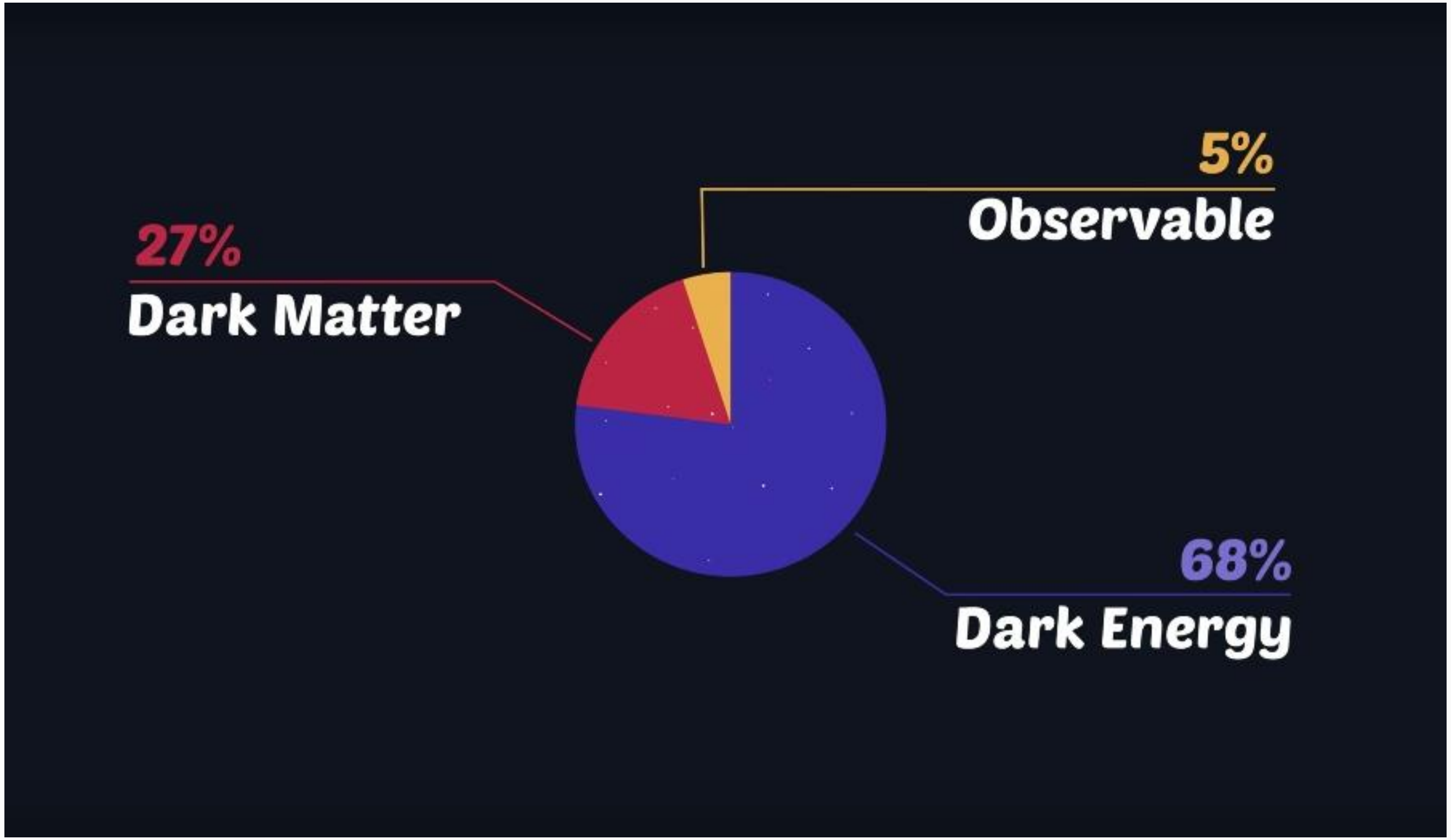
Science & Technology

50 Important Topics - 2024	
Scheduled Date	**Subject**
01/04/24	Economy
02/04/24	Science & Technology
03/04/24	Environment & D.M.
04/04/24	Science & Technology
05/04/24	Environment & D.M.
06/04/24	------------
07/04/24	------------
08/04/24	Economy
09/04/24	Science & Technology
10/04/24	Economy
11/04/24	English
12/04/24	International Relations
13/04/24	------------
14/04/24	------------
15/04/24	Geography
16/04/24	Polity & Governance
17/04/24	Polity & Governance
18/04/24	Geography
19/04/24	Polity & Governance
20/04/24	Maths
21/04/24	------------
22/04/24	Reasoning
23/04/24	Environment & D.M.
24/04/24	Social Schemes

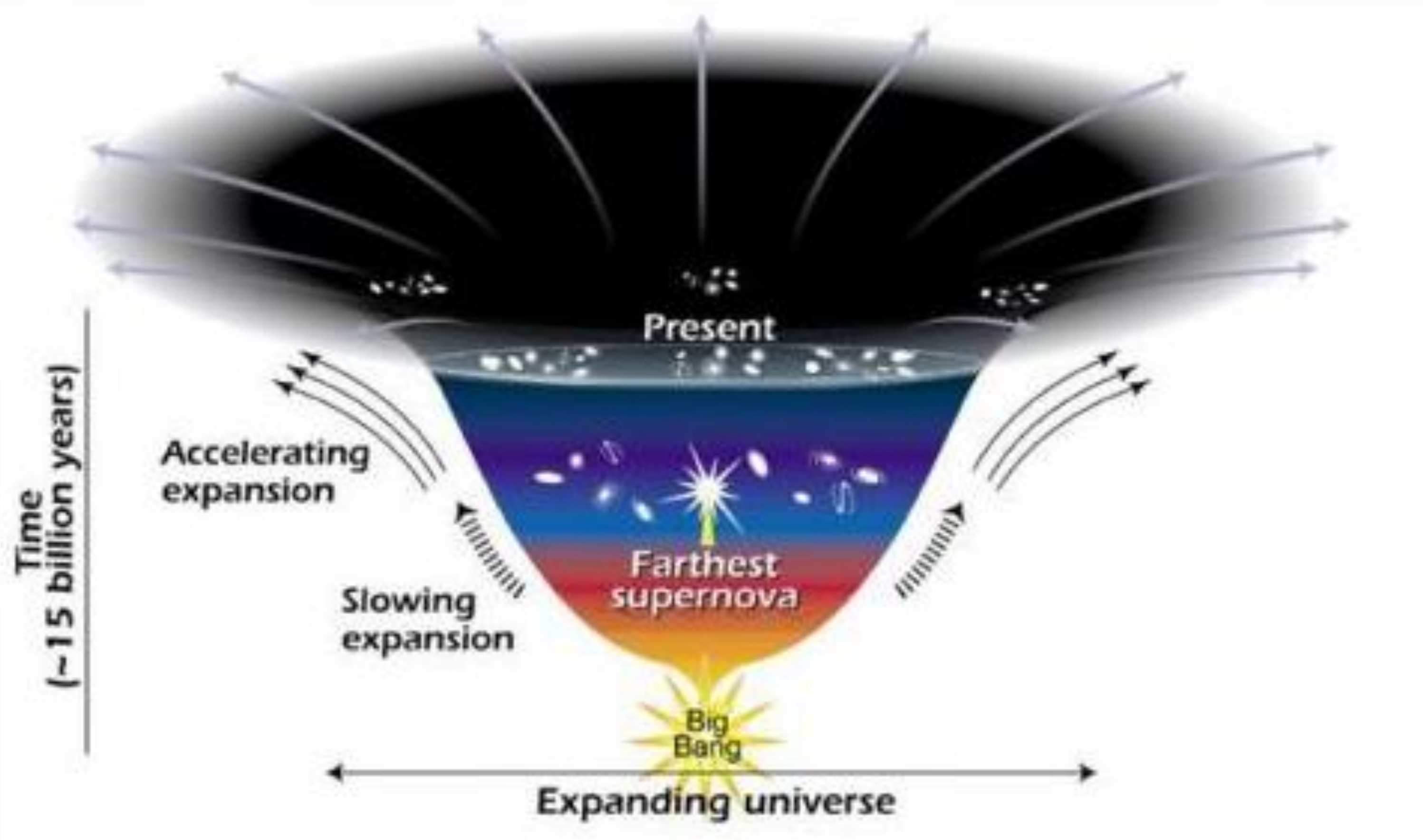
50 most important topics Science & Technology UPSC 2024

What is the Universe?

- The universe is everything.



Expansion of UNIVERSE



What is Space?

From the perspective of an Earthling, outer space is a zone that occurs **about 100 kilometers (60 miles) above the planet**

- No appreciable air to breathe or to scatter light
- Blue gives way to **black because oxygen molecules are not in enough** abundance to make the sky blue.
- Space is a **vacuum**, meaning that **sound** cannot carry because molecules are not close enough together to transmit sound between them
- However. Gas, dust and other bits of matter float around "emptier" areas of the universe, while more **crowded regions can host planets**, stars and galaxies.

Karman Line

Context-Boundaries play an important role in science because they help differentiate and define things that might otherwise blend together.

Karman line

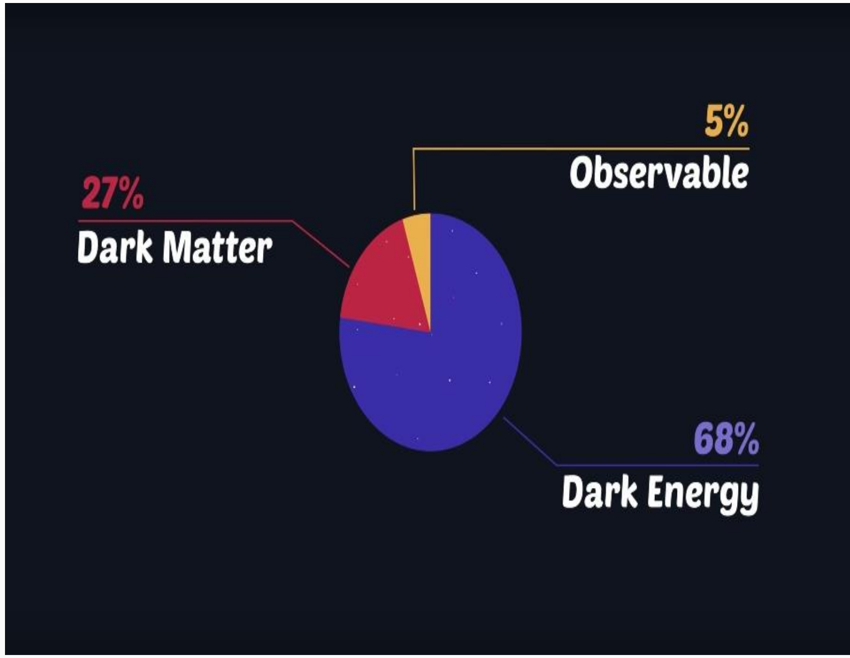
- Located at 100 km above sea level, it is an **imaginary line** that demarcates the earth's atmosphere from space.
- **Though not all scientists and spacefarers accept it**, a majority of countries and space organisations recognise this boundary between earthsky and space. It was **established in the 1960s** by a record-keeping body called Fédération Aéronautique Internationale (FAI). Anyone **individual who crosses this line qualifies as an astronaut.**
- Crossing the Kármán Line physically doesn't mean much. Within a short distance on either side of the line, there is **no significant difference** in the pressure or the composition of air. The earth's gravity continues to exert its pull here. Even the earth's atmosphere doesn't end here. .

