Anti-Satellite Missile

Defence Research & Development Organisation
Ministry of Defence

ASAT on launch pad

Anti-Satellite Missile

Defence Research & Development Organisation
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2020

PM Modi congratulating the DRDO Scientists after the successful launch of ASAT.

Message

India's space programme is critical for India's security as well as its economic and social development. Our space assets comprise 102 spacecraft missions including satellites for communication, weather forecasting, earth observation, navigation, scientific research, and defence. It is important to safeguard these space assets through effective deterrence. Mission Shakti was an important milestone in this direction.

On March 27, 2019 India conducted an anti-satellite (ASAT) missile test from the Dr. A.P.J. Abdul Kalam Island launch complex. Through this Mission, India has successfully demonstrated its capability to intercept a satellite in outer space based on complete indigenous technology. India has joined an exclusive group of nations including USA, Russia and China, who have such capability.

Mission Shakti is the story of the challenges involved in developing the country's first anti-satellite missile through untiring efforts of our DRDO scientists who worked round-the-clock to meet the target in less than two years. The anti-satellite test was carried out without creating any space debris, which is in keeping with India's philosophy and ethos as a responsible member of the comity of nations.

I compliment DRDO for publishing this book to tell the story of Mission Shakti, particularly to young readers. Presented in a simple yet innovative style, as a conversation betweeen teenagers and their science teacher, it will educate young students about this remarkable Mission.

I am confident that the book will motivate young readers to take up careers that will help develop advanced technologies to safeguard India's national security.

Ajit Doval, KC
National Security Adviser

Chairman DRDO Dr. G Satheesh Reddy (center) just before the launch of ASAT

Message

27 March 2019 is the most memorable day for India when the country's Defence Research and Development Organisation (DRDO), successfully destroyed a satellite in space with its anti-satellite missile. Known as **Mission Shakti**, it demonstrated that India can defend her space, the 4th dimension of warfare after land, air and sea. With this success, India has become the fourth country alongside US, Russia and China to have this capability, an achievement every Indian should be proud of.

The success of the ASAT has shown what can be achieved by dedicated teamwork and determination. The mission was one of the most complex defence operation under taken by DRDO in which a missile launched from ground had to hit and neutrilise with pinpoint accuracy a fast-moving satellite in orbit hundreds of kilometres away. This was indeed a herculean challenge, which was met with extraordinary precision using highly innovative concepts and technologies.

DRDO has developed state-of-the-art technologies in the areas of missile systems, fighter aircraft, main battle tank, radar & electronic warfare systems, naval systems, air & missile defence systems and life science systems, etc., for achieving self-reliance in the area of defence.

Today a country's strength and prosperity lies mainly in its technological superiority and I hope this book on Mission Shakti will motivate and inculcate a spirit of science and technology in the children of the nation to meet India's future challenges.

Jai Hind.

Dr. G Satheesh Reddy
Secretary, Department of Defence R&D
and Chairman DRDO

ASAT launch on 27 March 2019

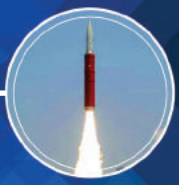
Preface

Outreach is an essential part of creating public awareness, especially when it comes to defence related developments like missiles. Mission Shakti was one such mission the success of which not only made the people of the country proud but also curious. Many people didn't quite understand what ASAT is and what had really happened? This was particularly so for young people, especially students in schools. To satisfy their curiosity and to make them understand the kind of challenges faced during Mission Shakti, DRDO decided to bring out a small book about the Mission.

Written in a lucid, non-technical language and profusely illustrated, the book brings out the salient features of Mission Shakti, explaining the intricacies of the complex mission and how success was achieved. A conversational format has been adopted to reduce monotony and make it a lively reading.

We hope the book will help make the reader understand the kind of challenges DRDO has to take up and how it tackles them to come out with flying colours, as it has done with the ASAT.

Dr Alka Suri
Director, DESIDOC



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A BIG MOMENT

There was great excitement and jubilation when Prime Minister Narendra Modi announced in a televised broadcast on 27 March 2019 that India has successfully neutrialised an Indian satellite in orbit with an indigenous anti-satellite missile. PM hailed the first test of such weaponry as a breakthrough establishing India as a military space power and described the event as a big moment for India. Something that all of us should be proud of.

"We are not just capable to defend ourselves on land, water and air, but now also in space. It shows the remarkable dexterity of India's outstanding scientists and the success of our space programme," he said. He congratulated everyone on the success of Mission Shakti.

With this success, India became the fourth country after the US, Russia and China to

DRDO's ASAT Missile Launch

have the anti-satellite (ASAT) missile technology. But many people didn't quite understand what had really happened. This was particularly so for young people, especially students in schools like 14-year-old Biplab and 13-year-old Aparna who studied in a government school.

Luckily, their physics teacher Mr. Ghosh was a keen observer of India's defence programme and had been following every new development in the field.

Naturally, Biplab and Aparna had no better person to satisfy their curiosity about the anti-satellite missile.

Next day, they went straight to Mr. Ghosh after reaching school. But their teacher had to take his classes. So, he told them to meet him after school hours.

Biplab and Aparna were so excited they couldn't think of anything else and eagerly waited for the end of school hours.

Immediately after the last bell of the school rang, the two rushed to the teachers' room to meet their physics teacher.

Biplab: Sir, tell us all about what an anti-satellite missile is and how it can destroy a satellite in orbit.

Ghosh: Well, children, that's a long story. Before I tell you about anti-satellite missile, you'll have to learn about satellites, how they work and much more.

To do that it'll be best if you can come over to my house on Sunday morning so that we can spend the whole day talking about it. We can have lunch together.

Biplab and Aparna (together): Thank you, Sir.

After Biplab and Aparna returned home, they told their parents about the Sunday visit to their physics teacher's house. Their parents were delighted that the children would learn about India's latest achievement.

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What is Space?

On Sunday morning, after breakfast, Biplab picked up Aparna from her house and together they went to Mr. Ghosh's house.

