

Missile System/Classification

Missile System

A missile is an intelligent unmanned rocket designed to carry the payload to a designated point with an aim of destroying the object/target. The missile is designed keeping in mind its target, trajectory, warhead, range, velocity and launch platform.

Missile vs Rocket

A powered, guided munition that travels through the air or space known as a missile (or guided missile). A powered, unguided munition is known as a rocket. Unpowered munitions not fired from a gun are called bombs whether guided or not; unpowered, guided munitions are known as guided bombs or smart bombs.

How does Missile Work?

- **Propulsion System** – The propulsion system in a missile is required to achieve terminal conditions like range, speed and warhead carrying capability. The missile is propelled either by rockets or jet engines using solid or liquid fuel. Some missiles use hybrid technology for propelling it to its intended point.
- **Guidance System** – The function of the guidance system is to maintain the missile in its desired flight path by using altitude control mechanism. This is done by controlling the pitch, roll and yaw of the weapon. The guidance system operates as an autopilot, damping out fluctuations that tend to deflect the missile from its intended flight path. In some missiles, the guidance commands are generated internally by the missile's computer. In others, the commands are transmitted to the weapon by some external source. The guidance for the missiles is provided by GPS, Inertial guidance system, lasers, TV, Infra-red and radar. Sometimes a combination of two or more systems can be used to provide precision guidance and targeting to the missile.
- **Aerodynamics Features** – The aerodynamic features of a missile, also called Control Rolling Surfaces, are used to control the Missile's Flight. The fins, wings and tail are the three major aerodynamic control surfaces used to steer the missile. The missile's course can be altered by moving these controlling surfaces.
- **Terminal Guidance** – In case of precision weapons, the target seeker comes into picture when the missile starts detecting its target. The mechanism also works to determine the time of activating the warhead. After finding out the target, the device sends an electrical impulse to trigger the activation system. The target seeker is based either on radar or InfraRed (IR) or laser devices.
- **Warhead** – The warhead of a missile is selected keeping in mind its target type. It inflicts damage on the target and hence determines the missile's lethality. An optimum position of burst is used to achieve the desired effect on the target limits – the closer the burst to the target, the smaller the warhead needed. In other cases where the missile is required to cause destruction on hard targets, before detonation of warhead, penetration is achieved by employing a variety of technologies.

Propulsion Systems

- **Solid Propulsion:** Solid fuel is used in solid propulsion. Generally, the fuel is aluminium powder. Solid propulsion has the advantage of being easily stored and can be handled in fuelled condition. It can reach very high speeds quickly. Its simplicity also makes it a good choice whenever large amount of thrust is needed.
- **Liquid Propulsion:** The liquid propulsion technology uses liquid as fuel. The fuels are hydrocarbons. The storage of missile with liquid fuel is difficult and complex. In addition, preparation of missile takes considerable time. In liquid propulsion, propulsion can be controlled easily by restricting the fuel flow by using valves and it can also be controlled even under emergency conditions. Basically, liquid fuel gives high specific impulse as compared to solid fuel.
- **Hybrid Propulsion:** There are 2 stages in hybrid propulsion solid propulsion and liquid propulsion. This kind of propulsion compensates the disadvantages of both propulsion systems and has the combined advantages of the 2 propulsion systems.
- **Ramjet:** A Ramjet engine does not have any turbines unlike turbojet engines. It achieves compression of intake air just by the forward speed of the air vehicle. The fuel is injected and ignited. The expansion of hot gases after fuel injection and combustion accelerates the exhaust air to a velocity higher than that at the inlet and creates positive push. However, the air entering the engine should be at supersonic speeds. So, the aerial vehicle must be moving in supersonic speeds. Ramjet engines cannot propel an aerial vehicle from zero to supersonic speeds.
- **Scramjet:** Scramjet is an acronym for Supersonic Combustion Ramjet. The difference between Scramjet and Ramjet is that the combustion takes place at supersonic air velocities through the engine. It is mechanically simple, but vastly more complex aerodynamically than a jet engine. Hydrogen is normally the fuel used.
- **Cryogenic:** Cryogenic propellants are liquefied gases stored at very low temperatures, most frequently liquid hydrogen as the fuel and liquid oxygen as the oxidizer. Cryogenic propellants require special insulated containers and vents which allow gas to escape from the evaporating liquids. The liquid fuel and oxidizer are pumped from the storage tanks to an expansion chamber and injected into the combustion chamber where they are mixed and ignited by a flame or spark. The fuel expands as it burns and the hot exhaust gases are directed out of the nozzle to provide thrust.

Launch Platforms

- Aircraft
- Ground Vehicles
- Ships
- Submarines

Speed

- **SUBSONIC** – speed less than that of sound.
- **SUPERSONIC** – speed greater than that of sound.
- **HYPERSONIC** – speeds of more than five times the speed of sound (Mach 5).