Karman Line

Why then do we need the Kármán Line?

- The Kármán Line was established to **regulate airspace**.
- It marks, roughly, the altitude beyond which a **traditional aircraft can’t fly**.
- Any aircraft flying beyond it **needs a propulsion system to pull away** from the earth’s tug.
- It also acts as a **legal reference** that separates airspace that a country can claim to own from space itself, which is governed like international waters.

Dark ENERGY

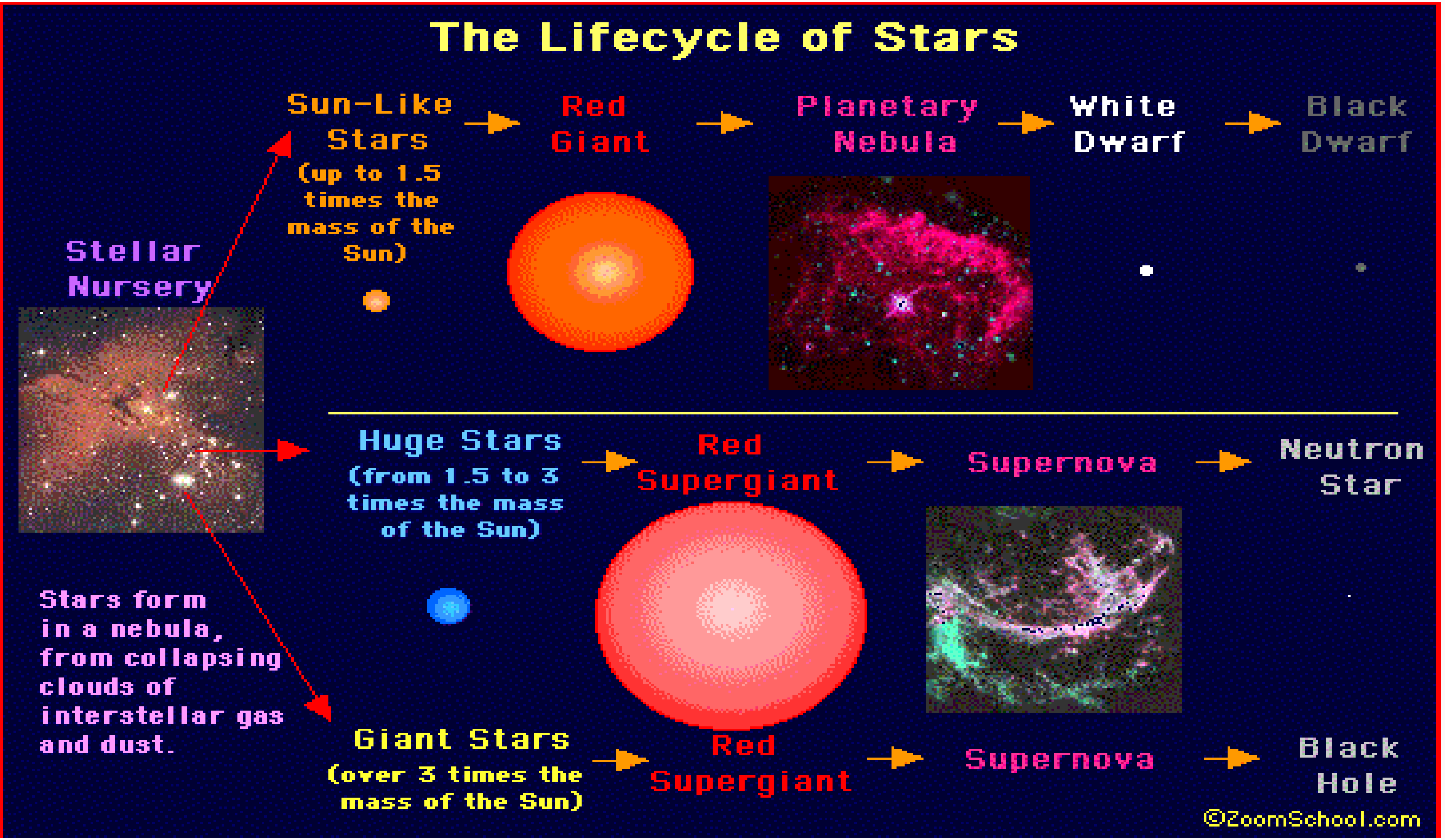


- It had always been assumed that the matter of the Universe would slow its rate of expansion.
- **Mass creates gravity, gravity creates pull,** the pulling must slow the expansion. But observations showed that the **expansion of the Universe, rather than slowing, is accelerating.**
- Something, not like matter and not like ordinary energy, is pushing the galaxies apart.
- This "stuff" has been **dubbed dark energy**

Dark MATTER

- The velocity of **rotation for spiral galaxies depends on the amount of mass contained in them.**
- But the **outer arms of the Milky Way are rotating much too fast** to be consistent with the amount of matter that we know exists in them.
- Such fast rotation is possible only when there is more mass, and that extra mass is believed to come from the **dark matter**.

Life cycles of stars



STARS

Chandrasekhar Limit

- **M**aximum mass theoretically possible for a stable white dwarf star.
- A limit which mandates that **no white dwarf** (a collapsed, degenerate star) can be **more massive than about 1.4 times the mass of the Sun.**
- Any degenerate object more massive must inevitably collapse into a neutron star or black hole

- Nobel laureate Subrahmanyan Chandrasekhar, who first proposed the idea in 1931. He was awarded the Nobel Prize in Physics in 1983 for his work on the physical processes involved in the structure and evolution of stars.

What Is a Black Hole?

- A black hole is a place in space where **gravity pulls so much that even light can not get out.** The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.
- Because no light can get out, people can't see black holes. They are invisible. Space telescopes with special tools can help find black holes. The special tools can see how stars that are very close to black holes act differently than other stars.

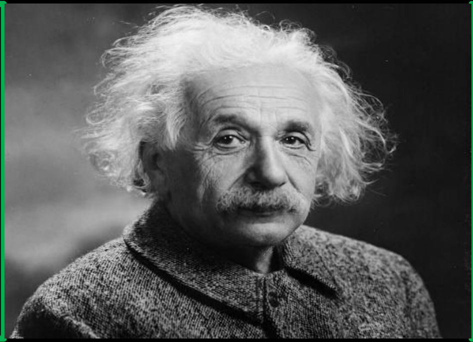
Primordial Black hole	❑ Smallest ❑ Size-atom with mass of mountain ❑ Formation after big bang ❑ Not much of evidence
Stellar Black hole	❑ Medium ❑ Size-20 times mass of sun ❑ Formation-Collapse of star- supernova explosion ❑ Indirect evidence
Supermassive black hole	❑ Massive ❑ Size-of solar system ❑ Almost every galaxy contain BH at centre ❑ Indirect evidence ❑ Sagitarius A star (Milky way),BH in M-87

