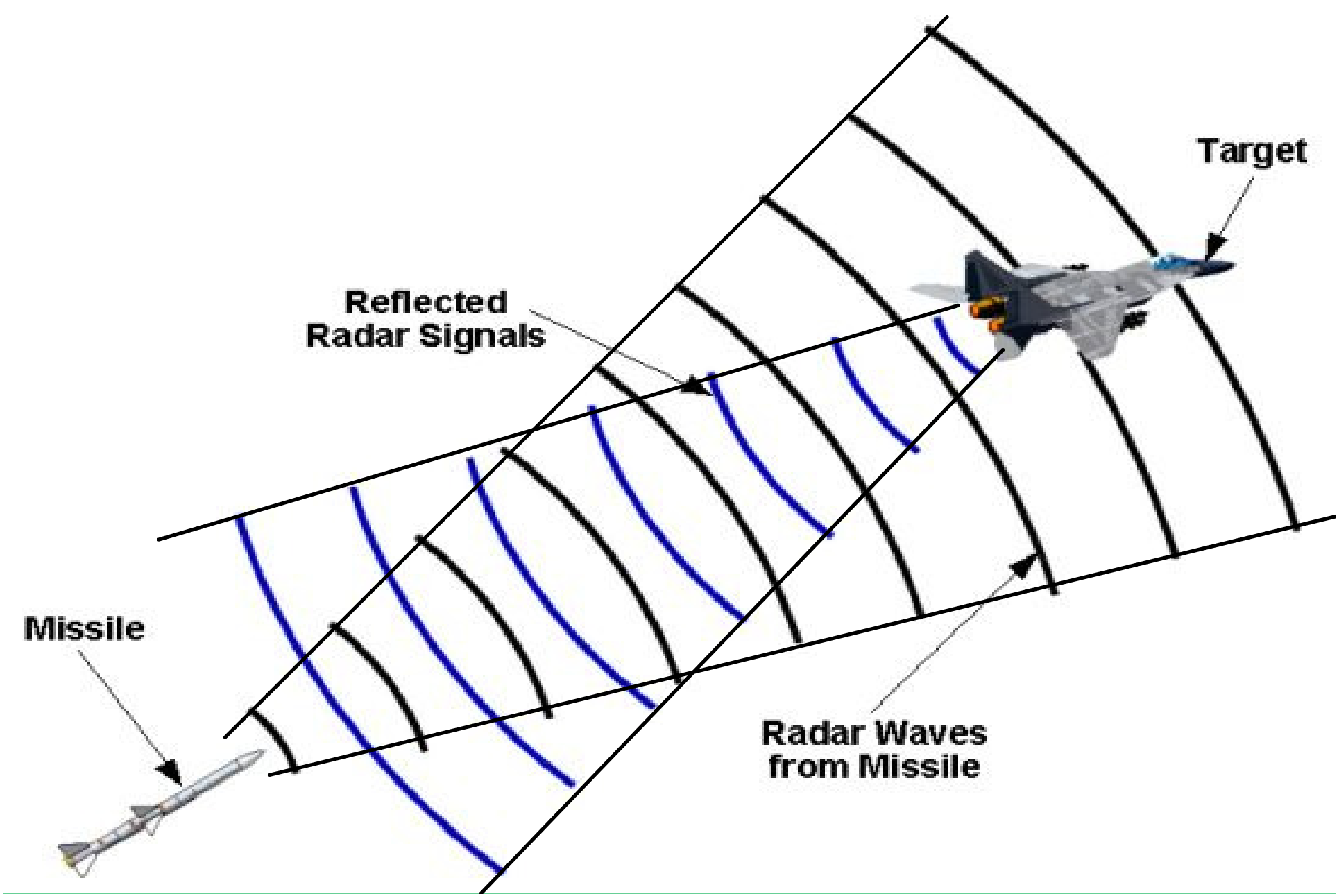
HOMING


Reflected
Waves
Radar
Reflected
Waves
Radar
Target
Characteristic
Semi-Active
Active
Passive