Ghosh: Welcome, children. Glad to see you. Let's go to my study where we'll talk.

After reaching the study, Mr. Ghosh spoke first.

Ghosh: Let's begin from the beginning. We know that satellites orbit in space. Do you know what space is?

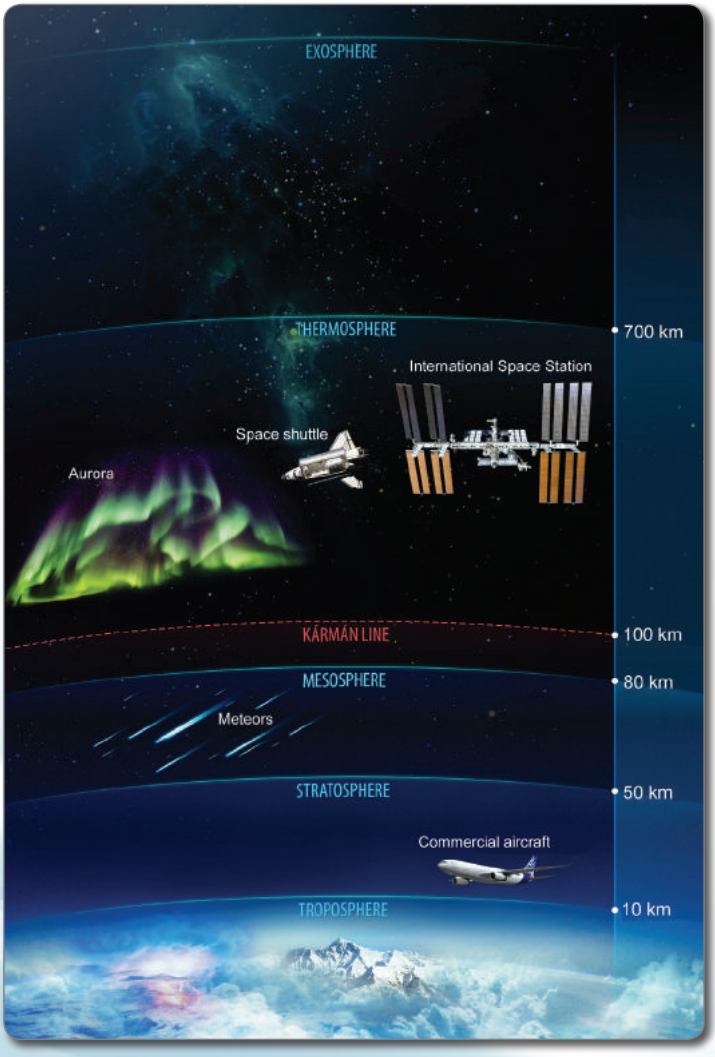
Biplab: I've only vague idea. Please tell us, Sir.

Ghosh: Our Earth is surrounded by an envelope of air that we call the atmosphere that sustains us. The atmosphere consists of a mixture of gases—mainly nitrogen, oxygen, carbon dioxide, water vapour and minute amounts of other gases. Space begins beyond the Earth's atmosphere.

Aparna: But Sir, where does space begin?

Ghosh: You know that the Earth's atmosphere is the densest near the ground and becomes thinner as we go up and that's why it's difficult to breathe at high atitudes.

Beyond 100 km from the ground, the atmosphere is so thin that it is like a vacuum. Although there is no sharp boundary, this is where space begins. This imaginary boundary has been named the 'Karman line'.



Layers of the atmosphere

Biplab: How far does space extend, Sir?

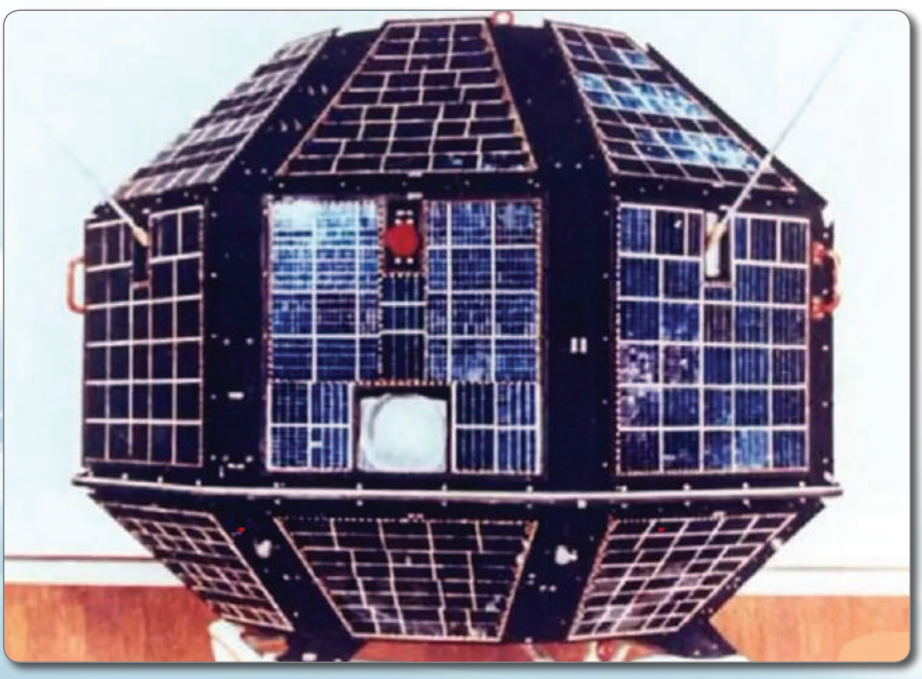
Ghosh: Beyond the Karman line, space extends up to as far as we can see. No one knows exactly how big space is, but we know that it extends to many trillions of kilometres. Remember, stars, planets, our solar system, galaxies, the Milky Way – all exist in space. And all artificial satellites move in space.

□□□□

Satellites

Biplab: Sir, what are satellites and how are they useful for us?

Ghosh: Let me first make one thing clear. By definition, a satellite is an object that moves around a larger object. You know our Moon is a satellite of Earth. Other planets of our solar system also have their own satellites. All these are natural satellites. But here we are not talking about natural satellites. Rather we are referring to manmade or artificial satellites which are placed in orbit around Earth.