NOTHING CAN ESCAPE FROM BLACKHOLE

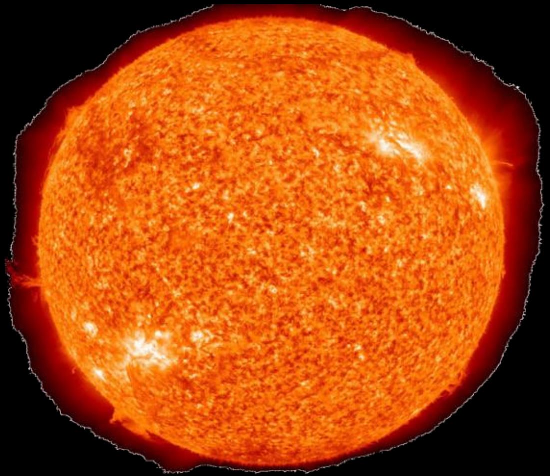
Newton law of escape velocity

❑ Escp vel of BH>Speed of light

Einstein special theory of relativity

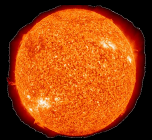


❑ No object can travel faster than speed of light



5 Lakh Km

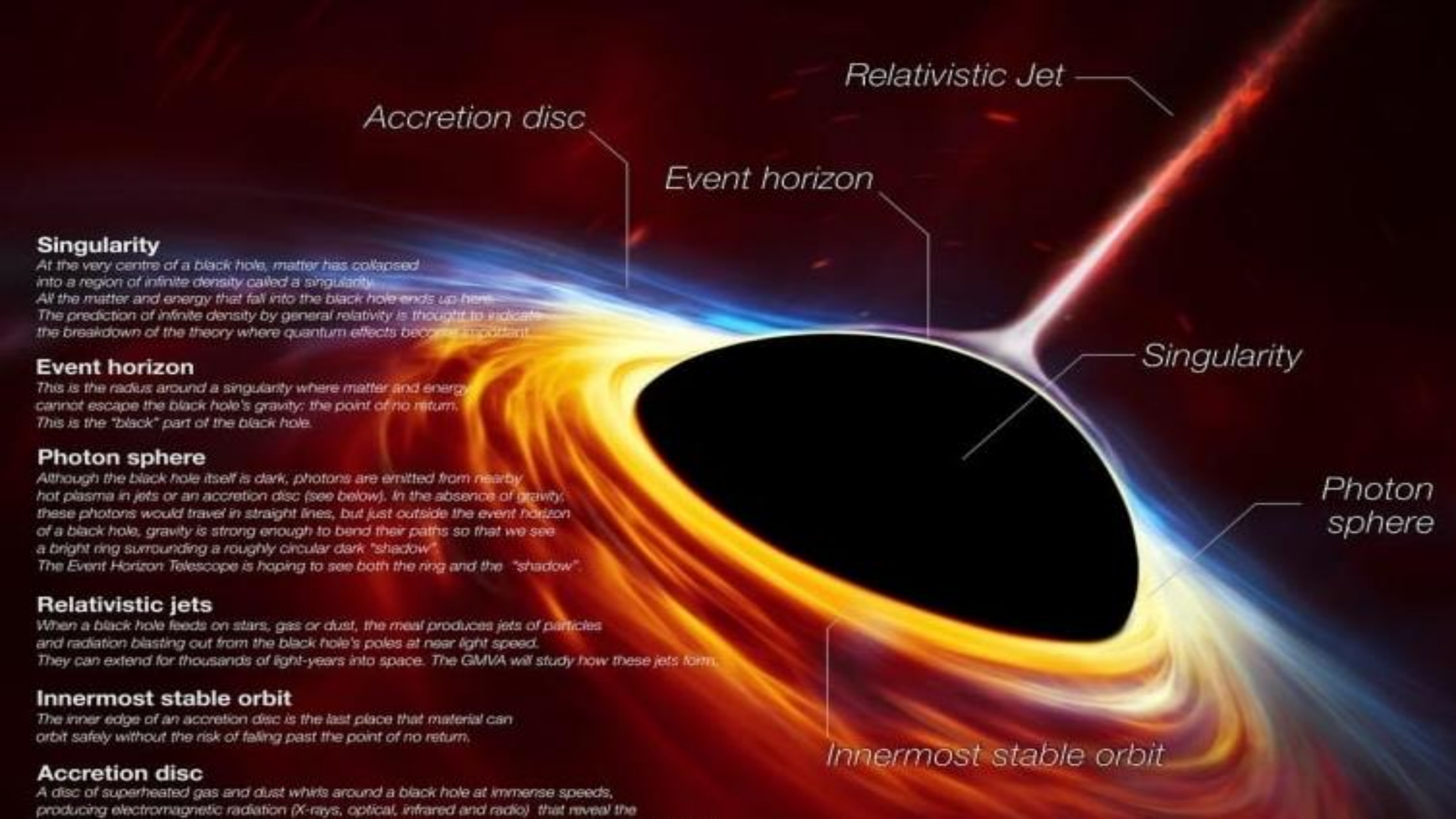
Compressed →



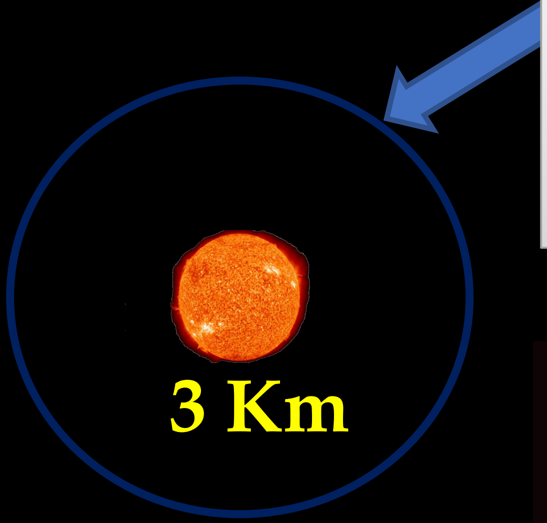
3 Km

Density become infinite

Singularity-
Pt where density become infinite


Relativistic Jet
Accretion disc
Event horizon
Singularity
Photon sphere
Innermost stable orbit
Singularity
At the very centre of a black hole, matter has collapsed
into a region of infinite density called a singularity.
All the matter and energy that fall into the black hole ends up here.
The prediction of infinite density by general relativity is thought to indicate
the breakdown of the theory where quantum effects
Event horizon
This is the radius around a singularity where matter and energy
cannot escape the black hole's gravity: the point of no return.
This is the "black" part of the black hole.
Photon sphere
Although the black hole itself is dark, photons are emitted from nearby
hot plasma in jets or an accretion disc (see below). In the absence of gravity,
these photons would travel in straight lines, but just outside the event horizon
of a black hole, gravity is strong enough to bend their paths so that we see
a bright ring surrounding a roughly circular dark "shadow".
The Event Horizon Telescope is hoping to see both the ring and the "shadow".
Relativistic jets
When a black hole feeds on stars, gas or dust, the meal produces jets of particles
and radiation blasting out from the black hole's poles at near light speed.
They can extend for thousands of light-years into space. The GMVA will study how these jets form.
Innermost stable orbit
The inner edge of an accretion disc is the last place that material can
orbit safely without the risk of falling past the point of no return.
Accretion disc
A disc of superheated gas and dust whirls around a black hole at immense speeds,
producing electromagnetic radiation (X-rays, optical, infrared and radio) that reveal the

- ❑Surface hiding pt of singularity called Event Horizon
- ❑i.e Any event happened beneath this horizon can’t be seen bcz nothing can escape



White holes

- are theoretical cosmic regions that function in the opposite way to black holes.
- Just as nothing can escape a black hole, **nothing can enter a white hole**.
- Physicists describe a white hole as a black hole's "**time reversal**"
- While a black hole's event horizon is a sphere of no return, a white hole's event horizon is a boundary of no admission — space-time's most exclusive club. No spacecraft will ever reach the region's edge.

White holes

How do white holes differ from black holes?

- The white hole is, in a hand-wavy sense, the inverse of a black hole. So in a black hole, you have an **intense gravitational field** that pulls things in you've got this one-way membrane called the event horizon. You **cross that event horizon, and then you are captured,** you cannot escape from that black hole. Gravity has got you, and your future is destined to be at the center of the black hole, no matter what you do.

- Now a white hole is the flip of that. So a **white hole is almost like anti-gravity** endlessly ejecting material. With a white hole, you have an event horizon, where stuff from the inside crosses the event horizon and gets ejected into the universe, and you can't actually get into the white hole.

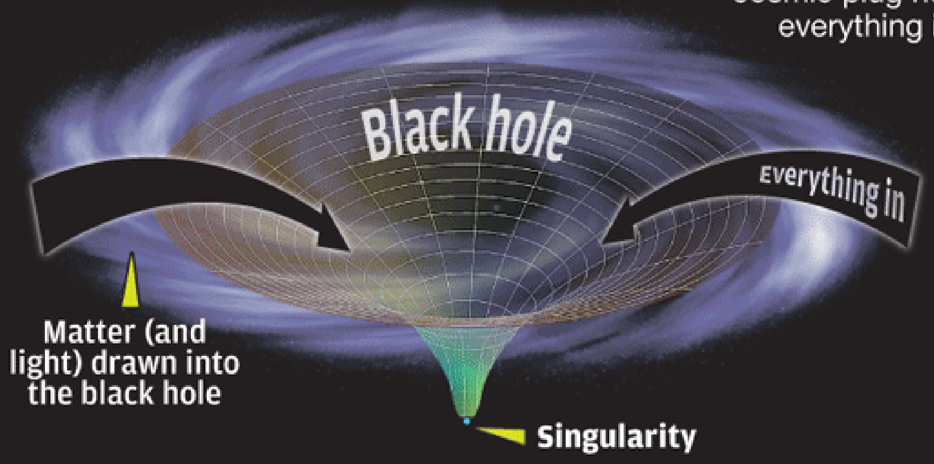
- So in the black hole, you can pass inwards, but not outwards in a white hole, you can pass outwards but not inwards.

Small bangs, time travel and mirror universes – meet the white hole

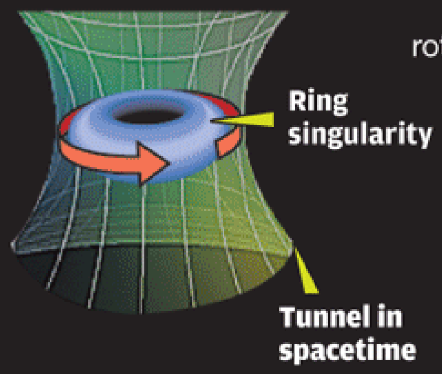
A white hole is the theoretical opposite of a black hole. Just as nothing can escape the pull of a black hole, nothing can enter a white hole – they are both one-way streets, running in opposite directions.
To understand how they might form, you have to understand what creates a black hole...

1. A black hole is usually formed when a massive star dies. Once the dying star has cast off its star stuff in a supernova, its core – no longer held in check by nuclear processes – collapses under its own weight

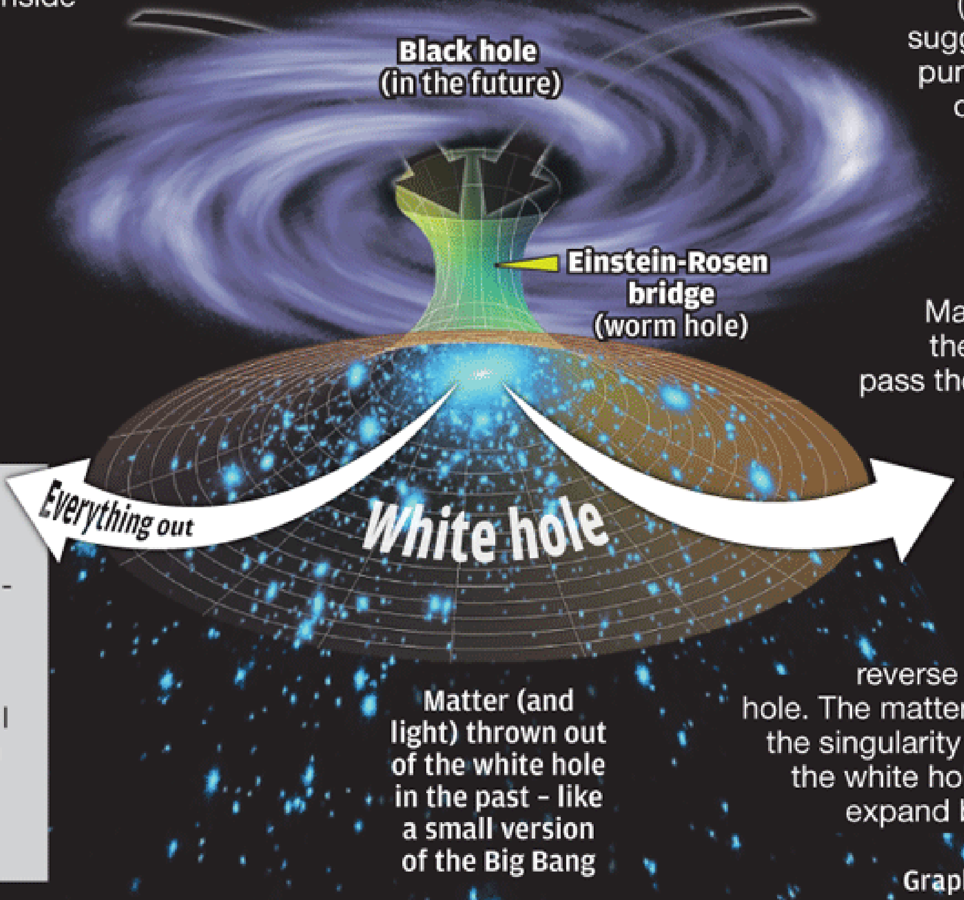
2. It gets smaller and smaller until it becomes an impossibly dense speck of weirdness called a singularity. This super-dense speck bends the fabric of spacetime around it (see box below), forming a gravity well that acts like a cosmic plug hole – sucking everything inside



3. Sometimes, the star's core is still rotating when collapses. As it collapses into a singularity, it's rotation speeds up (like an iceskater pulling their arms in). It spins so fast that its material spreads out to form a donut. Instead of focusing on a single point, spacetime becomes wrapped around this ring creating a tunnel



4. This tunnel punches through the fabric of space-time and emerges in the past (it has also been suggested that they punch a hole into a different, parallel universe). This tunnel is called an Einstein-Rosen bridge, or wormhole. Matter pulled in by the black hole can pass though this tunnel