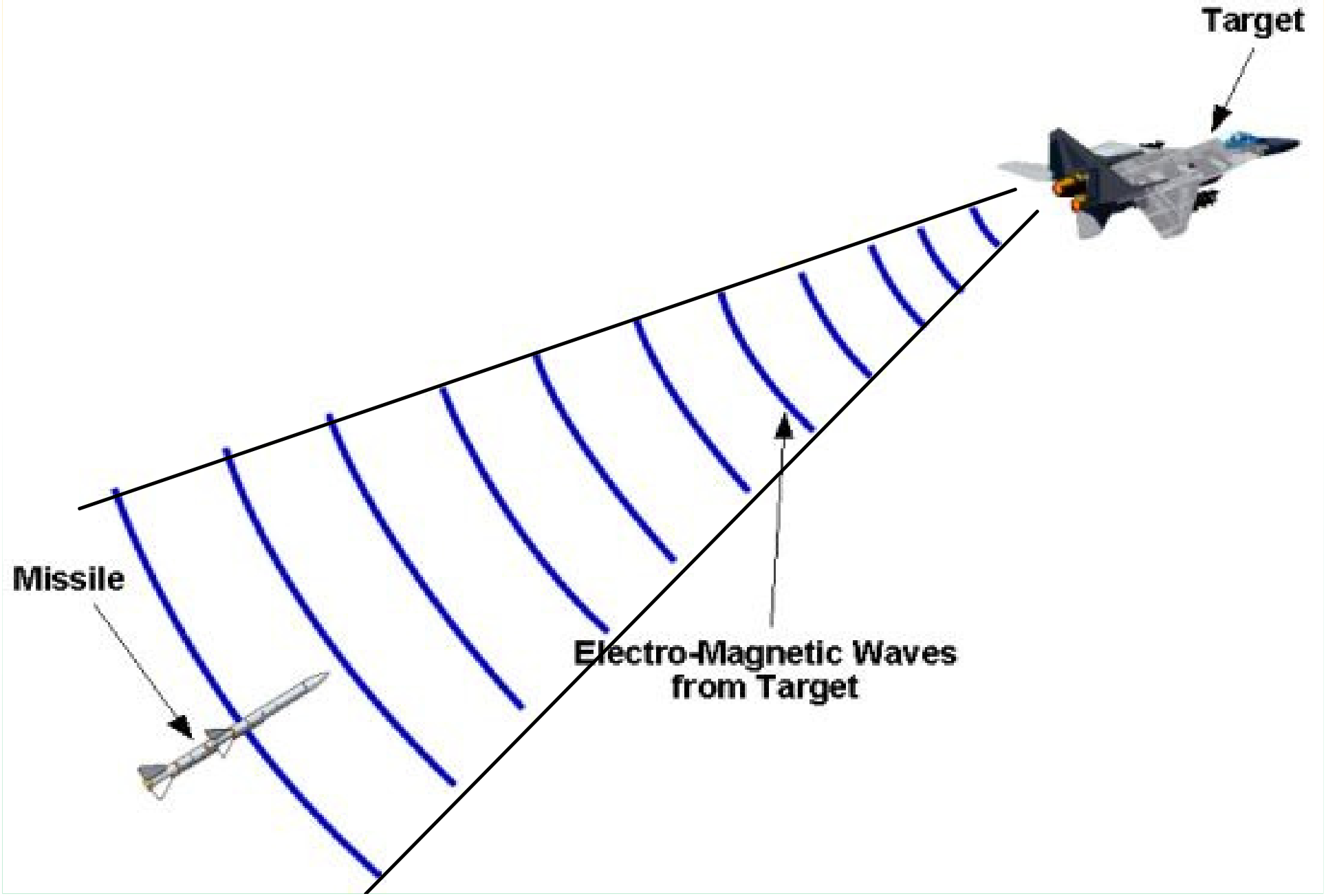
SEMI-ACTIVE HOMING



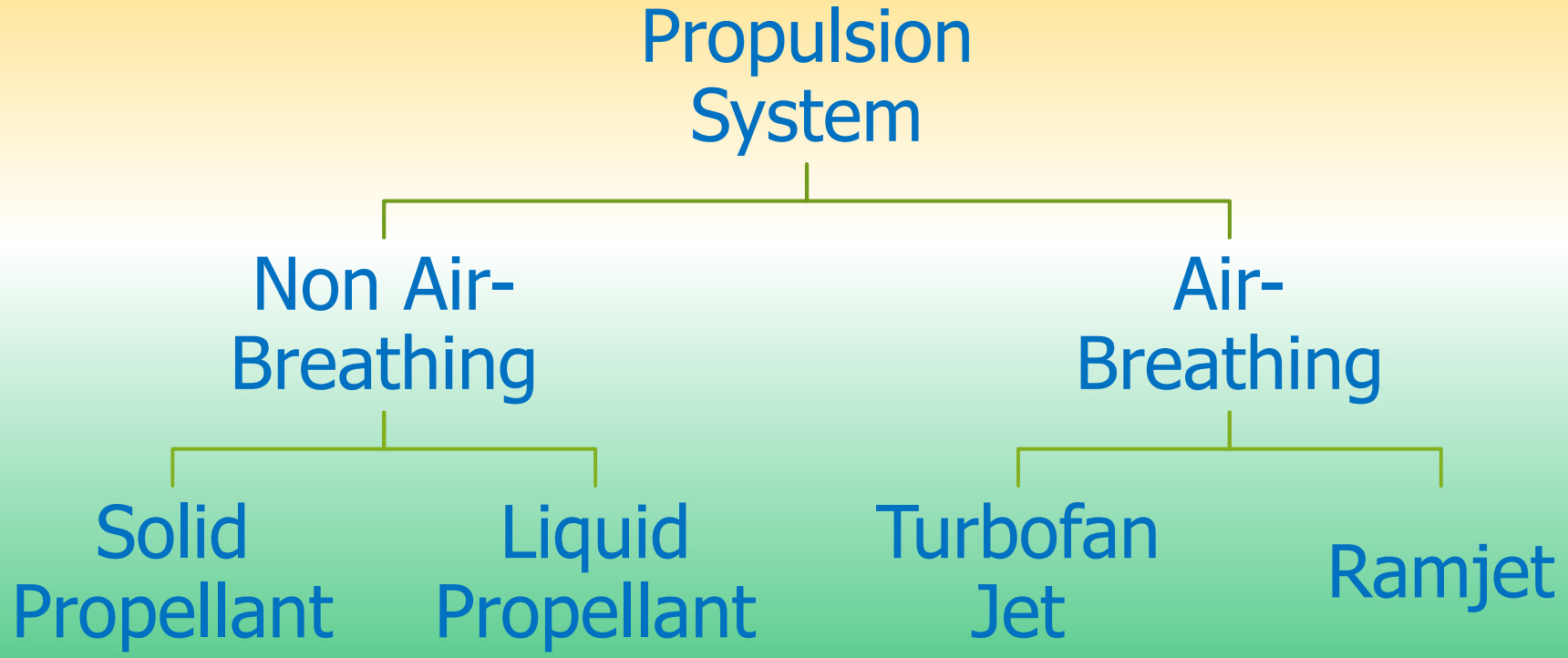
ACTIVE HOMING



PASSIVE HOMING



PROPULSION


Propulsion System
Non Air-Breathing
Air-Breathing
Solid Propellant
Liquid Propellant
Turbofan Jet
Ramjet

WARHEADS

A. Conventional Warheads

1. Fragments (Metallic) and Blast Effect:

This type contains 40% of its total weight as Explosive and rest as Metal Fragments or / and surrounding metallic or composite casing. In addition, there is fuse for safety and trigger action.

Explosive is a solid chemical mixture / compound that burns extremely rapidly, producing gases at high temperature and pressure, resulting in a blast wave and spreading of high velocity metal fragments (1600 – 1700 m/s) all around.

Contd.

Damage is caused by blast effect and fragments. Used against surface targets and airborne targets.

Explosives: Gun Powder, TNT, RDX, HMX (With metallic powders as additives)

Metal: Steel, Tungsten Alloy

2. Hollow charge / Shaped Charged Warheads:

High purity copper cone melts due to explosive and forms high velocity, high density sharp jets to defeat armour.

