5. MISSILE DEFENCE SYSTEMS - DEFENCE

The renewed hostilities between the United States-led coalition (including Israel and United Arab Emirates) and Iran have tested a newly integrated regional air and missile defence network in West Asia A missile defence system is an integrated military architecture designed to detect, track, intercept, and destroy hostile missiles before they reach their intended targets.

These targets may include civilian population centres, military bases, command infrastructure, nuclear facilities, and industrial hubs.Modern missile defence systems combine advanced sensors, interceptor missiles, surveillance platforms, and command-and-control networks to create a protective shield against aerial threats.

1. Core Components of a Missile Defence System

1. Early Warning and Detection Systems

• Satellites equipped with infrared sensors detect missile launches by identifying the heat signature of rocket engines.
• Long-range ground-based radars track missile trajectory, altitude, and velocity.
• These systems provide early warning, enabling timely defensive responses.

2. Tracking and Targeting Systems

• Radar networks continuously track incoming missiles and calculate projected impact points.
• Advanced algorithms determine the type of missile (ballistic, cruise, or hypersonic) and assess threat levels.

3. Command and Control Centres

• Data from satellites and radars is transmitted to central command centres.
• Military authorities evaluate the threat and decide whether interception is required.
• Command systems coordinate the launch of interceptor missiles.

4. Interceptor Missiles

• Interceptors are defensive missiles designed to destroy incoming threats mid-flight.
• They may employ:
1. Explosive warheads with proximity fuses, or
2. Hit-to-kill technology, where interception occurs through direct high-speed collision.

2. Phases of Ballistic Missile Flight

Missile defence systems attempt interception during one of the three phases of missile flight.

1. Boost Phase

• Occurs immediately after launch while the missile's engines are still burning.
• Lasts about 3–5 minutes.
• Interception is difficult because defence systems must be located very close to the launch site.

2. Midcourse Phase

• The missile travels through outer space outside the atmosphere.
• This is the longest phase of missile flight.
• Exo-atmospheric interceptors typically engage targets during this phase.

3. Terminal Phase

• The missile re-enters Earth's atmosphere and moves toward its target.
• Interception occurs at lower altitudes using terminal defence systems.

3. How an Interceptor Missile Works

1. Detection

• Early-warning satellites detect the missile launch.
• Radar systems begin tracking its trajectory, velocity, and altitude.

2. Decision

• Command centres process incoming information to determine threat levels.
• Military authorities decide whether to deploy interceptor missiles.

3. Launch and Midcourse Guidance

• An interceptor missile is launched toward the incoming threat.

• Continuous radar updates guide the interceptor toward the target.

4. Target Destruction

• The interceptor destroys the missile through:

1. Proximity detonation, or
2. Direct kinetic impact (hit-to-kill).

5. Post-Interception Assessment

• Radar systems verify whether the threat has been neutralised.

• Additional interceptors may be launched if necessary.

4. India's Missile Defence Architecture

India is developing a multi-layered Ballistic Missile Defence (BMD) system led by the Defence Research and Development Organisation (DRDO).

1. Prithvi Air Defence (PAD)

• Designed for exo-atmospheric interception.

• Intercepts ballistic missiles at altitudes between 50 km and 180 km.

• Targets missiles during the midcourse phase outside the atmosphere.

2. Advanced Air Defence (AAD)

• Designed for endo-atmospheric interception.

• Intercepts missiles during the terminal phase at altitudes up to 30 km.

• Serves as the second defensive layer if the first interception fails.

• Together, PAD and AAD create a two-layer ballistic missile defence shield.

5. Layered Air Defence Shield in India

Apart from ballistic missile interceptors, India deploys several air defence systems to counter aircraft, drones, and cruise missiles.

1. Long-Range Defence

S-400 Triumf

• Advanced Russian-developed surface-to-air missile system.

• Engagement range up to 400 km.

• Capable of intercepting aircraft, cruise missiles, and ballistic missiles.