Stealth Technology

- Stealth technology also termed LO technology (low observable technology) is a sub-discipline of military tactics and passive electronic countermeasures, which cover a range of techniques used with personnel, aircraft, ships, submarines, missiles and satellites to make them less visible to radar, infrared, sonar and other detection methods. It corresponds to military camouflage for these parts of the electromagnetic spectrum (Multi-spectral camouflage).
- In simple terms, stealth technology allows an object to be partially invisible to Radar or any other means of detection. This doesn't allow the object to be fully invisible on radar. All it can do is to reduce the detection range of an object or enemy platform. This is similar to the camouflage tactics used by soldiers in jungle warfare. Unless the soldier comes near you, you can't see him. Though this gives a clear and safe striking distance for the objects using it, there is still a threat from radar systems, which can detect stealth platforms.

Classification of Missiles

Classification

A missile is an intelligent unmanned rocket designed to carry the payload to a designated point with an aim of destroying the object/target. The missile is designed keeping in mind its target, trajectory, warhead, range, velocity and launch platform.

On the basis of Type

- **Cruise Missile:** A cruise missile is an unmanned self-propelled (till the time of impact) guided vehicle that sustains flight through aerodynamic lift for most of its flight path and whose primary mission is to place an ordnance or special payload on a target. They fly within the earth's atmosphere and use jet engine technology. These vehicles vary greatly in their speed and ability to penetrate defences. Cruise missiles can be categorised by size, speed (subsonic or supersonic), range and whether launched from land, air, surface ship or submarine. Depending upon the speed such missiles are classified as:
 - **Subsonic cruise missile:** It flies at a speed lesser than that of sound. It travels at a speed of around 0.8 Mach. The well-known subsonic missile is the American Tomahawk cruise missile. Some other examples are Harpoon of USA and Exocet of France.
 - **Supersonic cruise missile:** Supersonic cruise missile travels at a speed of around 2.3 Mach i.e. it travels a kilometre approximately in a second. The modular design of the missile and its capability of being launched at different orientations enable it to be integrated with a wide spectrum of platforms like warships, submarines, different types of aircraft, mobile autonomous launchers and silos. The combination of supersonic speed and warhead mass provides high kinetic energy ensuring tremendous lethal effect. BRAHMOS is the only known versatile supersonic cruise missile system which is in service.
 - **Hypersonic cruise missile:** Hypersonic cruise missile travels at a speed of more than 5 Mach. Many countries are working to develop hypersonic cruise missiles. BrahMos Aerospace is also in the process of developing a hypersonic cruise missile, BRAHMOSII, which would fly at a speed greater than 5 Mach.
 - **Ballistic Missile:** A ballistic missile is a missile that has a ballistic trajectory over most of its flight path, regardless of whether or not it is a weapon delivery vehicle. Ballistic missiles are categorized according to

their range, maximum distance measured along the surface of earth's ellipsoid from the point of launch to the point of impact of the last element of their payload. The missile carries a huge payload. The carriage of a deadly warhead is justified by the distance the missile travels. Ballistic missiles can be launched from ships and land based facilities. For example, Prithvi I, Prithvi II, Agni I, Agni II and Dhanush ballistic missiles are currently operational in the Indian defense forces.

On the basis of Launch Mode

- **Surface-to-Surface Missile:** A surface-to-surface missile is a guided projectile launched from a hand-held, vehicle mounted, trailer mounted or fixed installation. It is often powered by a rocket motor or sometimes fired by an explosive charge since the launch platform is stationary.
- **Surface-to-Air Missile:** A surface-to-air missile is designed for launch from the ground to destroy aerial targets like aircrafts, helicopters and even ballistic missiles. These missiles are generally called air defence systems as they defend any aerial attacks by the enemy.
- **Surface (Coast)-to-Sea Missile:** A surface (coast)-to-sea missile is designed to be launched from land to ship in the sea as targets.
- **Air-to-Air Missile:** An air-to-air missile is launched from an aircraft to destroy the enemy aircraft. The missile flies at a speed of 4 Mach.
- **Air-to-Surface Missile:** An air-to-surface missile is designed for launch from military aircraft and strikes ground targets on land, at sea or both. The missiles are basically guided via laser guidance, infrared guidance and optical guidance or via GPS signals. The type of guidance depends on the type of target.
- **Sea-to-Sea Missile:** A sea-to-sea missile is designed for launch from one ship to another ship.
- **Sea-to-Surface (Coast) Missile:** A sea-to-surface missile is designed for launch from ship to land based targets.
- **Anti-Tank Missile:** An anti-tank missile is a guided missile primarily designed to hit and destroy heavilyarmoured tanks and other armoured fighting vehicles. Antitank missiles could be launched from aircraft, helicopters, tanks and also from shoulder mounted launcher.