Aryabhata, India's first satellite

Artificial satellites are used for all sorts of purposes. Satellites like the Hubble Space Telescope, the International Space Station, and the Russian Mir space station have helped scientists explore space in new and exciting ways.

Satellites contribute considerably to our well-being and enable us to achieve our objectives in new and innovative ways. Today it is estimated that there are more than 4,800 satellites in operation, owned by over 60 countries.

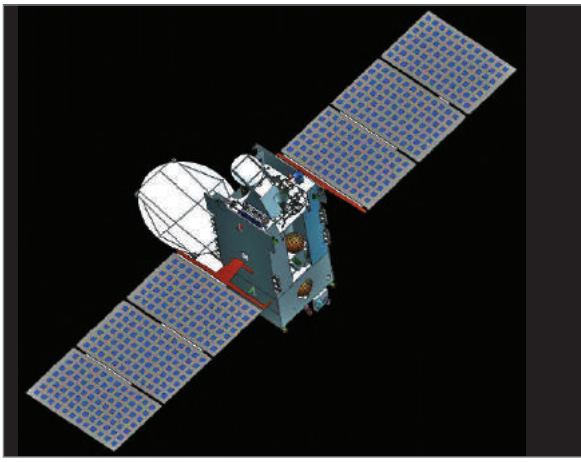
Aparna: We hear about communication satellites, remote sensing satellites and many others. How do they differ from each other?

Ghosh: Satellites can be of many types and they are used for diverse purposes such as long-distance telecommunication, television networking, Earth observation, weather observation and monitoring, and much more. And to serve their specific purposes they have to be placed in certain specific types of orbits.

Communication satellites like our INSATs and GSATs are placed in the geostationary orbit about which I'll tell you later. It is by virtue of these communication satellites that we can watch cricket matches and other

events live from any part of the world on TV and listen to radio programmes in our favourite language through DTH channels, sitting in our homes.

INSAT-4B communication satellite

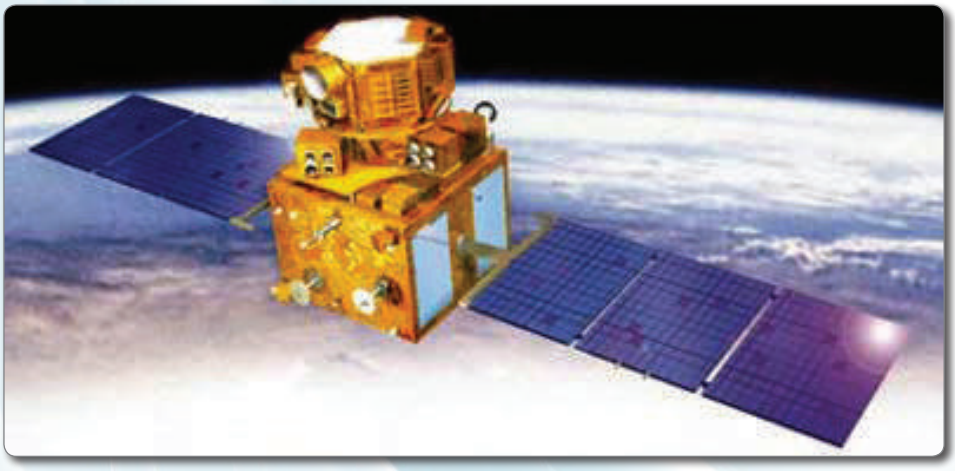


GSAT-31 communication satellite

Aparna: What do remote sensing satellites do?

Ghosh: Remote sensing satellites are a special kind of satellites which are used for the Earth observation from space. They carry special cameras and sensors to scan and image the ground below from space in different wavelengths with high resolution. Remote sensing satellites are routinely used to gather cartographic data for making detailed maps, detect and monitor crop diseases and large forest fires, locate fish schools in oceans, and track the growth of cities and changes in farmland or forests over several years or even decades.

Biplab: Sir, we have heard about spy satellites. What are they?



IRS-P6, Resourcesat, remote sensing satellite

Ghosh: Spy satellites are primarily reconnaissance satellites – Earth observation satellites or communications satellites deployed for intelligence gathering applications. These satellites are usually placed in a low Earth orbit at an altitude of 300-1200 km.

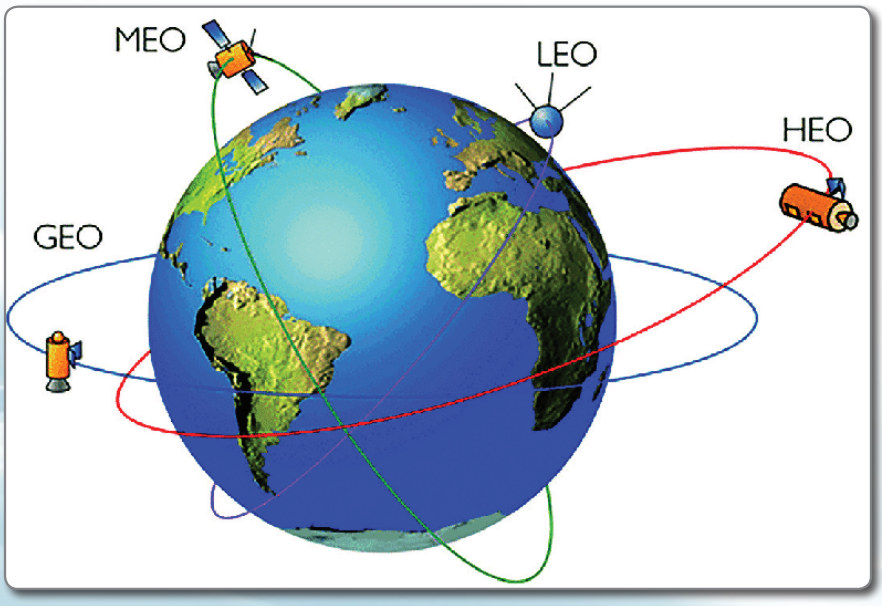
A military satellite is an artificial satellite used for a military purpose. The most common missions are intelligence gathering, navigation and military communications. Using these satellites, the armed forces can talk secretly, gather intelligence and navigate troops without the enemy's knowledge. The first military satellites were photographic reconnaissance missions.