3. Kinetic Energy Penetrators cum Blast Type

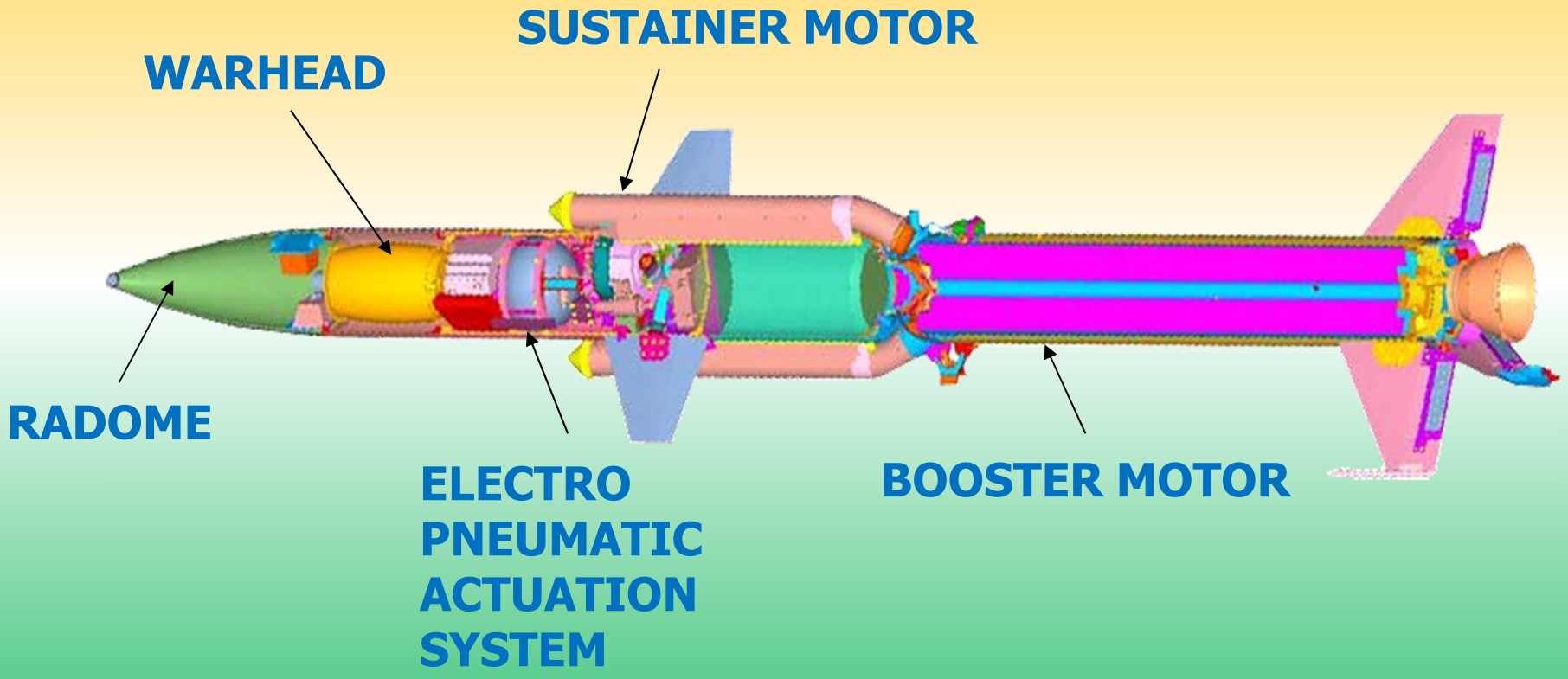
4. Incendiary type

5. Bus type Warhead with Child Stores

B. Nuclear, Biological and Chemical (NBC) Warheads

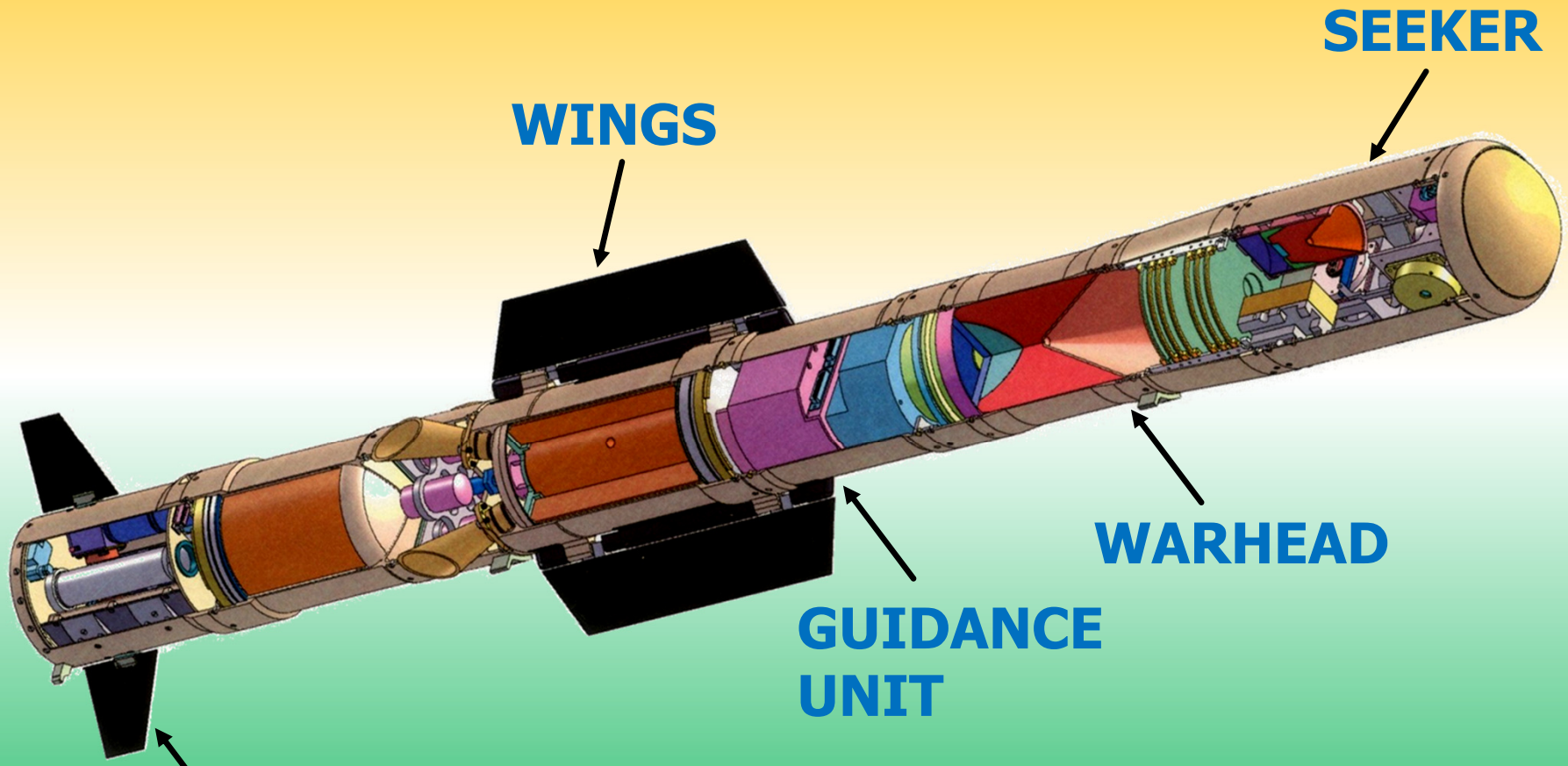
Contd.

MAJOR MISSILE SUBSYSTEMS



AKASH

MAJOR MISSILE SUBSYSTEMS

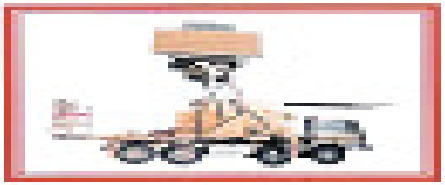


NAG

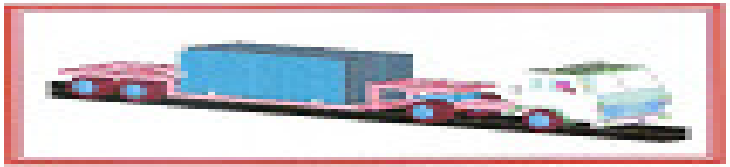
AKASH

AKASH GROUND SYSTEM

Group Headquarters



SU-CAR



INTEGRATED POWER SUPPLY VEHICLE

Combat Battery

BATTERY LEVEL RADAR

BATTERY SURVEILLANCE RADAR

AKASH ARMY LAUNCHER

AKASH MISSILE

EQUIPMENT MAINTENANCE VEHICLES (GEN, REM, MSR&MSHT)

Technical Battery

TRANSPORT CUM LOADER VEHICLE

INTEGRATED AIR COMPRESSOR AND STORAGE VEHICLE

MOBILE STATION FOR MISSILE CHECKOUT

NAG

TRISHUL

PRITHVI

AGNI

MATERIALS USED

For Rocket Motor Casing, Liquid Propellant tanks & Airframes of Missiles

SOLID ROCKET CASING MATERIALS

Casing

- Maraging Steels

M-150 to 350 available, M-250 steel desirable for Rocket Motor, because

Micro crack tolerance levels are high due to high fracture toughness

Aging temperature is approximately 480° C

Good weldability

- Medium Carbon Alloy Steels

	UTS / YS MPa	% Elongation	Fracture Toughness
4130	1230 / 1030	16.5	70
4340	1500 / 1365	14	60
D-6AC	1630 / 1570	9.6	99