On the basis of Range

This type of classification is based on maximum range achieved by the missiles. The basic classification is as follows:

- Short Range Missile
- Medium Range Missile
- Intermediate Range Ballistic Missile
- Intercontinental Ballistic Missile

On the basis of Propulsion

• **Solid Propulsion:** Solid fuel is used in solid propulsion. Generally, the fuel is aluminium powder. Solid propulsion has the advantage of being easily stored and can be handled in fuelled condition. It can reach very high speeds quickly. Its simplicity also makes it a good choice whenever large amount of thrust is needed.

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- **Cryogenic:** Cryogenic propellants are liquefied gases stored at very low temperatures, most frequently liquid hydrogen as the fuel and liquid oxygen as the oxidizer. Cryogenic propellants require special insulated containers and vents which allow gas to escape from the evaporating liquids. The liquid fuel and oxidizer are pumped from the storage tanks to an expansion chamber and injected into the combustion chamber where they are mixed and ignited by a flame or spark. The fuel expands as it burns and the hot exhaust gases are directed out of the nozzle to provide thrust.

Category of Important Indian Missiles:

- Surface-To-Air Missiles
- Air-to-air missiles
- Surface-to-surface missiles
- Defence Missile
- Cruise Missiles
- Submarine Launched Ballistic Missiles
- Anti-Tank Missile

Recently India has launched several missiles which are considered as the landmark of achievement of the nation.

The list of important Indian Missiles is given below:

Air-to-air missiles	Name of the Missile	Type of Missile	Operational Range	Speed
	MICA	Air-to-Air Missiles	500 m to 80 km	Mach 4

	Astra Missile	Air-to-Air Missiles	80-110 km	Mach 4.5 +
	Novator K-100	Medium Range air-to-air missile	300–400 km	Mach 3.3
Surface-To-Air Missiles	Trishul	Short-Range surface to air missile	9 km	
	Akash Missile	Medium-range surface-to-air missile	30-35km	Mach 2.5 to 3.5
	Barak 8	Long-Range surface to air Missile	100 km	Mach 2
Surface-to-surface Missiles	Agni-I	Medium-range ballistic missile	700-1250 km	Mach 7.5
	Agni-II	Intermediate-range ballistic missile	2,000–3,000 km	Mach 12
	Agni-III	Intermediate-range ballistic missile	3,500 km – 5,000 km	5–6 km/s
	Agni-IV	Intermediate-range ballistic missile	3,000 – 4,000 km	Mach 7
	Agni-V	Intercontinental ballistic missile	5000 – 8000 Km	Mach 24
	Prithvi I	Short-Range Ballistic Missile	150 km	–
	Prithvi II	Short-Range Ballistic Missile	350 km	–
	Dhanush	Short-Range Ballistic Missile	350 – 600 km	–
	Shaurya	Medium-Range Ballistic Missile	750 to 1,900 km	–
	Prahaar	Short-Range Ballistic Missile	150 km	–
Cruise Missiles	BrahMos	Supersonic cruise missile	290 km	Mach 2.8 to 3 Mach

	BrahMos II	Hypersonic cruise missile	300km	Mach 7
	Nirbhay	Subsonic cruise missile	1,000 -1500 km	Mach 0.8
Defence Missile	Prithvi Air Defence	Exo-atmospheric Anti-ballistic missile	Altitude-80km	Mach 5+
	Prithvi Defence Vehicle	Exo-atmospheric Anti-ballistic missile	Altitude-30km	Mach 4.5
	Advanced Air Defence	Endoatmospheric Anti-ballistic missile	Altitude-120km	
Submarine Launched Ballistic Missiles	Ashwin	Ballistic Missile	150-200km	Mach 4.5
	Sagarika	Ballistic Missile	700 – 1900 Km	
	K-4	Ballistic Missile	3,500–5,000 km	
	K-5	Ballistic Missile	6,000 km	
Anti-Tank Missile	Amogha	Anti-Tank Guided Missile	2.8 km	
	Nag	Anti-Tank Guided Missile	4km	230 m/s
	Helina	Anti-Tank Guided Missile	7-8km	

Important facts- Missiles in India

1. The Integrated Guided Missile Development Program (IGMDP) was launched in 1983.
2. This program was launched with an agenda to develop five missile systems in the country – Trishul, Akash, Nag, Prithvi, and Agni-I.
3. These above missiles are of the intermediate-range surface-to-surface missile.
4. Tessy Thomas who is an Indian scientist and Director General of Aeronautical Systems and the former Project Director for Agni-IV missile in Defence Research and Development Organisation(DRDO) is known as the ‘Missile Woman’ of India.
5. Prithvi was the first Indian single staged liquid-fuelled surface-to-surface Missile.