Satellite orbits

Now let me tell you something about satellite orbits. I've told you that different types of satellites are deployed in different types of obits. Aparna, can you tell me how many types of orbits are there for artificial satellites?

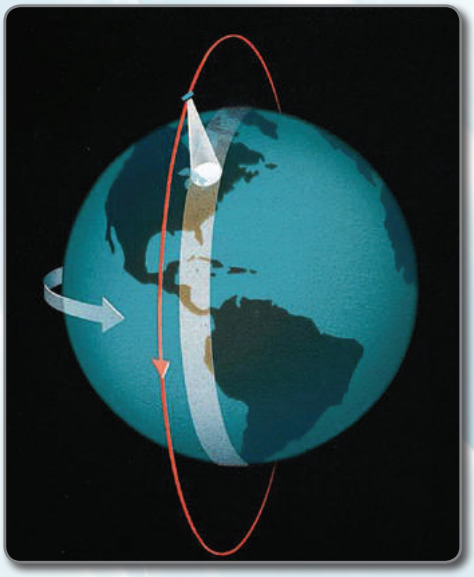
Aparna: I don't have much idea, Sir. Please tell us.

Ghosh: There are essentially three types of Earth orbits: low Earth orbit (LEO), medium Earth orbit (MEO), and high Earth orbit (HEO). Low Earth orbit ranges from 150 to 2,000 km in height; medium Earth orbit from 2,000 to 35,000 km and high Earth orbit from 35,780 km and above.

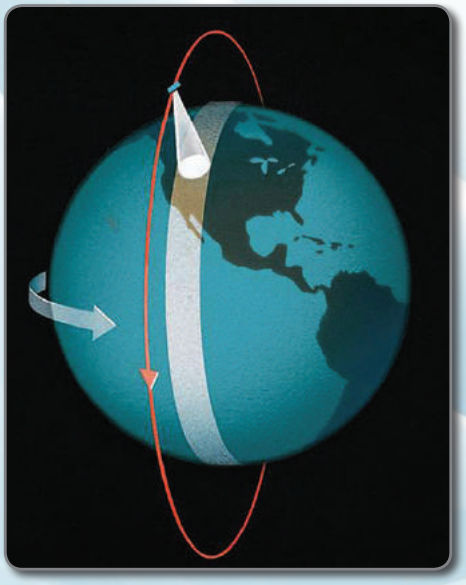


Orbits of artificial satellites

The polar orbit is a special type of low Earth orbit oriented in a north-south direction where the satellite passes over both the poles. Polar orbits are used mainly for remote sensing satellites.



Polar orbits



A satellite in Earth orbit at a height of 35,780 km takes just about 24 hours to complete one revolution and the orbit is called a geosynchronous orbit. There is a

special geosynchronous orbit that lies directly above the equator which is called the geosynchronous equatorial orbit (GEO) or geostationary orbit.

Orbit	Altitude	Uses
Low Earth orbit (LEO)	Up to 2,000 km	- Intelligence, surveillance, and reconnaissance - Human spaceflight
Medium Earth orbit (MEO)	Approx. 2,000 to 35,000 km	- Communications - Position, navigation, and timing
Highly elliptical orbit (HEO)	Up to 2,000 km at perigee (nearest to Earth) Approx. 40,000 km at apogee (farthest from Earth)	- Communications - Intelligence, surveillance, and reconnaissance - Missile warning
Geosynchronous equatorial orbit (GEO) or geostationary orbit	Approx. 35,780 km	- Communications - Intelligence, surveillance, and reconnaissance - Missile warning

The height of the orbit or distance between a satellite and Earth's surface determines how fast the satellite moves around the Earth. An Earth-orbiting satellite's

motion is mostly controlled by Earth's gravity. The closer a satellite is to the ground, the stronger is the pull of gravity and faster does the satellite move.

Aparna: Sir, how much time does a satellite take to complete one revolution around Earth?

Ghosh: It depends on the type of orbit. A satellite in low Earth orbit may take 90-100 minutes while a satellite in middle Earth orbit or high elliptical orbit may take much longer.

An interesting feature of the geostationary orbit is that a satellite in this orbit takes just about 24 hours to complete one revolution in the west-to-east direction – the same time it takes Earth to rotate once on its axis. As a result, the satellite appears stationary in the sky from the ground.

Remember, since a satellite in the geostationary orbit appears stationary in the sky from ground, dish antennas on the ground can be pointed in a fixed direction to maintain communication with the satellite without the need to turn it to follow the satellite in the sky. This is a big advantage of using satellites in the geostationary orbit for communication.

□□□□

Missiles

Aparna: Sir, what is the difference between missiles and rockets?

Ghosh: Aparna, missiles are also a kind of rockets and can have stages including solid and liquid stages. But missiles are not used to launch satellites; they are mostly used as a weapon used to attack and destroy an enemy target far away, especially in a war.