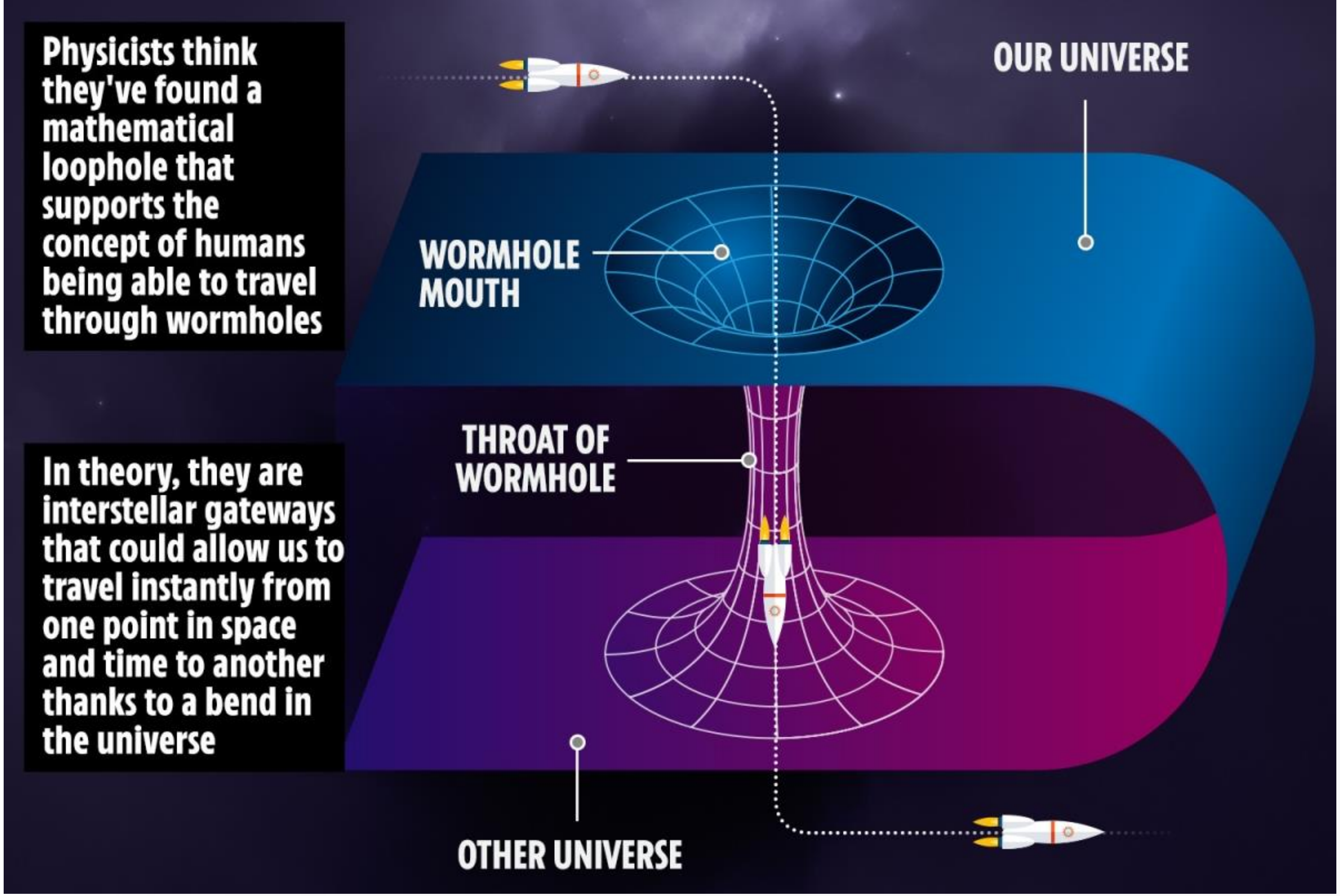
5. The far side of this wormhole can be seen as being like a black hole in reverse – this is a white hole. The matter emerging from the singularity at the centre of the white hole is released to expand back into space

Getting heavy with the singularity

Gravity is basically the effect that a heavy object has on the fabric of spacetime that surrounds it. If you imagine spacetime as a bed sheet, if you place an object on that sheet, it makes a dent. Anything coming within the influence of that dent will 'fall' in towards the object that made it – this is gravity.

A heavier object bends spacetime even more (making a deeper dent) - increasing the gravitational effect. A the singularity at the centre of a black hole possesses so much mass, concentrated in such a small area, that it bends spacetime to an infinitely small point. Nothing – not even light – can escape the gravitational pull of the singularity

Graphics: Ben Gilliland

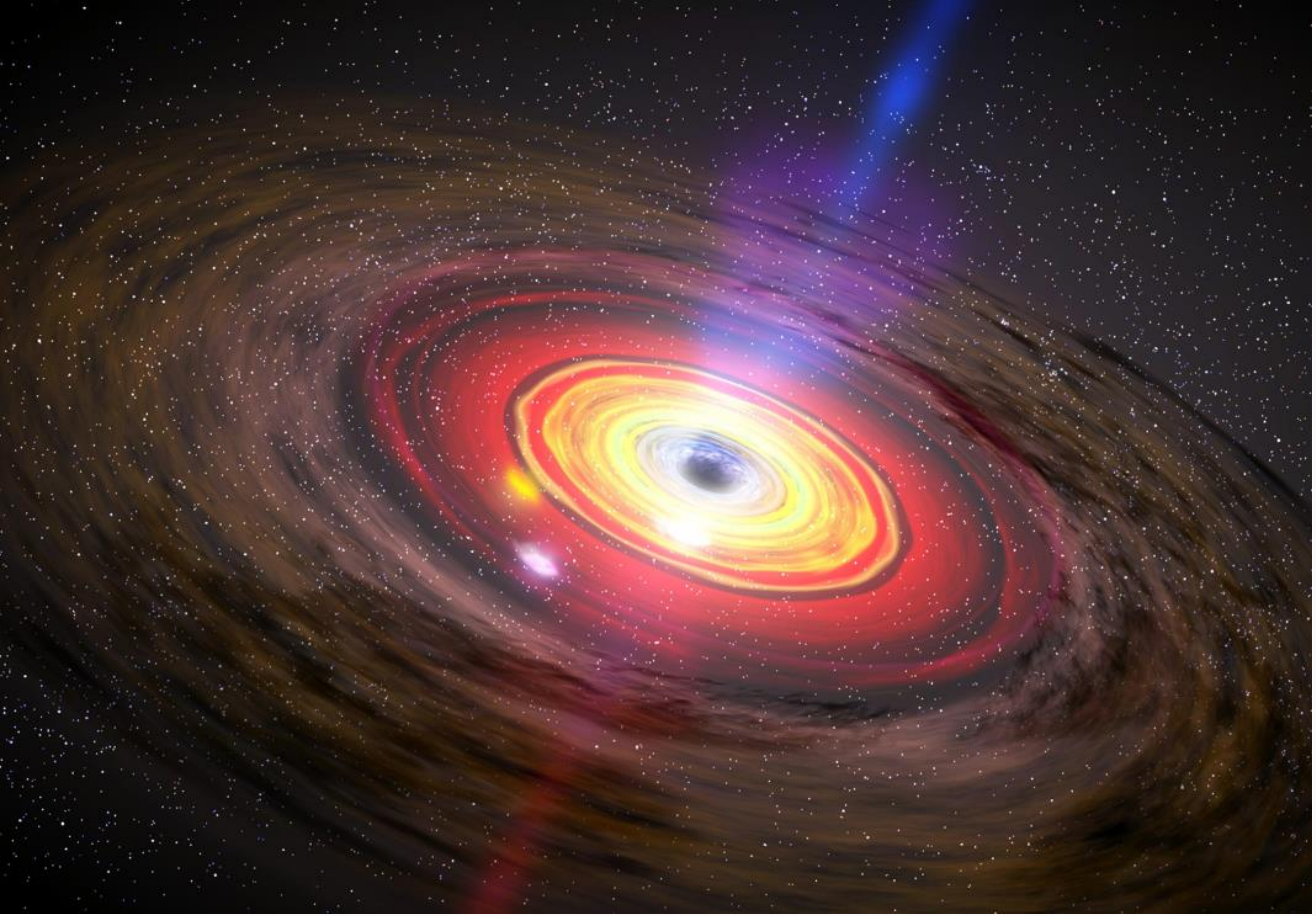

Physicists think they've found a mathematical loophole that supports the concept of humans being able to travel through wormholes
OUR UNIVERSE
WORMHOLE MOUTH
THROAT OF WORMHOLE
In theory, they are interstellar gateways that could allow us to travel instantly from one point in space and time to another thanks to a bend in the universe
OTHER UNIVERSE

QUASAR

- **Recently discovered the most distant 'radio-loud' quasar (P172+18) with the help of European Southern Observatory's Very Large Telescope (ESO's VLT).**
  - **The higher the redshift of the radio wavelength, the farther away is the source.**

Quasars

- are very luminous objects in **faraway galaxies that emit jets at radio frequencies**.
- They are **only found in galaxies that have supermassive blackholes** which power these bright discs.
- However, 90 per cent of them do not emit strong radio waves, making this newly-discovered one special



QUASAR

Significance

- This particular quasar appears to the scientists as it was when the **universe was just around 780 million** years old. The **glowing disc around a blackhole 300 million times more massive than our Sun**, thus, holds clues about the ancient star systems and astronomical bodies.
- It is also one of the fastest accreting quasars, which **means it is accumulating objects from the galaxy at an enormous speed**

Conceptual clarity	
Statements	**Correct/Incorrect**
1. There is a black hole behind every quasar, but not every black hole is a quasar	
2. Quasars are found in galaxies that have supermassive blackholes which power these bright discs.	
3. Every galaxy hosts a quasar	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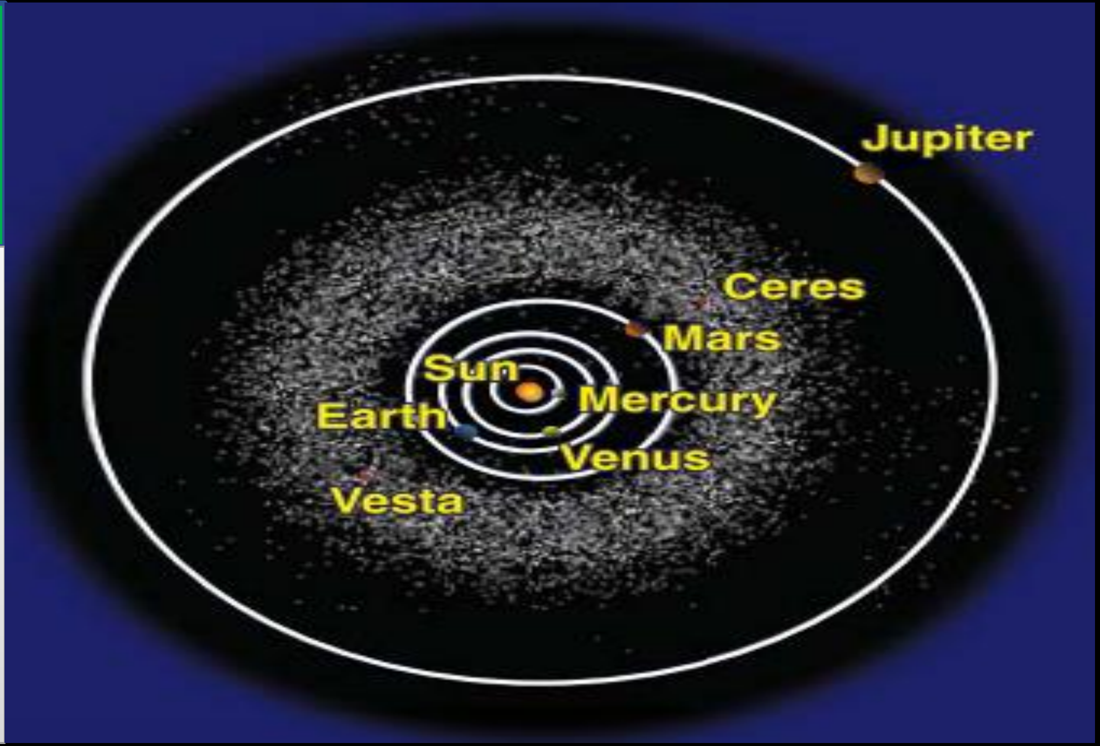
ASTEROID

What is an asteroid

- ❑ Small rocky object left over from formation of solar system
- ❑ Size-small to 600 miles (Ceres)



What are asteroids made of

- C-type-Carbonaceous material
- 75% 0f total
- Mostly water & hardly any metallic element

- S-type-Silicate material
- 17% of total asteroids
- Fe,Nickel,Mg
- Hardly any water but little brighter than C type

- M-type-Metal
- Platinum
- Large amount of platinum on earth come from this asteroid

What do asteroid find disturbing	❑ **Gravity of Jupitor & mars tosses up asteroid from main ateroid belt.** ❑ **Impact on earth (Meteorite)-climate change eg killed all dinosaurs 65 bill yrs ago**
Why do we study asteroids	❑ **Have not changed much in billion yrs ago** ❑ **Can tell us what the early solar system was like**

NASA DART crash

- **Double Asteroid Redirection Test (DART) Mission:** NASA's DART (Double Asteroid Redirection Test) has **successfully crashed into the asteroid Dimorphos.** Scientists expect the impact to alter the asteroid's orbit. However, it will take a few weeks before NASA can determine how much the asteroid's path was changed due to the impact.