List Of Scientific and Technological Developments 2015-16		
Discovery/ Development	Country/ Organization	Trivia/ Description

Space Research and Discovery

High-thrust cryogenic engine CE20	ISRO, India	Used in heavy launch vehicle GSLV Mk-III.
Astronomy satellite ASTRO-H	JAXA, Japan	Japan Aerospace Exploration Agency launched it from Tanegashima Space Centre.
Jupiter-like planets	UK	Exhibit properties similar to Jupiter.
Outer planet system	US,UK, Australia	It has 7,000 astronomical units (AU) width. (Neptune is 30 AU from the Sun)
Largest black hole in Milky Way	Keio University Japan	Signs of an invisible black hole with mass 105 times the mass of Sun.
IRNSS 1-E Satellite	ISRO, India	Polar Satellite Launch Vehicle, in its 33rd flight (PSLV C-31) launches the IRNSS 1-E, the next step in the Indian Regional Navigational Satellite System.
Galactic archaeology	India	Method to detect dwarf galaxies dominated by dark matter. Also explains ripples on outer disk of galaxy.
Presence of Neon gas in Moon's atmosphere	NASA	NASA spacecraft LADEE (Lunar Atmosphere and Dust Environment Explorer) confirmed the presence of Neon gas in Moon's atmosphere.
Indian satellite Cosmos 2510	Russia	1st satellite having early warning system. Will detect missiles heading towards Russia.

Water on Mars	NASA	Images by Mars Reconnaissance Orbiter (MRO) show dark, narrow streaks running downhill.
OSAT	ISRO, India	India's 1st dedicated multi wavelength space observatory.
l-m aircraft	NASA	A glider prototype that would be deployed on Mars for agency's missions.
Galaxy	Portugal	The brightest galaxy in the early universe, named after Cristiano Ronaldo.
s largest asteroid impact zone	Australia	Found in Warburton Basin of central Australia.
438b and Kepler 442b	USA	2 Earth-like planets spotted by Nasa's Kepler space telescope.
ational Waves Detected	LIGO, US	2 arms of the Laser Interferometer Gravitational-Wave Observatory in the US directly detected gravitational waves predicted by Einstein's General Theory of Relativity. Third arm planned in India.

Defence and Combat

Dhanush Ballistic Missile	India	It is a naval variant of India's indigenously-developed Prithvi missile. Missile has a strike range of 350km.
INS Astradharini	India	1 st indigenously-designed and built torpedo launch and recovery vessel.
INS Kochi	India	INDIGENOUSLY BUILT LARGEST DESTROYER WARSHIP.

Akash Missile	India	INDIGENOUSLY-BUILT SURFACE-TO-AIR MISSILE. STRIKE RANGE OF 25KM AND CAN CARRY WARHEADS UP TO 60KG.
BrahMos Supersonic Cruise Missile	India	SUCCESSFUL 48TH TEST FIRING OF BRAHMOS. HAS A RANGE OF 290KM AND A MACH 2.8 SPEED.
Akash Weapon System (AWS)	India	INDIGENOUSLY DEVELOPED AND INDUCTED INTO THE INDIAN ARMY.

Health and Medicine

ZikaVac	GenScript Biotech, India	World's first vaccine for Zika Virus.
BGR-34	India	1 st Ayurvedic anti-diabetic drug. BGR is acronym for Blood Glucose Regulator.
Artificial Liver Tissue	India	1 st artificial liver tissue using 3-D printing technology.
Mosquirix	UK	World's 1 st Malaria vaccine.
Cardiac Microphysiological System (Mini heart)	USA	Heart on a microchip using human stem cells.
		by Indian-origin scientist Anurag Mathur.
Treatment for Fungal Keratitis	CCMB Hyderabad, India	nanoparticle-based drug delivery method to fight Fungal Keratitis
DNA sequencing based blood test	USA	help diagnose Ebola & other pathogens.

Science and Technology

A new kind of 2D semiconducting material	USA	Made of tin & oxygen or tin monoxide (SnO). Material will be used in electronics.
NBeG 47	India	First machine harvestable chickpea variety. To address labour shortage & reduce hard work.
Elements 113, 115, 117 & 118	IUPAC	Added to 7 th Row of the Periodic Table by International Union of Pure and Applied Chemistry.
Pruthvi Chip	Prithvi Labs, India	Chip powers a system that can use TV White Space or wasted spectrum bandwidth to beam Internet to scores of households.
Quantum Dot (QD) Spectrometer	USA	Small enough to fit inside a smartphone camera.
		Spectrometers measure properties of light.
Leap Second 2015	India	30th June 2015 clocked 1 second longer as an extra second was added to the clocks world-wide at 23:59:59.
World's first water-based computer	India-America	Asynchronous computer that operates using the unique physics of moving water droplets.
World's first facial recognition ATM	China	ATM will not allow users to withdraw cash unless their face matches their IDs
Edge Web Browser	USA	Announced by Microsoft. Claimed to enhance user experience.