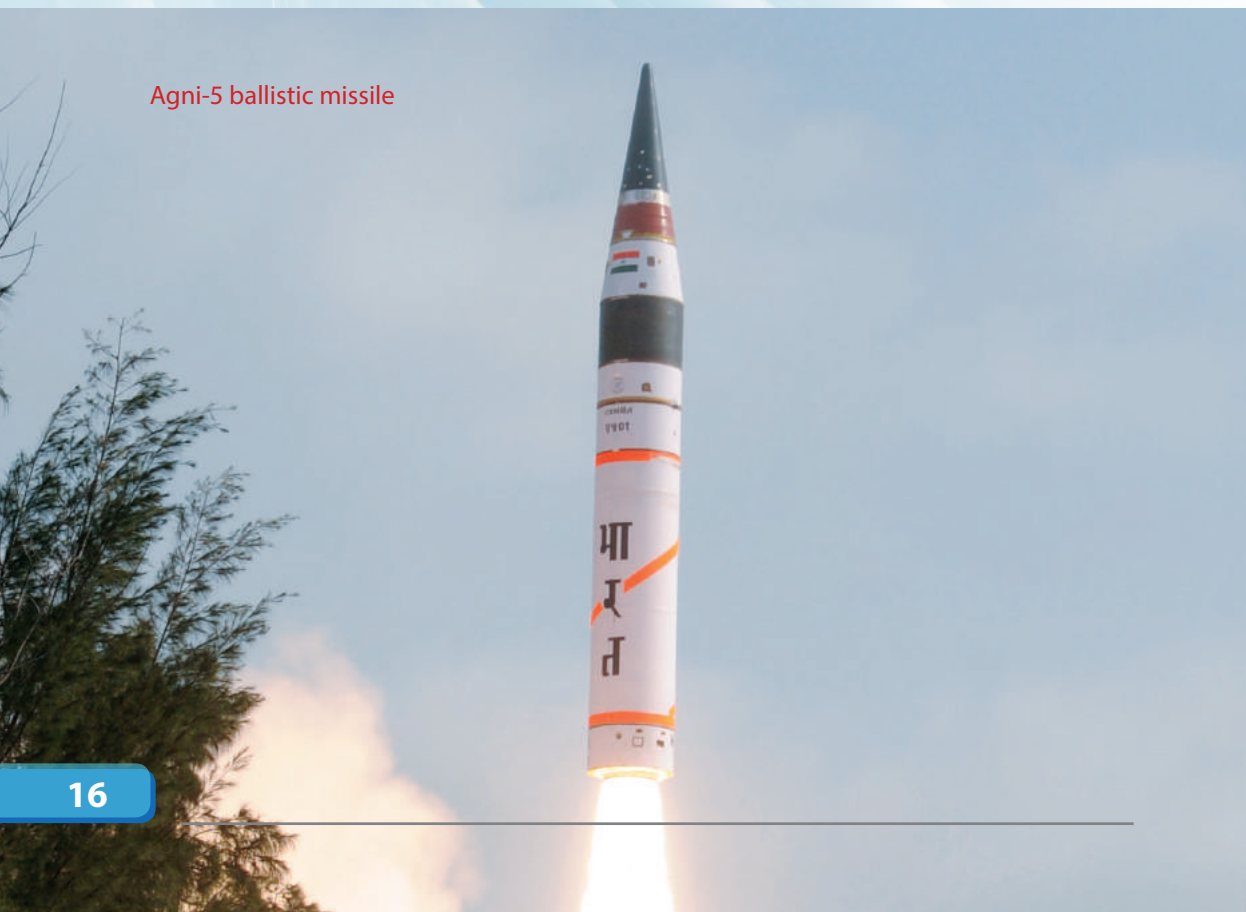
Missiles are mostly used to target and destroy enemy's asset on land, in air or at sea. Depending on the way they are used, missiles can be classified into several categories:

- Surface-to-surface missile
- Surface-to-air missile
- Air-to-surface missile
- Air-to-air missile
- Anti-tank missile
- Cruise missile
- Submarine launched missile
- Anti-ballistic missile
- Anti-satellite missile

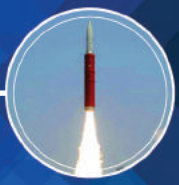
India builds all these types of missiles for its defence forces.

Biplab: Sir, what is the difference between a ballistic missile and a cruise missile?

Ghosh: A ballistic missile is a missile which is initially powered and guided but mostly falls under gravity with increasing speed on to its target. During flight a ballistic missile goes up very high and may enter space and re-enter the atmosphere before hitting the target. It is used to deliver one or more warheads on a predetermined target on land.



Agni-5 ballistic missile



A cruise missile, on the other hand, is a guided missile with wings that remains in the atmosphere throughout flight and flies the major portion of its flight path at almost constant speed. Cruise missiles are designed to deliver a large warhead over long distances with high precision.

BrahMos air launched

Biplab: Sir, who builds missiles in India?

Ghosh: In India, missile development was started under the Integrated Guided Missile Development Programme (IGMDP) – a Ministry of Defence programme for research and development of a comprehensive range of missiles. The project was started in 1982 under the leadership of Dr. A.P.J. Abdul Kalam, popularly known as the Missile Man of India, who later became President of India.

Missile development has been a major activity of the Defence Research and Development Organisation (DRDO) since 1982. Its prime responsibility has been to do research in advanced technology to develop the state-of-the-art weapons for our armed forces so that we have decisive edge over our adversaries. DRDO has been working towards enhancing self-reliance in defence systems in accordance with the requirements laid down by our army, air force and navy.

Akash surface-to-air missile

Astra air-to-air missile

Nag anti-tank missile

Aparna: Sir, what are all the missiles developed by DRDO?

Ghosh: Variety of missiles developed by DRDO are:

Surface-to-Surface Missiles

Name	Type	Range
Agni-I	Medium-range ballistic missile (MRBM)	750+ km
Agni-II	Intermediate-range ballistic missile (IRBM)	2,000+ km
Agni-III	Intermediate-range ballistic missile (IRBM)	3,500+ km
Agni-IV	Intermediate-range ballistic missile (IRBM)	4,000+ km
Agni-V	Intercontinental ballistic missile (ICBM)	5,500+ km
Prithvi I	Short-range ballistic missile	150+ km
Prithvi II	Short-range ballistic missile	350+ km
Dhanush	Short-range ballistic missile	350+ kg
Prahaar	Short-range ballistic missile	150 km
Shaurya	Medium-range ballistic missile	750+ km

Surface-to-Air Missiles

Name	Type	Range
Akash	Medium-range surface-to-air missile	30 km
QRSAM	Medium-range surface-to-air missile	30 km
LRSAM/ MRSAM	Long range surface to air missile	70 km

Air-to-Air Missiles

Name	Type	Range
Astra	Short and long-range air-to-air missile	20 km (short-range) and 80–110 km (long-range)