NASA DART crash

DART mission

- It is a **low-cost spacecraft**
- It has two solar arrays and uses **hydrazine propellant** for maneuvering the spacecraft.
- It carries about **10 kg of xenon** which will be used to demonstrate the **agency's new thrusters called NASA Evolutionary Xenon Thruster–Commercial (NEXT-C) in space.**
- The spacecraft carries a **high-resolution imager** called Didymos Reconnaissance and Asteroid Camera for Optical Navigation (**DRACO).**
- Images from DRACO **will be sent to Earth in real-time** and will help study the impact site and surface of Dimorphos (the target asteroid).
- DART will also carry a **small satellite or CubeSat named LICIACube** (Light Italian CubeSat for Imaging of Asteroids).

NASA DART crash

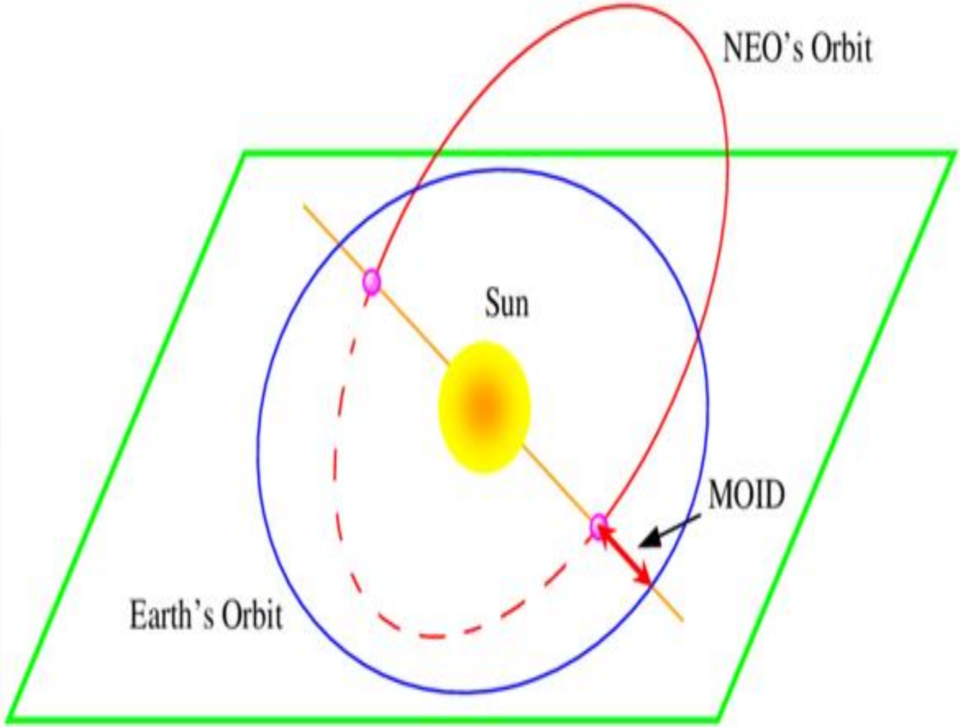
Asteroid Impact Deflection Assessment (AIDA)

- **Method of Planetary defence**

❑ **Blowing** up the asteroid before it reaches Earth,

❑ **Deflecting** it off its Earth-bound course by hitting it with a spacecraft (**AIDA**)

NASA DART crash



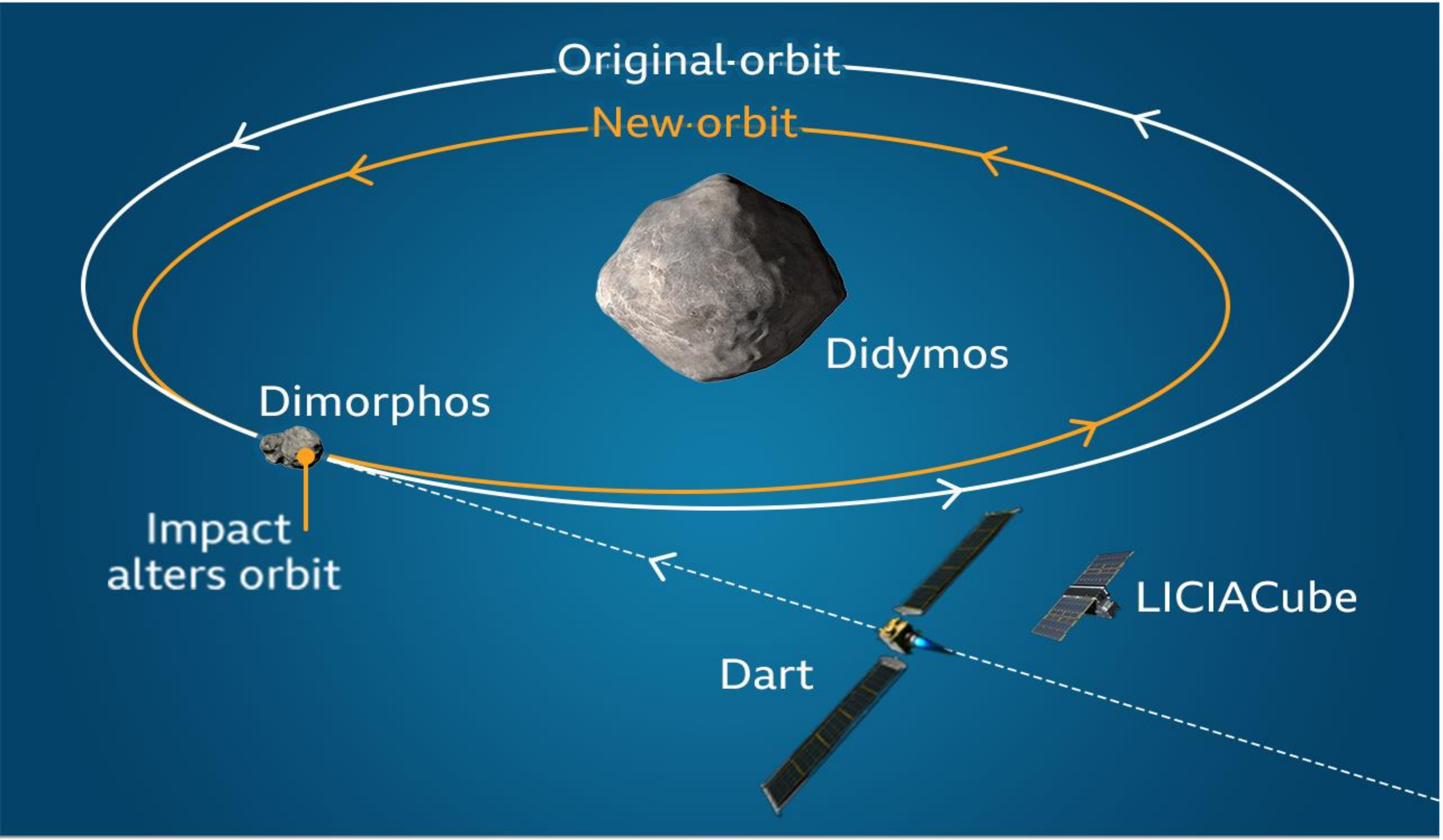
Potentially Hazardous Asteroids (PHAs)

- All asteroids with a minimum orbit intersection distance (MOID) of 0.05 au or less and an absolute magnitude (H) of 22.0 or less are considered PHAs.

- **Minimum Orbit Intersection Distance** is a method **for calculating the minimum distance between two almost overlapping elliptical orbits**

- An asteroids that **can't get any closer to the Earth (i.e. MOID) than 0.05 au (roughly 7,480,000 km or 4,650,000 mi) or are smaller than about 150 m (500 ft) in diameter** (i.e. H = 22.0 with assumed albedo of 13%) are **not considered PHAs**

Nasa spacecraft crashes into asteroid's moon



Source: Nasa, Johns Hopkins Applied Physics Laboratory
BBC

Hayabusa-JAXA

- ❑ Sample return mission
- ❑ Near earth asteroid-Itokawa
- ❑ Launch-2003---return 2010
- ❑ First asteroid sample return

Hayabusa-2

- ❑ 2014
- ❑ Rygugu asteroid (C-type)
- ❑ Return-2020

- ❑ Organic matter+ water

OSIRIS-Rex-NASA

- ❑ Lauch-2016
- ❑ Return-2023
- ❑ Bennu(C-type)

Osiris-Rex

Context-After seven years of long wait, the US space agency **NASA's first asteroid sample has landed on Earth.**

About

- Osiris-Rex launched in 2016, landing on the asteroid Bennu and collected **roughly nine ounces (250 grams) of dust from its rocky surface**
- According to NASA, the debris of the asteroid should "**help us better understand the types of asteroids that could threaten Earth.“**
- The analysis of the asteroid, scientists believe, will **help researchers better understand the formation of the solar system** and how Earth became habitable.