Research and Discovery

frog Ghatixalus magnus	India	Discovered in the high ranges of Idukki district in the Western Ghats of Kerala.
Himalayan Forest Thrush	China	The bird has been named Himalayan forest thrush Zoothera salimalii. The scientific name honors the great Indian ornithologist Sálim Ali.
Musa Indandamanensis	India	Sweet banana species. Bananas of this species are very sweet and are eaten by tribal people of the island.
4 new species of Fish; Puntius Nelsoni, Puntius Nigronotus, Systemus	India	es of Fish discovered in Kerala.
Chryseus and Systemus Rufus		
Butterfly called Banded Tit	India	species discovered in forests of Changlang, Arunachal Pradesh.
Snow Leopard	India	dangered snow leopards for the 1st time in the North Sikkim Plateau.
New tree frog genus	India	ew genus of tree hole- breeding frogs in the forests
Dracula Ant	India	a group of citizen scientists in the Western Ghats region of Kerala.
New species of Giant Tortoise named Chelonoidis donfaustoi	Galapagos islands	in the Galapagos weigh up to 250kg and live longer than 100 years.

World's longest Continental Volcanic Chain	Australia	of continental volcanoes. ost 2000 km along east coast.
Mount Aso Volcano	Japan	ive volcano of Japan. September 2015.
New fish species named Puntius Dolichopterus	India	m a small water stream n city of Kerala.
1st species of Yeti Crab named Kiwa tyleri	Antarctica	he first species of Yeti Crab in Antarctica in the ONE.
Blue whales	India	00 years Blue Whales were sighted off the coast of Maharashtra.
New species of fish called Pethia Striata	India	the Kudremukh National Park, Karnataka.
Maria Elena South (MES)	Chile	the Earth, Atacama Desert in Chile.
New Catfish Species Glyptothorax Senapatiensis	India	pecies in the Chindwin river drainage in Senapati district of Manipur.
Opah, world's first fully warm-blooded fish species	US, Australia	om National Oceanic and Atmospheric Administration discovered world's first fully warm- blooded fish species
New species of Geckos, Cnemaspis Adii	India	ruins of the World Heritage Site of Hampi, Karnataka.
Grey Hypocolius	India	he bird species and sole member of the genus Hypocolius.

Rare Spiders Martensopoda Sancto and Stenaelurillus Albus	India	long to the Sparassidae and Salticidae families.
2 bloom-forming algal species, Ulva Paschima	India	the west coast of India
Bast and Cladophora Goensis Bast		
Endangered forest owl, Athene Blewitti)	India	s to the typical owls' family, Strigidae that is on the verge of extinction.
World's smallest goanna lizard species	Australia	er Peninsula Goanna while its scientific name is is.
Plant Species Nepenthes Zygon	UK	most a decade and helping to keep down cockroaches.

1. List of Important Missiles of India

Prithvi Air Defense (PAD)	Defense Missile Exo-atmospheric Anti-ballistic missile	80 Km Altitude
Advanced Air Defence	Defense Missile Endo-atmospheric Anti-ballistic missile	30 Km Altitude
Prithvi Defense Vehicle (PDV)	Defense Missile Exo –atmospheric Anti- ballistic missile	120 Altitude
Akash	Surface to Air Missile Medium range surface to air Missile.	30 to 35 Km
Barak 8	Surface to Air Missile Long range surface to air Missile.	100 Km
Trishul	Surface to Air Missile Low level surface to air Missile.	0.5 Km to 9 Km
Pradyumna Ballistic Missile Interceptor	Surface to Air Missile	300 to 2,000 Km

or Prithivi Air Defense (PAD)		
Agni I	<u>Surface to Surface Air Missile</u> Medium Range Ballistic Missile	700 to 1250 Km
Agni II	<u>Surface to Surface Air Missile</u> Intermediate-range ballistic missile (IRBM)	2,000 to 3,000 Km
Agni III	<u>Surface to Surface Air Missile</u> Intermediate-range ballistic missile (IRBM)	3,500 to 5,000 Km
Agni IV	<u>Surface to Surface Air Missile</u> Intermediate-range ballistic missile (IRBM)	3,000 to 4,000 Km
Agni V	<u>Surface to Surface Air Missile</u> Intercontinental ballistic missile	5,000 to 8,000 Km
Agni VI	<u>Surface to Surface Air Missile</u> Four-stage intercontinental ballistic missile	8,000 to 12,000 Km
Prithvi I	<u>Surface to Surface Air Missile</u> Short Range Ballistic Missile (Tactical)	150 Km
Prithvi II	<u>Surface to Surface Air Missile</u> Short Range Ballistic Missile (Tactical)	350 Km
Prithvi III	<u>Surface to Surface Air Missile</u> Short Range Ballistic Missile (Tactical)	350 to 600 Km
Dhanush	<u>Surface to Surface Air Missile</u> Short Range Ballistic Missile (Tactical)	350 – 600 km
Prahaar (Pragati)	<u>Surface to Surface Air Missile</u> Short Range Ballistic Missile (Tactical)	150 km
Shaurya	<u>Surface to Surface Air Missile</u> Medium-Range Ballistic Missile (MRBM)	750 to 1900Km
Sagarika (K15)	<u>Submarine Launched Ballistic Missile</u>	700 to 1900Km
K4	<u>Submarine Launched Ballistic Missile</u>	3,500 to 5,000 Km
K5	<u>Submarine Launched Ballistic Missile</u>	6,000 Km

2. Important Missiles of India - Facts

In addition to the above here are some facts related to Missiles of India that you must know. Run through the points mentioned below to acknowledge the power of Indian Army.