Anti-Tank Missiles

Name	Type	Range
Nag	Anti-tank guided missile	4 km
Helina (Helicopter launched Nag)	Anti-tank guided missile	7-8 km
Man-portable ATGM	Anti-tank guided missile	2.8 km

Cruise Missiles

Name	Type	Range
Nirbhay	Subsonic cruise missile	1,000 -1,500 km
BrahMos	Supersonic cruise missile	290 km
BrahMos Air launched	Supersonic cruise missile	300 km

Submarine Launched Ballistic Missiles

Name	Type	Range
Sagarika (K-15)	Ballistic missile	700+ km
K-4	Ballistic missile	3,500+ km
K-5	Ballistic missile	5,000+ km

Anti-Ballistic Missiles

Name	Type	Target Class
PDV	Exo-atmospheric	IRBM
AAD	Endo-atmospheric	IRBM

Akash: Sir, now tell us more about Mission Shakti.

Ghosh: Yes, I'll do. But before that let's have lunch.

□□□□

MISSION SHAKTI

Ghosh: Children, you may know that till now, war meant fighting on land, in air or at sea. As you've seen, India has developed a variety of missiles for fighting these wars. Today, space has become one of the new frontiers of national defence. So, there is another dimension to safeguard against enemies and that is space. And it is to safeguard our space assets, especially our satellites, that Mission Shakti was conceived.

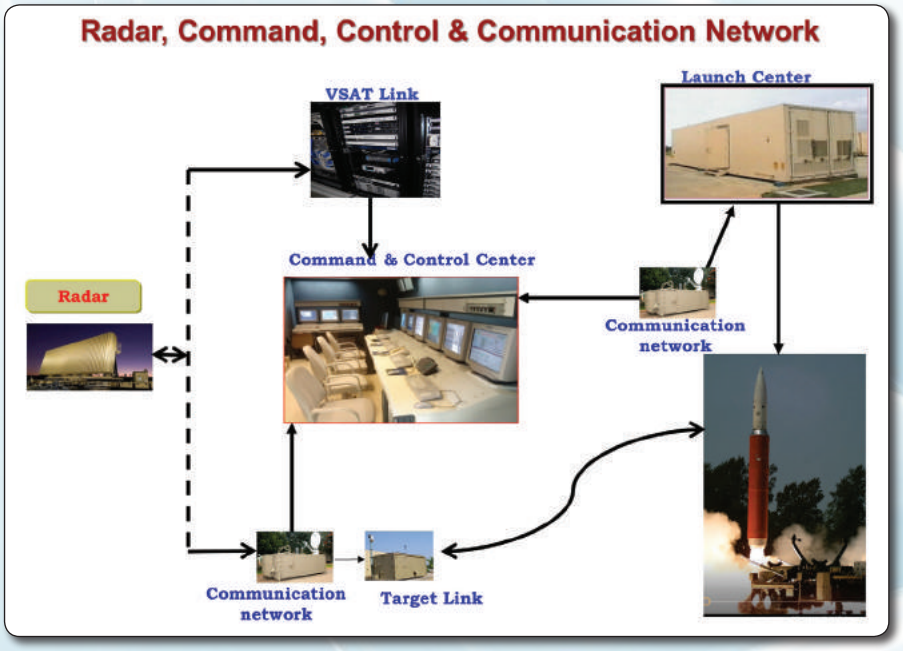
In 2014, Prime Minister Narendra Modi asked our defence scientists to work on futuristic deterrence technologies. He insisted that everything for developing them must be done within the country. We should not be dependent on any other country; it should be 100% Indian. That is how Mission Shakti was born.

Aparna: Sir, please tell us about anti satellite weapons.

Ghosh: Anti-satellite weapons can be broadly of two types known as 'Soft kill' and 'Hard kill'. The 'Soft kill' option includes the use of electronic warfare and/or directed energy weapons technologies such as the use of lasers to temporarily or permanently damage the enemy satellite. The 'Hard kill' option includes the use of missile interceptors to physically destroy the enemy satellite.

DRDO decided to go for the second option and utilise the experience gained, and the technology and systems developed as part of the Indian Ballistic Missile Defence Programme for the design and development of the Indian ASAT system.

DRDO had to do extensive groundwork to prepare for the mission, which included setting up multiple ground radar sensors, mission control centres (MCC), launch control centres (LCC), launchers, and hit-to-kill capable missile interceptors.



Weapon system configurations

The ASAT system was finally configured with long-range boosters and hit-to-kill vehicle along with the required weapon system elements like radars, command, control, communications, computers and intelligence (C4I), and launchers.

Biplab: When did work on India's anti satellite missile start?

Ghosh: The project got the official go-ahead towards the end of 2016 and work started in early 2017. The missile hardware/software was developed by DRDO work centres and nearly 150 scientists worked round the clock to reach the intended launch date target. Due to the sensitive nature of the project, utmost secrecy was maintained, and work was initiated in a very low profile disguised as another routine long-range ballistic missile target mission. Work continued unabated, and in a span of just two years after receiving the go-ahead, DRDO came out with India's first anti satellite or ASAT missile.

In fact, the project was implemented in the fastest time-frame possible and it showed DRDO's capability in carrying out such programmes. The technology used has been completely developed indigenously.

In the meantime, to have a satellite in orbit ready for the ASAT missile test, ISRO was asked to launch a satellite for defence application. The satellite was launched by ISRO on 24 January 2019 as a regular customer launch, but they did not know the specific purpose of the mission. The dimension of the satellite was chosen such that it replicated a typical adversary's defence satellite.

Aparna: It must have been a quite difficult task to make the ASAT missile hit the satellite because satellites in orbit move very fast.

Ghosh: You're right, Aparna. It was indeed a very complex mission.