Different processes like Vacuum degassing, Vacuum Arc Melting (VAM), Electro-slag Remelting (ESR), Vacuum Arc Remelting (VAR), Vacuum Induction Melting (VIM) are used to:

- Enhance cleanness (Very low impurities)
- Yields greater reproducibility of properties batch to batch
- Greater ductility and toughness
- Combination of high tensile strength, toughness and elongation
- Higher strength-to-density ratio

Contd..

B. Titanium Alloys:

Used in high pressure air bottles, motor casings

Example: Ti-6Al-4V

C. Composites:

- Motor casings, Airframes shells possess high strength to density ratio
- Glass fibres - Epoxy Resin,
- Kevlar fibres – Epoxy Resin
- Carbon fibres – Epoxy

D. Aluminium Alloys:

- Aerospace Quality
- Weldable and flow formable (Example: AA 2014, 2219, 6061, 7075)
- Used for Liquid Propellant Tanks, Airframes, Wings etc.

CARBON – CARBON COMPOSITES

Unique combination of high strength at very high temperature.

Uses:

- Nose tip of Re-entry Modules
- Rocket Nozzle throat-zone
- Brake discs in aircrafts
- Leading edges of Control Surfaces

Contd..

Unique Properties:

- Best high temperature material (melts beyond 3000^{o} C)
- High thermal conductivity and low coefficient of expansion
- Retains high strength upto 3000^{o} C
- Thermally stable and withstands high thermal and mechanical shock.

Contd..

Process:

- Carbon fibres woven 3D to 6D impregnated with polymeric resin
- Carbon fibres can be Pitch based or PAN based.
- Carbonisation process increases density. (Approximately 2 gm/cm^3 attained by DRDO)

Weakness: Prone to Oxidation

Life can be enhanced (upto approximately 100 hours) by Multilayer Coatings of inhibitor.

Composites:

Carbon Phenolic and Silica – Phenolic are used as ablative liners, C-C and pyrolytic graphite are used for Rocket motor throat zone.

CERAMICS

Ceramics used in high-performance radomes (Ex. Fused Silica) and IR domes (Ex. Zinc Sulphide, ZnS) because of the following features:

- Low Dielectric Permittivity and Low Dielectric Loss (Stable with temperature)
- High strength at ambient and high temperatures
- High elastic modulus
- High thermal shock resistance
- All weather capability (rain erosion and particle impact resistance)

MATERIALS USED FOR RADARS, GUIDANCE RECEIVERS AND CONTROL

SUPER MAGNETS

Neodymium magnet (NdFeB or NIB, rare-earth magnet), is a permanent magnet made from an alloy of neodymium, iron and boron to form the Nd2Fe14B tetragonal crystalline structure.

Unique Features:

- High Coercivity
- Greater resistance to demagnetisation
- High saturation magnetisation (much higher than Sm-Co Magnets) and less expensive also.

Contd..

- China produces 70% or more of Rare Earth Magnets (95% of Rare Earth Elements)
- Processed by Powdered Metallurgy (Sintered)
- Rapid Solidification or Bonded Magnetisation
- Uses in missiles:
  - Electro-magnetic Actuators
  - Magnetrons

Contd..

- Ferrite Rods used in Phase Shifters, Steering Arrays (Akash multifunction PAR)

- Compounds like Lead (II) Sulphide (PbS), Indium Antimonide (InSb), Mercury Cadmium Telluride (HgCdTe) and Mercury Zinc Telluride (HgZnTe) used as Imaging Infrared (IIR) detectors in Focal Planar Arrays (FPAs) used for Missile Seeker applications.(NAG homing seeker)

SPECIAL CHEMICALS

- Structural materials and coating materials are used for imparting certain characteristics to missile body for stealth.
- Variety of adhesives / bonding agents are used in processing, installation of sensors, assembly and integration operations for potting of electronic assemblies to protect against vibrations and humidity.
- Most of these chemicals are polymers.