- **Defence Research and Development Organisation (DRDO)** is the organisation responsible for the military's research and development.
- Former President Dr. APJ Abdul Kalam is also known as the "Missile Man of India"
- India is the first nuclear weapons country to have a no first use policy.
- Prithvi was the first missile to be built by India.
- BrahMos, the world's fastest cruise missile is developed jointly by India & Russia and named

after *after two rivers*, the Brahmaputra of India and the Moskva of Russia.

- Agni-V is India's longest-range missile to carry a nuclear warhead.
- "K" missiles are faster, lighter and stealthier and named after Dr. APJ Abdul Kalam.

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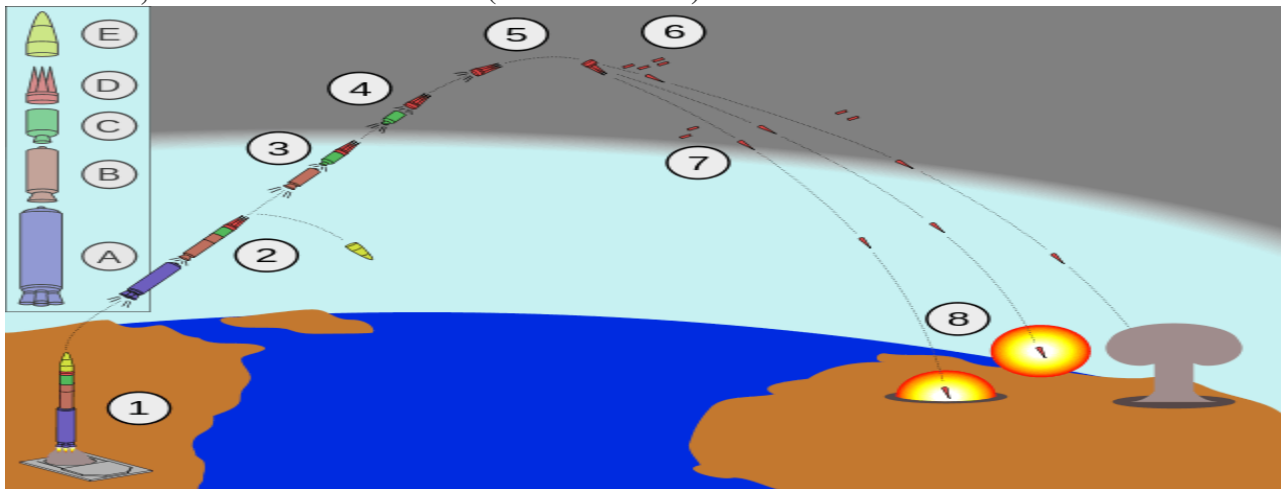
- Ballistic Missile vs. Cruise Missile
- Ballistic Missile
 - Types of ballistic missiles based on the range
- Cruise missile
 - Types of cruise missiles based on speed
- Differences between Ballistic Missile and Cruise Missile
- Integrated Guided Missile Development Programme (IGMDP)
- India's Missile Systems
- Prithvi Missiles
- Agni Missiles
- Anti-satellite weapons (ASAT)

Ballistic Missile vs. Cruise Missile

The terms 'ballistic missile' and 'cruise missile' appear in news articles wherever there is a missile test. It is essential for us to understand these terms to understand various Indian missile defence systems.

Ballistic Missile

- A ballistic missile follows a ballistic trajectory to deliver one or more warheads on a predetermined target.
- A ballistic trajectory is the path of an object that is launched but has **no active propulsion during its actual flight** (these weapons are guided only during relatively brief periods of flight).
- Consequently, the trajectory is fully determined by a given **initial velocity, effects of gravity, air resistance, and motion of the earth (Coriolis Force)**.



- Shorter range ballistic missiles stay within the Earth's atmosphere.
- Longer-ranged intercontinental ballistic missiles (ICBMs), are launched on a sub-orbital flight trajectory and spend most of their flight out of the atmosphere.