You know that targets on land, in air or at sea are either stationary or slow-moving. So, hitting them even from a long distance is not very difficult. But here we were dealing with a satellite in orbit moving extremely fast – about 8 km per second at a height of a few hundred kilometres.To be successful, the missile, travelling at a speed of more than 3 km per second, which makes relative velocity between target and missile 11 km/sec, had to hit a small and fast-moving satellite target precisely in the middle at that distance. To do that, the satellite's position in orbit had to be computed with extreme precision and ASAT missile launch at

the right moment from ground so that the paths of the two intersect. Any error in computing the position of the target satellite and its velocity before and after the missile launch would make the missile miss the target. This was indeed a colossal challenge, which the DRDO scientists accepted and accomplished with extraordinary precision.

Biplab: Sir, what are the critical technologies of the ASAT system?

Ghosh: To be able to perform its assigned task, the ASAT requires powerful rocket engines capable of generating huge velocities. It also needs: Powerful rocket motors, capable of putting the kill vehicle into the orbital heights. Hit-to-kill capability with: Imaging Infrared Seeker; Divert and Attitude Control System; High-accuracy Inertial Navigation System; Onboard data receivers; and long-range radars, command, control and communication systems with wide area network.

I must tell you that the ASAT missile is an interceptor missile, which means it is used to stop something on the way, in this case a satellite in orbit. DRDO calls it 'Ground launched ASAT interceptor'. The ASAT missile is a newly developed 13-metre-tall three-stage interceptor missile. The first stage and second stage of

the missile use solid propellant rocket motors and the third stage uses liquid fuel.

Full Missile

Second Stage rocket and Kill Vehicle

Kill Vehicle

Missile on launcher

Biplab: Sir, after launch, how did the missile reach the fast-moving target satellite with such an accuracy to hit it?

Ghosh: The amazing accuracy was achieved by using an advanced anti-satellite hit-to-kill guidance & control technology consisting of the intelligent guidance and control algorithms/logics, state-of-the-art sensors like imaging infrared seeker, inertial navigation system and fast response divert and attitude control system to name a few.

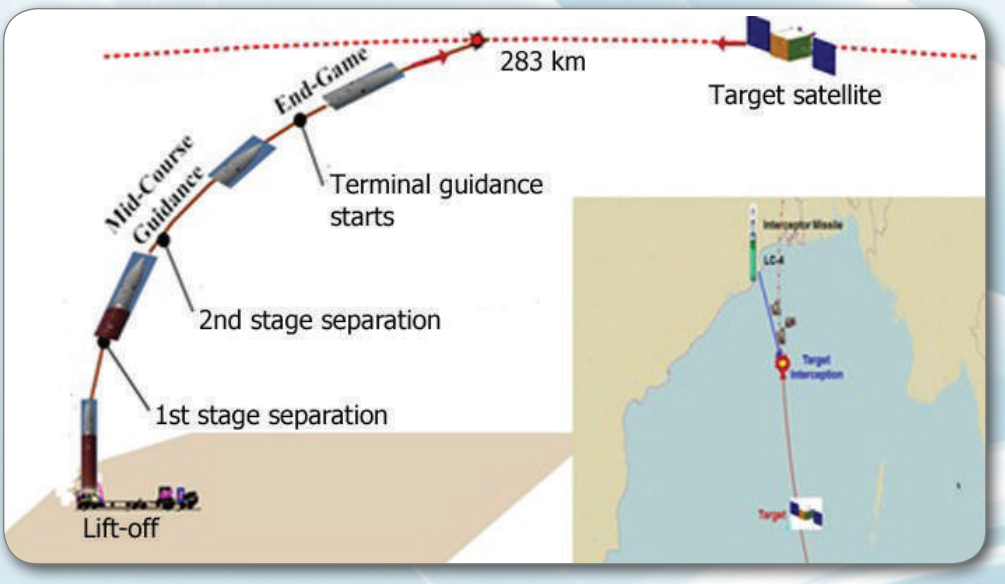
Biplab: But how does the ASAT system engage the satellite?

Ghosh: To engage the satellite, it has first to be detected. Radars are used for this purpose. The radar sends a pulse of radio waves into space and waits for the echo after the pulse hits the satellite and bounces off it. Based on the time difference between the instant a pulse is sent and the instant it is received back, the distance of the satellite can be computed, like we do with sound echoes. The direction of the satellite is given by the direction of the echo received. By using this distance and direction information, the satellite velocity can be computed. This data is then sent to the Command & Control Centre where a huge set of software processes

it and finds out if it is an enemy satellite or any other body. If it turns out to be an enemy satellite, then the software computes when to fire the ASAT missile. This is very critical because the speed of the satellite is close to 8 km per second and it is thousands of kilometres away when the missile is fired; any miscalculation could mean the missile completely missing the target satellite.

Biplab: What happens after the ASAT missile lifts off?

Ghosh: After liftoff, the rocket boosters give enough thrust so that the missile can accelerate and attain the desired speed to reach to the target on time. All through

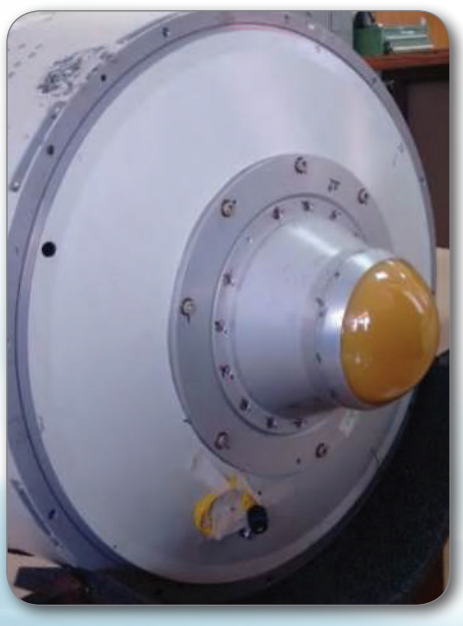


DRDO ASAT missile trajectory

this period, the ground radar sends the data to the missile in flight. The missile has a guidance and control system, which uses the satellite's position and velocity information given by the radar in real time to steer the missile on a collision course with the satellite. After the rocket motors burn out, they are separated and only the top portion of the missile called 'kill vehicle' remains, which goes and directly hits the satellite.