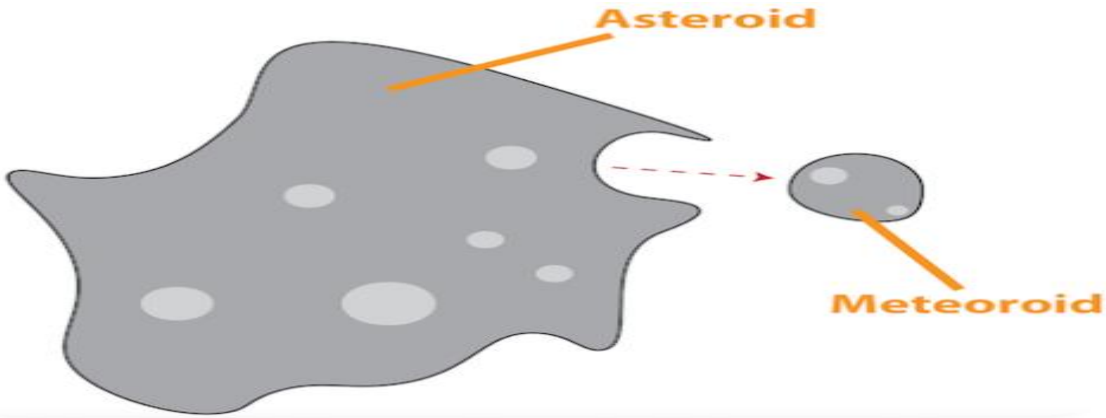
Osiris-Rex

Bennu asteroid

- Scientists believe Bennu, **about 500 meters (1,640 feet) in diameter**, is rich in **carbon** -- a building block of life on Earth -- and **contains water molecules** locked in minerals.
- Bennu surprised scientists in 2020 when the **probe, during its brief contact with the asteroid's surface, sank into the soil,** revealing an unexpectedly low density, like a **children's pool filled with plastic balls.**
- Understanding its composition could come in handy in the -- distant -- future.

Meteoroids

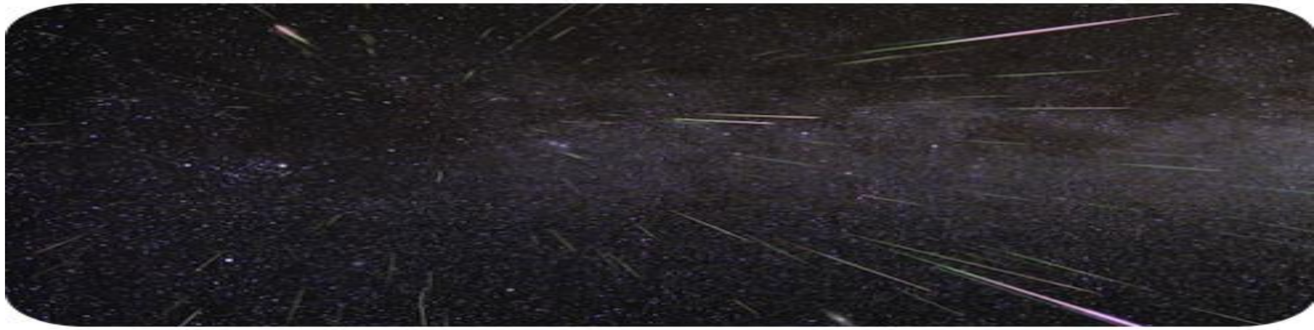
Sometimes one asteroid can smash into another. This can cause small pieces of the asteroid to break off. Those pieces are called **meteoroids**.



Meteors

If a meteoroid comes close enough to Earth and enters Earth's atmosphere, it vaporizes and turns into a **meteor**: a streak of light in the sky.

Because of their appearance, these streaks of light are sometimes called "shooting stars." But scientists know that meteors are not stars at all—they are just bits of rock!

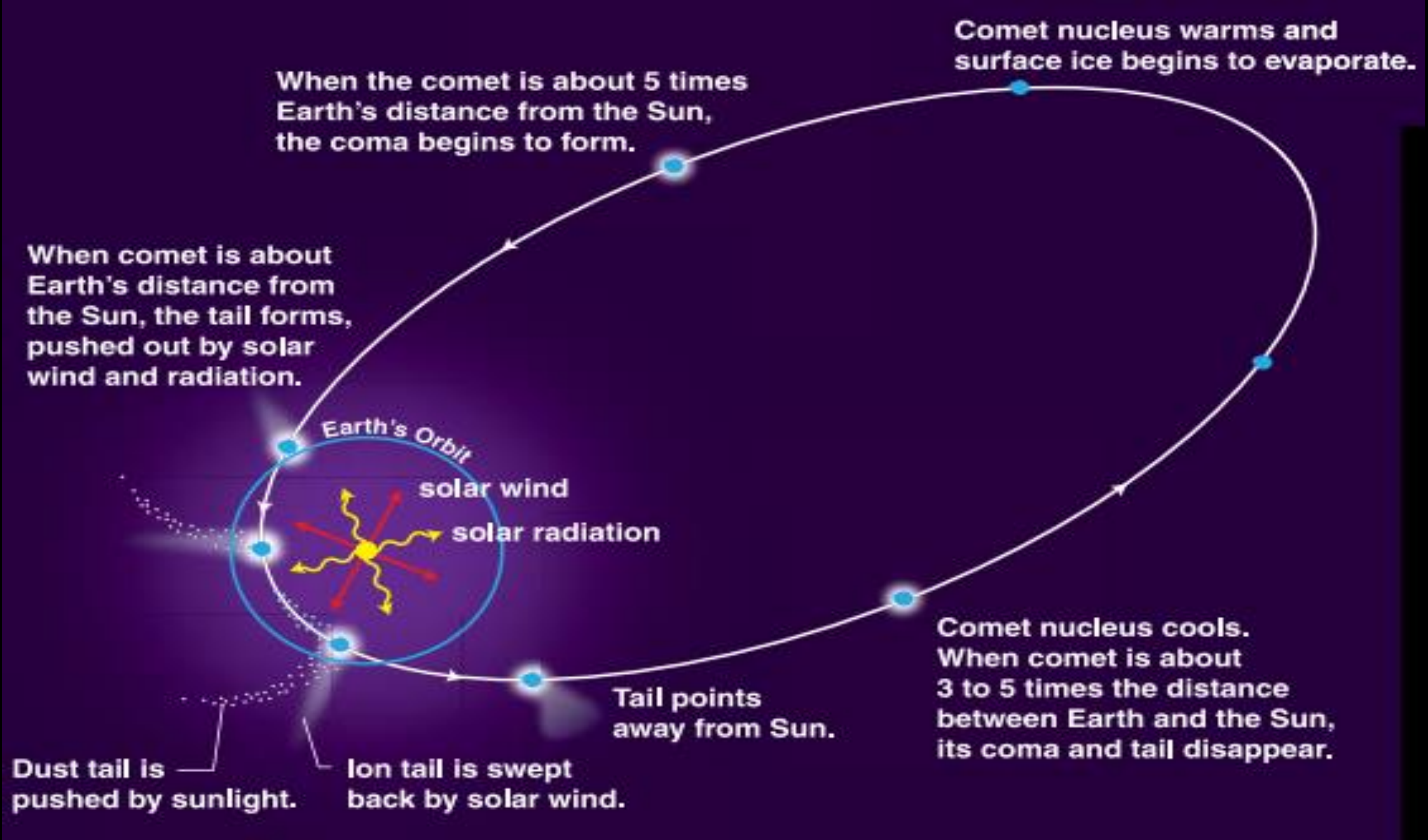


Meteorites

Sometimes meteoroid rocks don't vaporize completely in the atmosphere. In fact, sometimes they survive their trip through Earth's atmosphere and land as rocks on the Earth's surface. Those rocks are called **meteorites**.

COMET

What is Comet	❑ Dust,ice rock leftover after formation of solar system
Where do comets come from	❑ Oort cloud-stir up with gravitational pull of star ❑ Kuiper belt-gravitational pull of planets


Comet nucleus warms and surface ice begins to evaporate.
When the comet is about 5 times Earth's distance from the Sun, the coma begins to form.
When comet is about Earth's distance from the Sun, the tail forms, pushed out by solar wind and radiation.
Earth's Orbit
solar wind
solar radiation
Tail points away from Sun.
Comet nucleus cools. When comet is about 3 to 5 times the distance between Earth and the Sun, its coma and tail disappear.
Dust tail is pushed by sunlight.
Ion tail is swept back by solar wind.

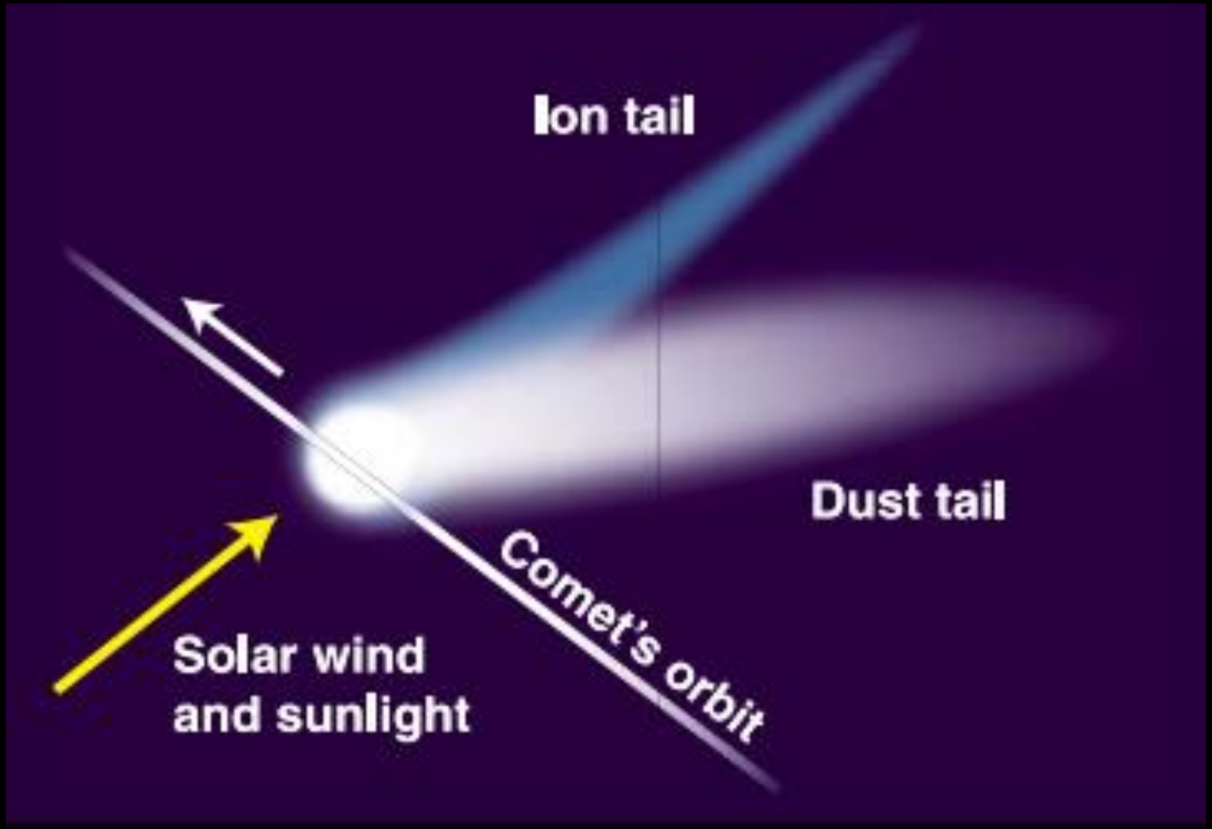
Comet-dust,ice,rock

Material boil

Cloud around nucleus

Solar wind push comma

Dust tail



Comets

Reside mostly in Kuiper Belt beyond orbit of Neptune, and in Oort Cloud in outer solar system.

Probably formed in the outer solar system.

Diameters range from about 6 - 25 miles.

Contain a lot of ice, along with rock, and hydrocarbons.

Surface is very unstable and changeable, as ice boils off when comet approaches Sun.