Types of ballistic missiles based on the range

- Short-range (tactical) ballistic missile (SRBM): Range between 300 km and 1,000 km.
- Medium-range (theatre) ballistic missile (MRBM): 1,000 km to 3,500 km.
- Intermediate-range (Long-Range) ballistic missile (IRBM or LRBM): 3,500 km and 5,500 km.
- Intercontinental ballistic missile (ICBM): 5,500 km +

Cruise missile

- A cruise missile is a guided missile (target has to be pre-set) used against terrestrial targets.
- It remains in the atmosphere throughout its flight.
- It flies the major portion of its flight path at approximately constant speed.
- Cruise missiles are designed to deliver a large warhead over long distances with high precision.

- Modern cruise missiles are capable of travelling at supersonic or high subsonic speeds, are self-navigating, and are able to fly on a non-ballistic, extremely low-altitude trajectory.

Types of cruise missiles based on speed

- Hypersonic (Mach 5): these missiles would travel at least five times the speed of sound (Mach 5). E.g. BrahMos-II.
- Supersonic (Mach 2-3): these missiles travel faster than the speed of sound. E.g. BrahMos.
- Subsonic (Mach 0.8): these missiles travel slower than the speed of sound. E.g. Nirbhay.

Differences between Ballistic Missile and Cruise Missile

Ballistic Missile	Cruise Missile
It is propelled only for a brief duration after the launch.	Self-propelled till the end of its flight.
Similar to a rocket engine.	Similar to a jet engine.
Long-range missiles leave the earth's atmosphere and reenter it.	The flight path is within the earth's atmosphere.
<ul style="list-style-type: none"> • Low precision as it is unguided for most of its path and its trajectory depends on gravity, air resistance and Coriolis Force. 	Hits targets with high precision as it is constantly propelled.
Can have a very long range (300 km to 12,000 km) as there is no fuel requirement after its initial trajectory.	The range is small (below 500 km) as it needs to be constantly propelled to hit the target with high precision.

- Heavy payload carrying capacity.

Payload capacity is limited.

Can carry multiple payloads

(Multiple Independently targetable Re-entry Vehicle)

Usually carries a single payload.

Developed primarily to carry nuclear warheads.

Developed primarily to carry conventional warheads.

E.g. Prithvi I, Prithvi II, Agni

I, Agni II and Dhanush missiles.

E.g. BrahMos missiles

Integrated Guided Missile Development Programme (IGMDP)

- IGMDP was conceived by Dr. A P J Abdul Kalam to enable India attain self-sufficiency in missile technology.
- IGMDP was conceived in response to the **Missile Technology Control Regime** that decided to restrict access to any technology that would help India in its missile development program.
- To counter the MTCR, the IGMDP team formed a consortium of DRDO laboratories, industries and academic institutions to build these sub-systems, components and materials.

Missile Technology Control Regime (MTCR)

- MTCR an informal grouping established in 1987 by Canada, France, Germany, Italy, Japan, the United Kingdom and the United States to limit the proliferation of missiles and missile technology.
- The MTCR seeks to limit the risks of proliferation of weapons of mass destruction (WMD).
- MTCR places particular focus on rockets and unmanned aerial vehicles capable of delivering a payload of at least 500 kg to a range of at least 300 km.
- The MTCR is not a treaty and does not impose any legally binding obligations.
- IGMDP was started in 1983 and completed in March 2012.

- Keeping in mind the requirements of various types of missiles by the defence forces, the development of five missile systems was taken up.
- 1. **Prithvi:** Short-range surface-to-surface ballistic missile (Prithivi means Earth Surface to Surface)
- 2. **Agni:** Intermediate-range surface-to-surface ballistic missile
- 3. **Trishul:** Short-range low-level surface-to-air missile
- 4. **Akash:** Medium-range surface-to-air missile (Akash means Sky Surface to Air)
- 5. **Nag:** Third generation anti-tank missile (Nag means Snake Nag slithers like a Snake to hit a tank!)
- After its success, the Agni missile program was separated from the IGMDF upon realizing its strategic importance.

India's Missile Systems

Missile	Type	
Astra	air-to-air	
Trishul		
Akash	surface-to-air	
Prithvi Air Defence (PAD)		
Nag	surface-to-surface Anti-tank missile	
Prahaar	surface-to-surface	SRBM
BrahMos	land, naval, air	Supersonic Cruise Missile
Nirbhay	land, naval, air	Subsonic Cruise Missile

K-15 Sagarika	underwater-to-surface	SLBM
Dhanush	sea-to-sea/surface	SRBM
Shaurya	surface-to-surface	SLBM

SLBM: Sub-marine launched ballistic missile

Missile	Features
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Astra	<ul style="list-style-type: none"> Astra is a beyond-visual-range (BVR) air-to-air missile (AAM). In terms of size and weight, the Astra is the smallest missile developed by the DRDO. It was envisaged to intercept and destroy enemy aircraft at supersonic speeds.
Trishul	<ul style="list-style-type: none"> Used as anti-sea skimmer (to fly low to avoid radar) from ships against low-flying attacks.
Akash	<ul style="list-style-type: none"> It has the capability to “neutralize aerial targets like fighter jets, cruise missiles and air-to-surface missiles” as well as ballistic missiles.
PAD	<ul style="list-style-type: none"> Anti-ballistic missile developed to intercept incoming ballistic missiles outside the atmosphere (exo-atmospheric).
Nag	<ul style="list-style-type: none"> 3rd generation anti-tank ‘fire and forget’ guided missile (lock-on before launch system) where the target is identified and

designated before the weapon is launched.