Aparna: Sir, what is a kill vehicle and how does it work?

Ghosh: The kill vehicle is the top portion of the missile, which can steer itself and collide with the satellite directly without the use of any explosive. The kill vehicle is like a human being in every respect. It has eyes called 'Imaging Infra-red (IIR) Seeker'. The only difference between our eyes and the IIR seeker is that our eyes sense the visible light whereas the IIR seeker senses the infrared light emitted by the satellite. As you know, infrared light is emitted by all bodies with temperature above absolute zero, that is, –273 degrees Celsius.



Imaging Infra-red seeker

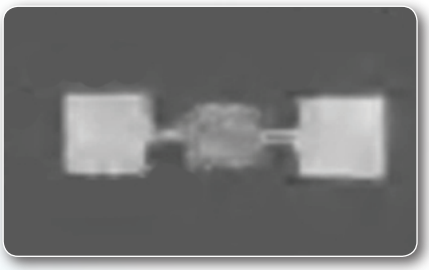
The IIR seeker continuously tracks the satellite and passes this information to the brain called on-board computer (OBC). The OBC receives the satellite data from the IIR seeker and information about the kill vehicle's position and velocity from another system called Inertial Navigation System (INS). The INS is a system, which tells the OBC where the kill vehicle is and which way it is looking. The OBC has the most advanced and intelligent software like our brain and processes the data from IIR and INS to find exactly which way to steer the kill vehicle. We need a physical system/force to move the kill vehicle much like the muscles that move our body as per the commands from our brain. This job is done by the DACS (Divert and Attitude Control System), which consists of four liquid rocket engines for moving the kill vehicle left-right-up-down and eight small rockets at the back of the kill vehicle to orient it in the desired direction. The DACS is an ultra-fast response system and executes the command from OBC in just $^{1}/_{100}$th of a second and moves the kill vehicle into the desired direction. In the last few seconds, the kill vehicle moves and adjusts its path nearly 50 to 100 times a second to hit the satellite exactly in the middle of it with a relative velocity of 11 km/sec. Can you believe that?

Now you can understand the complexity and the

Divert and Attitude Control System

accuracy required to hit a satellite that is moving at a speed of 8 km in a second. Just to give you an idea the speed of the satellite is so swift that it can travel over entire India from Kashmir to Kanyakumari by the time you finish your cup of tea, and the ASAT missile has to hit it exactly in the middle directly with utmost precision within 3 minutes.

Although it may seem impossible, this remarkable feat was achieved by DRDO on 27 March 2019. Only three other countries in the world have so far been able to pull off this kind of a complex mission.



Infrared seeker image of target satellite

I must mention here that in the present case, the ASAT missile destroyed the target by 'kinetic kill' – that means, by directly hitting the satellite with force and not by using any explosive. This called for many critical high-end technologies, which DRDO has developed completely indigenously.

Aparna: Which satellite did our ASAT missile destroy, Sir?

Ghosh: The target satellite was an active Indian satellite "Microsatellite-R", which was launched by ISRO on 24 January 2019 specifically for this purpose. The 18-tonne missile hit the 740-kg satellite, flying in a low Earth orbit at a height of 283 km, bang in the middle, barely three minutes after its launch.

I would like to tell you that the ASAT missile used during the test had the capability to hit satellites up to a height of 1,000 km in space, but the test was intentionally done at a lower level in order to ensure that debris from the hit fall back to earth very fast – within weeks – and do not pose any risk for other satellites. Mission Shakti was primarily aimed at demonstrating that India possessed the capability to intercept and kill satellites, which could

act as deterrent against space-based threats.

Biplab: I've read in some newspapers that by using ASAT missile to destroy a satellite in space, India may be entering an arms race in space. Is it true?

Ghosh: As I have mentioned before, the government has stated clearly that it has no intention of entering into an arms race in outer space. The country has always maintained that space must be used only for peaceful purposes. The government has also stated that India is against the weaponisation of outer space and support international efforts to reinforce the safety and security of space-based assets.

India believes that outer space is the common heritage of humankind and it is the responsibility of all space-faring nations to preserve and promote the benefits flowing from advances made in space technology and its applications for all.

Biplab: Sir, what is the international law on weapons in outer space?

Ghosh: The principal international treaty on space is the 1967 'Outer Space Treaty'. India is a signatory to this treaty and ratified it in 1982. The Outer Space Treaty prohibits only weapons of mass destruction in outer space, not ordinary weapons. Moreover, the

ASAT missile was not a space-based weapon but was launched from ground. Besides, as already stated, the test was not directed against any country. India's space capabilities do not threaten any country and nor are they directed against anyone.

At the same time, India is also committed to ensuring the country's national security interests and is alert to threats from emerging technologies. The capability achieved through the ASAT missile test provides credible deterrence against threats to our growing space-based assets.

According to a defence forces, in an era where defence forces rely on satellites for different aspects of security, including intelligence gathering, having ASAT missile capability sends a strong signal to adversaries.

Ghosh: Biplab and Aparna, I hope by now you have understood all about Mission Shakti. You must remember, in today's world, space-based capabilities of a country provide integral support to military, commercial, and civilian applications. Long-standing technological and cost barriers to space are falling, enabling more countries and commercial firms to participate in satellite construction, space launch, space exploration, and human spaceflight.

But we have to remember, although advancements in space technology are creating new opportunities, at the same time new risks for space-enabled services have emerged. In order to safeguard our interest in outer space, it was a must for India to have counter-space technologies. The Mission Shakti was a demonstration of our capability to safeguard our space assets through the means of deterrence.

Biplab and Aparna (*together*)**:** Thank you Sir, for telling us all about Mission Shakti. It's really a great achievement to ensure the protection of our nation from nefarious activities by enemy.

□□□□

DRDO DEVELOPED MISSILES

Clockwise from left top : Helicopter launched Nag; Ship launched BrahMos; LRSAM; Endo-Atmospheric Interceptor Missile; Nirbhay subsonic missile; Prahar short range ballistic missile; QRSAM; Man portable anti-tank guided missile

Agni IV

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