Develop comas and tails as they approach the Sun.

Orbit can be disturbed to toss comet into elongated orbit, so we see it in the inner solar system.

May have contributed large part of Earth's water.

Comets and Asteroids (common)

Part of solar system, leftovers from its formation.

Orbit the Sun.

Irregular shapes. Not massive enough to be spherical like a planet. May spin like a badly thrown football because of irregular shape.

Have crashed into Earth.

Asteroids

Most reside in Asteroid Belt between orbits of Mars and Jupiter.

Probably formed inside the orbit of Jupiter.

Diameters range from the size of small rocks to more than 600 miles.

Composed of rock and metals.

Surface is solid and stable, showing craters where other objects have crashed into it.

Surface does not boil off, thus no coma or tails.

Orbit is stable and fairly circular.

Have left craters on Earth, and may have caused mass extinctions, such as of the dinosaurs.

ASTEROID BELT

Origin

- **Early in the life** of the solar system, dust and rock circling the sun were pulled together by gravity into planets.
- But not all of the ingredients created new worlds.
- A region between Mars and Jupiter became the asteroid belt.

ASTEROID BELT

Whether the belt was made up of the remains of a destroyed planet, or a world that didn't quite get started

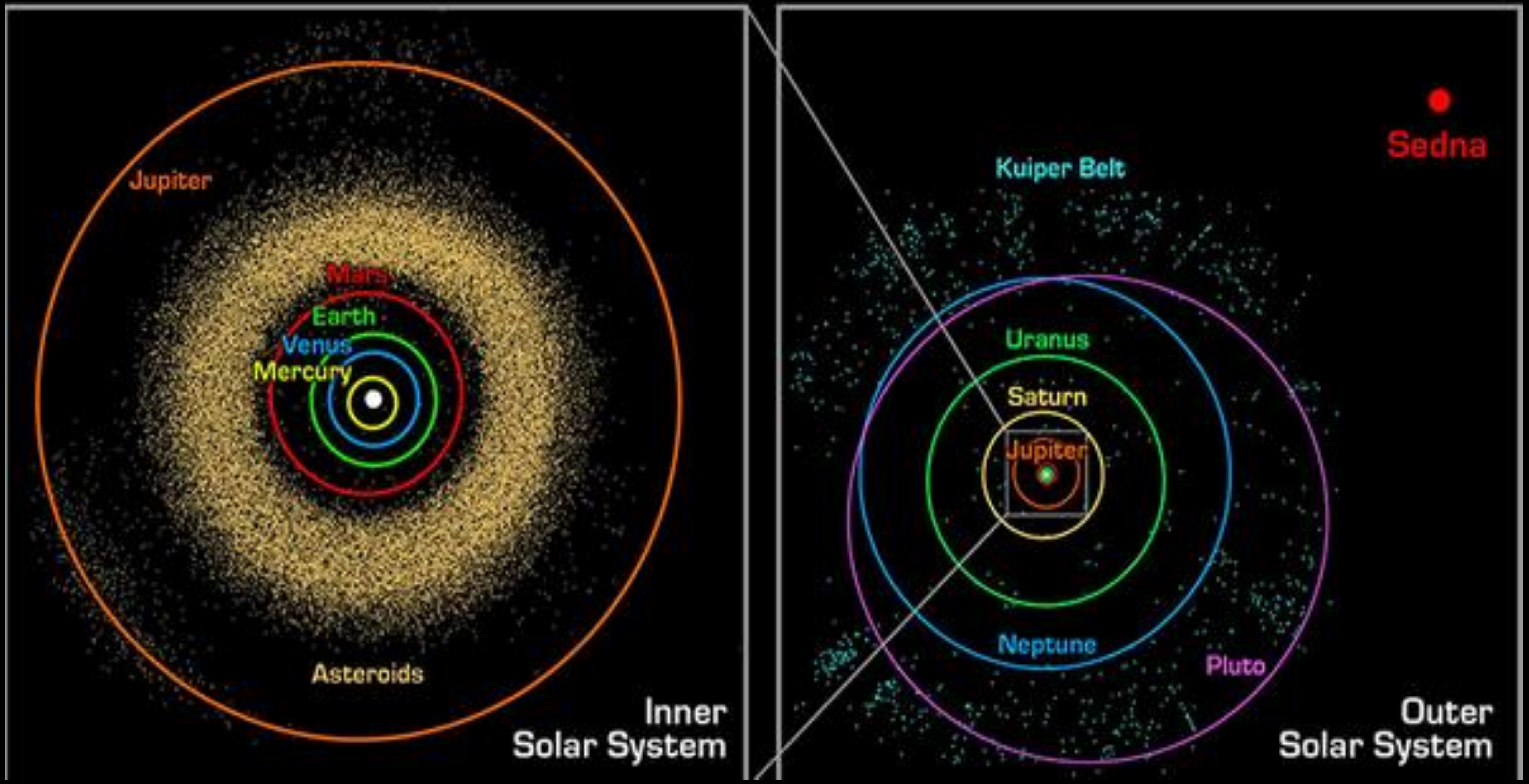
- According to NASA, the total mass of the belt is less than the moon, far too small to weigh in as a planet.
- Instead, the **debris is shepherded by Jupiter**, which kept it from coalescing onto other growing planets

ASTEROID BELT

Asteroid belt

- An asteroid is a bit of rock.
- It can be thought of as what was **"left over" after the Sun and all the planets were formed.** Most of the asteroids in our solar system can be found orbiting the Sun between the **orbits of Mars and Jupiter**.
- This area is sometimes called the "asteroid belt"

ASTEROID BELT



KUIPER BELT

- Region of the Solar System that exists **beyond the eight major planets**.
- It is similar to the asteroid belt, in that it contains many small bodies, all remnants from the Solar System's formation.
- But unlike the Asteroid Belt, it is **much larger –20 times** as wide and 20 to 200 times as massive.

KUIPER BELT

What is the Kuiper Belt?

- The **inner edge begins** at the orbit of Neptune, at **about 30 AU from the Sun**. (1 AU, or astronomical unit, is the distance from Earth to the Sun.)
- The **outer edge continues** outward to nearly **1,000 AU,** with some bodies on orbits that go even further beyond.

KUIPER BELT

- There are bits of **rock and ice, comets and dwarf planets** in the Kuiper Belt.
- Besides Pluto and a bunch of comets, other interesting Kuiper Belt Objects are **Eris, Makemake and Haumea**.
- They are dwarf planets like **Pluto.**

KUIPER BELT

Reason for small Kuiper Belt Objects (KBO)

- Are all small because they **might have come together to form a planet** had Neptune not been there.
- Instead, **Neptune's gravity stirred up** this region of space so much that the small, icy objects there weren't able to coalesce into a large planet

KUIPER BELT

Cold & hot Classical objects

- There are two main groups of objects in the classical Kuiper Belt, referred to as "cold" and "hot." These terms **don't refer to temperature -- instead, they describe the orbits of the objects,** along with the amount of influence Neptune's gravity has had on them.

Cold Classical KBO

- The cold classical KBOs have orbits that **never come very close to Neptune**, and thus they remain "cool" and unperturbed by the giant planet's gravity.