- Prahaar
 - High manoeuvrability.
 - Primarily a battlefield support system for the Army.
- BrahMos
 - It is a supersonic cruise missile developed as a joint venture between Indian and Russia.
 - It is the fastest supersonic cruise missile in the world.
 - It is the world's fastest anti-ship cruise missile in operation.
- Nirbhay
 - Subsonic missile which is ancillary (providing necessary support) to the BrahMos range.
- K-15
 - It forms the crucial third leg of India's nuclear deterrent vis-à-vis its submarine-launched ballistic missile (SLBM) capability.
- Sagarika
 - It was subsequently integrated with India's nuclear-powered Arihant class submarine.
- Dhanush
 - It is capable of carrying nuclear warheads.
 - It carries forward the legacy of the K-15 Sagarika.
- Shaurya
 - Surface-to-surface ballistic missile (SSM) variant of the K-15 Sagarika.
 - The nuclear capability of the missile enhances India's second-strike capability.
 - It reduces the dependence on the K-15 which was built with Russian assistance.

Prithvi Missiles

All the Prithvi variants are surface-to-surface SRBMs.

Name	Version	Range	Payload in kg
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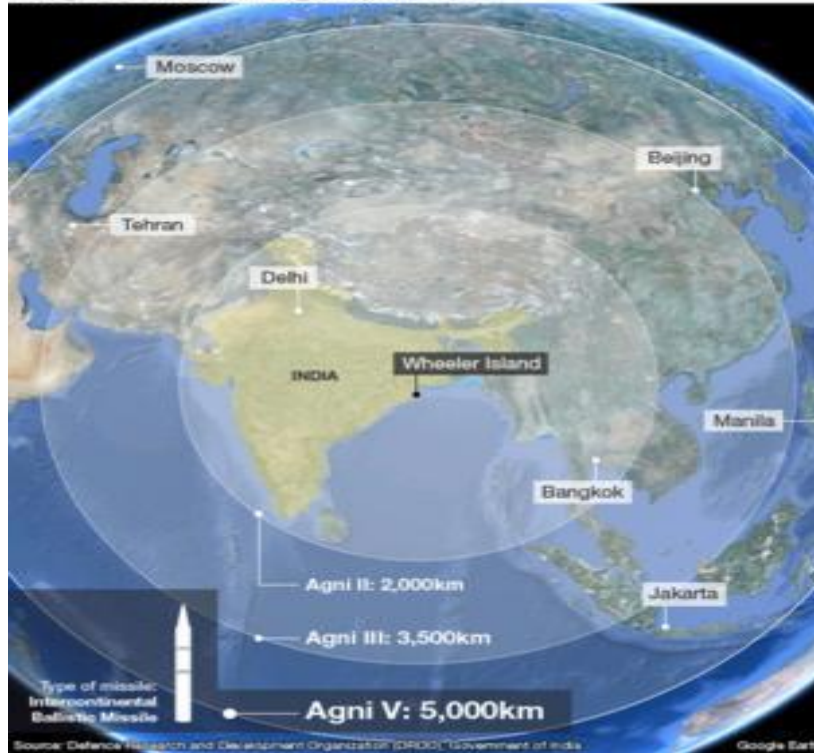
Prithvi I	Army version	150 km	1000
Prithvi II	Air force version	350 km	500
Prithvi III	Naval version	600 km	1000

Agni Missiles

Name	Type	Range	Payload in kg
Agni-I	MRBM	700 – 900 km	1,000
Agni-II	MRBM	2,000 – 3,000 km	750 – 1,000
Agni-III	IRBM	3,500 – 5,000 km	2,000 – 2,500
Agni-IV	IRBM	3,000 – 4,000 km	800 – 1,000
Agni-V	ICBM	5,000 – 8,000 km (Testing)	1,500 (3 – 10 MIRV)
Agni-VI	ICBM	8,000 – 10,000 km (Under development)	1,000 (10 MIRV)

MIRV: Multiple Independently targetable Re-entry Vehicle

Ranges of missiles Agni II, III and V



Anti-satellite weapons (ASAT)

- In March 2019, India successfully tested its ASAT missile.
- The ASAT missile destroyed a live satellite in Low Earth orbit (283-kilometre).
- As per DRDO, the missile is capable of shooting down targets moving at a speed of 10 km per second at an altitude as high as 1200 km.