2. Medium-Range Defence

Barak-8 (MRSAM/LRSAM)

• Jointly developed by India and Israel.

• Provides 360-degree protection for land and naval platforms.

• Effective range 70–100 km.

3. Short-Range Defence

Akash Missile System

• Indigenous surface-to-air missile system developed by DRDO.

• Range of 25–30 km.

• Protects airbases, army formations, and critical infrastructure.

SPYDER System

• Israeli-developed quick reaction air defence system.

• Designed to counter low-altitude aircraft, drones, and cruise missiles.

6. Mission Sudarshan Chakra

India has proposed Mission Sudarshan Chakra, a long-term plan to develop a comprehensive national missile defence shield by 2035.

Key objectives include:

1. Integration of AI-enabled threat detection systems.
2. Development of advanced radar networks and satellite surveillance.

3. Integration of all air defence assets into a network-centric command structure.
4. Strengthening indigenous defence manufacturing capabilities.

7. Major Missile Defence Systems of Other Countries

Russia

1. S-400 Triumf – Long-range air defence system.
2. S-300VM – Anti-ballistic missile capability.
3. S-350 Vityaz – Medium-range air defence.
4. S-500 Prometheus – Next-generation system capable of intercepting hypersonic missiles and satellites.

United States

1. THAAD (Terminal High Altitude Area Defense) – Intercepts ballistic missiles in the terminal phase.
2. Patriot PAC-3 MSE – Widely deployed missile defence system.
3. Golden Dome – A next-generation missile defence concept under development.

Israel

Israel operates one of the world's most advanced multi-layer missile defence systems:

1. Iron Dome – Intercepts short-range rockets.
2. David's Sling – Intercepts medium-range missiles.
3. Iron Beam – Laser-based defence system under development.

China

1. HQ-9 – Long-range air defence system.
2. HQ-22 – Medium-range surface-to-air missile system.
3. HQ-16 – Naval and land-based air defence system.

8. European Sky Shield Initiative (ESSI)

• A European initiative to strengthen continental air defence capabilities.

Key systems include:

1. IRIS-T SLM – German-developed medium-range air defence system.
2. Skyranger – Mobile air defence platform designed to counter drones and aircraft.

9. Key Challenges in Missile Defence

1. High Cost of Interceptors

• Missile interceptors can cost millions of dollars per unit.
• Offensive missiles and drones are often cheaper, creating cost asymmetry.

2. Saturation Attacks

• Adversaries may launch large numbers of missiles and drones simultaneously.
• Such attacks can overwhelm defence systems.

3. Hypersonic Weapons

• Hypersonic missiles travel at speeds greater than Mach 5.
• Their manoeuvrability makes interception extremely difficult.

4. Technological Complexity

Missile defence systems require integration of:

1. Advanced radar networks
2. High-speed computing systems
3. Satellite-based surveillance.

• Coordinating these technologies remains a major challenge.

10. Way Forward for India

1. Strengthening Indigenous Defence Technology

• Expand domestic development of interceptor missiles, radars, and sensors through DRDO and Indian defence industries.

2. Integration of AI and Advanced Sensors

• Use Artificial Intelligence and machine learning to improve threat detection and interception accuracy.

3. Expanding Strategic Surveillance

• Deploy additional military satellites and long-range radar networks for real-time missile tracking.

4. Enhancing Defence Manufacturing

• Encourage private sector participation under Atmanirbhar Bharat.

5. International Cooperation

• Collaborate with friendly countries on missile defence technologies, radar systems, and joint research.

Conclusion

• Missile defence systems have become a central component of modern national security strategies.

• With the emergence of hypersonic weapons, drone swarms, and advanced missile technologies, countries must develop layered and technologically sophisticated defence architectures.

• For India, strengthening indigenous missile defence capabilities, advanced surveillance systems, and integrated air defence networks will be essential for safeguarding national security in an increasingly missile-centric strategic environment.

Source: https://www.thehindu.com/sci-tech/science/missile-interceptors-in-us-iran-war-explained/article70689390.ece