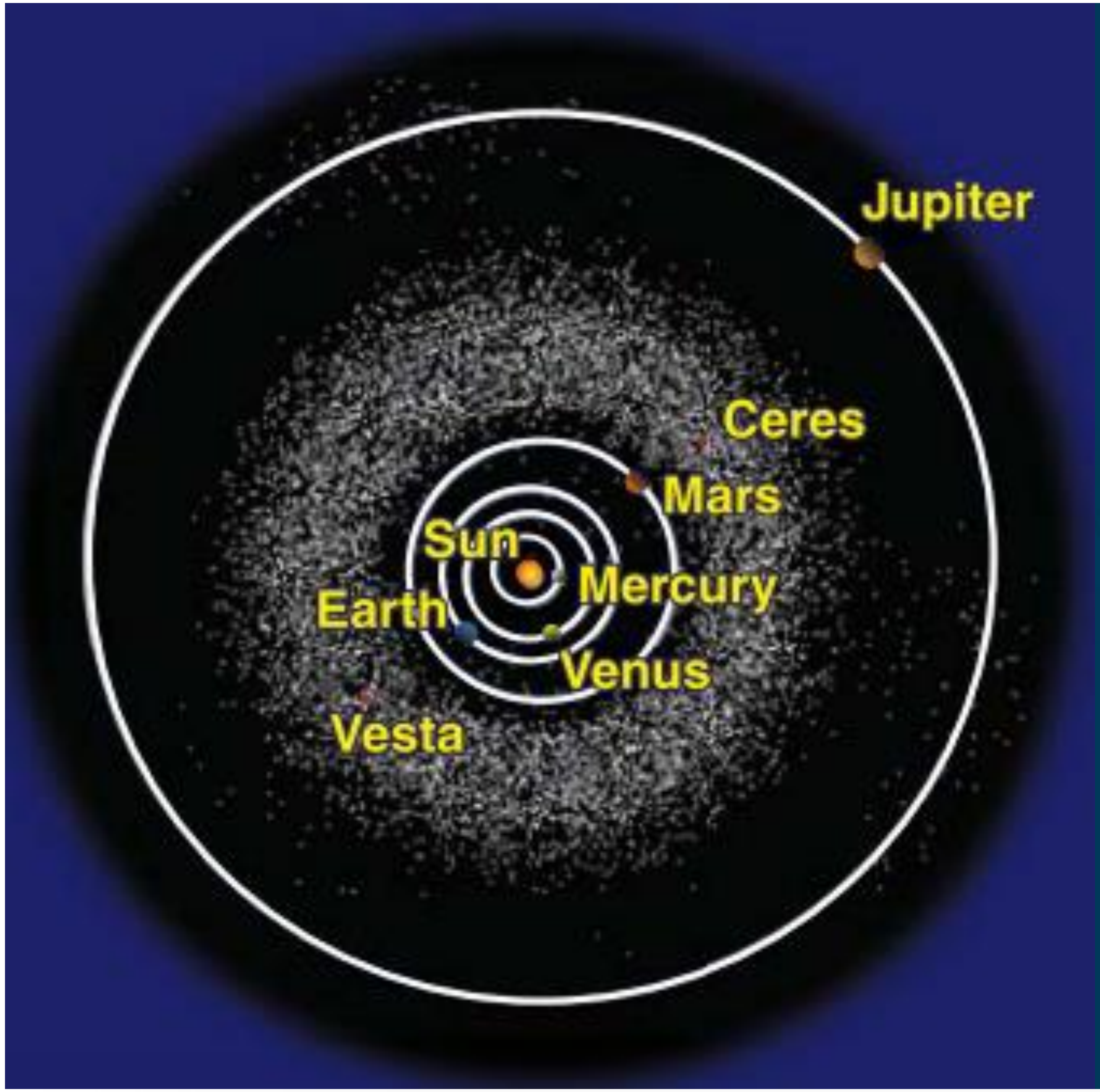
KUIPER BELT

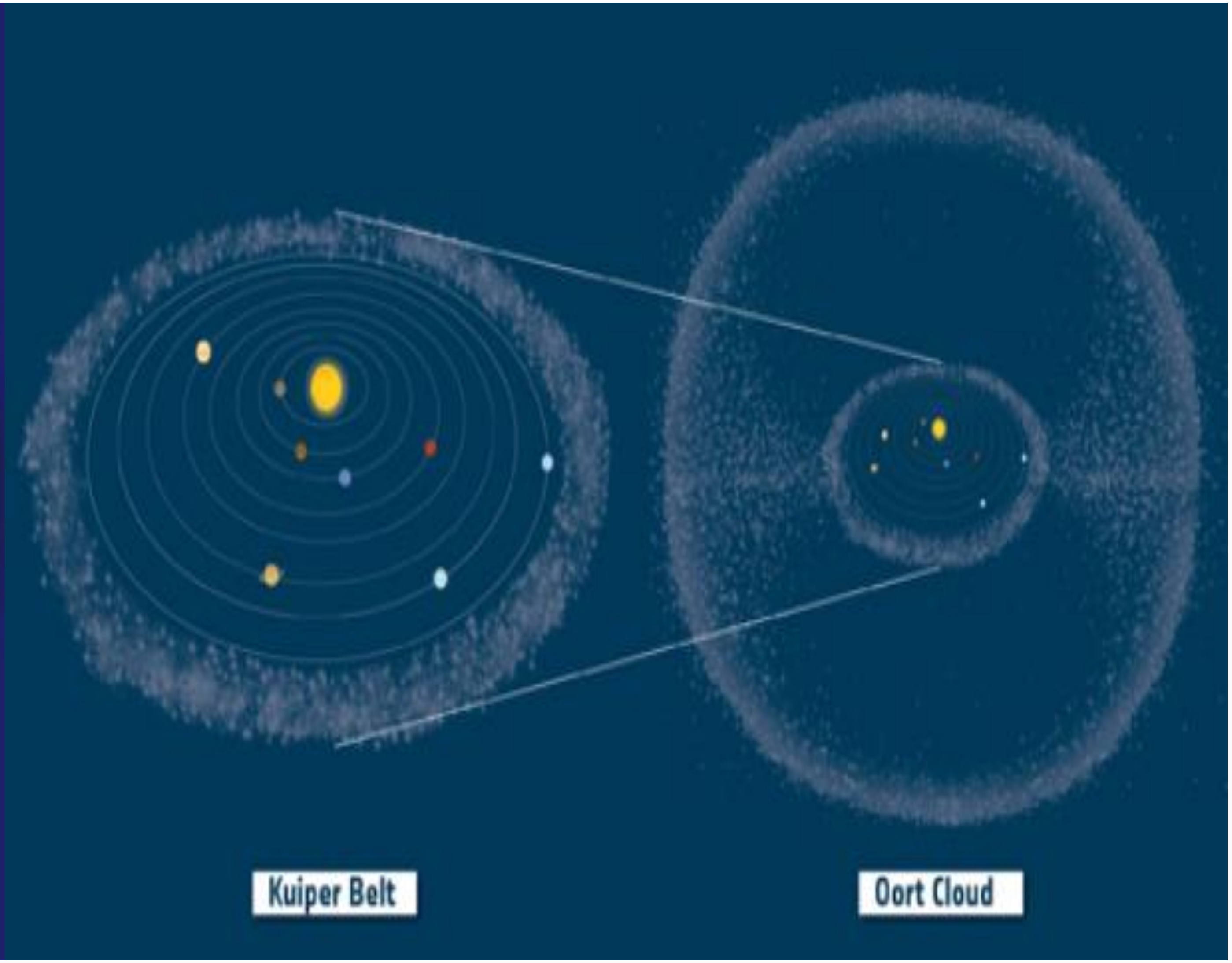
Hot classical KBOs

- Have had **interactions with Neptune in the past**.
- These interactions pumped energy into their orbits, which stretched them into an **elliptical shape**, and tilted them slightly **out of the plane** of the planets.

Oort cloud

- Unlike the orbits of the planets and the Kuiper Belt, which lie mostly in the same flat disk around the Sun, the Oort Cloud is believed to be a giant **spherical shell surrounding the rest of the solar system**.
- It is like a big, thick-walled bubble made of **icy pieces of space debris the sizes of mountains and sometimes larger.**
- The Oort Cloud might contain billions, or even trillions, of objects.
- Oort Cloud is the source of **most of those comets**.

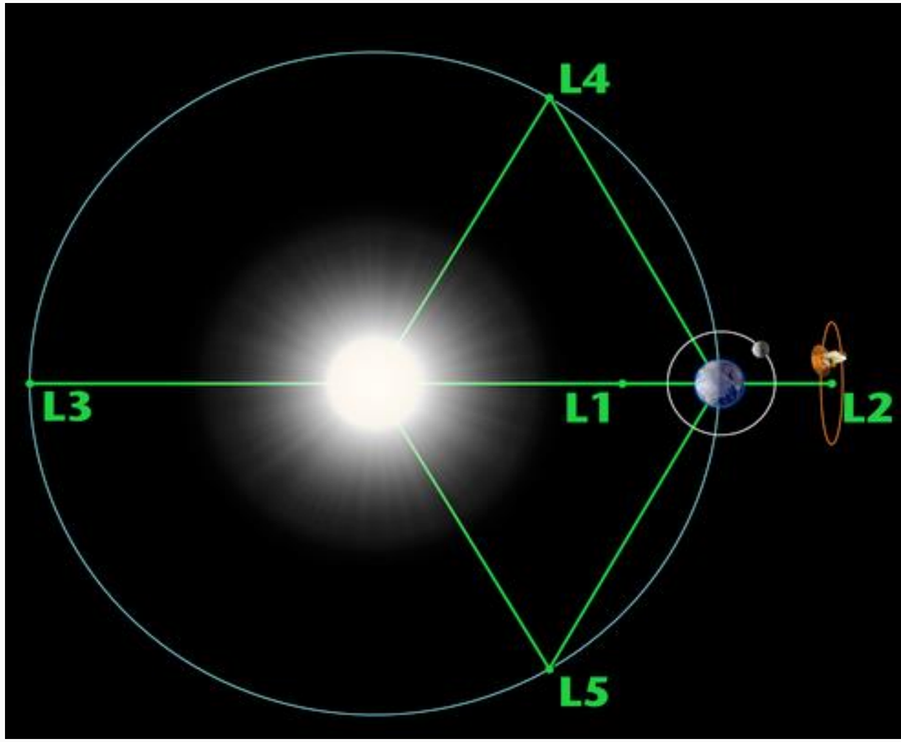

Jupiter
Ceres
Mars
Sun
Mercury
Earth
Venus
Vesta


Kuiper Belt
Oort Cloud

LAGRANGE POINTS

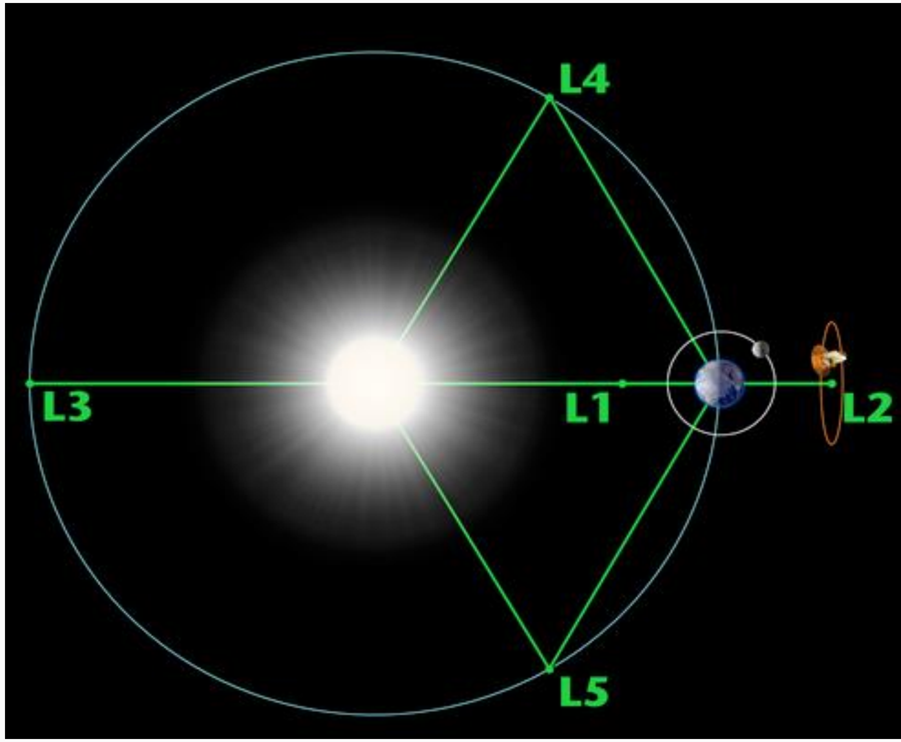
Lagrange Points

- are positions in space where **objects sent there tend to stay put**. At Lagrange points, the **gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them**.
- This mathematical problem, known as the **General Three-Body Problem**

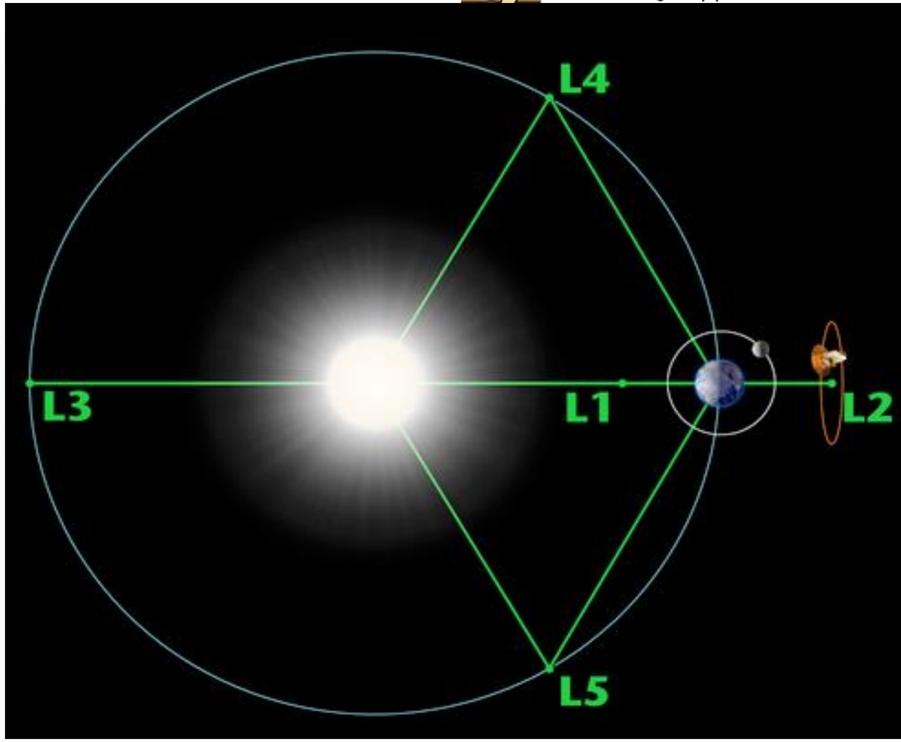


LAGRANGE POINTS

- There are five special points where a small mass can orbit in a constant pattern with two larger masses.
- **Unstable Lagrange points -** labeled L1, L2 and L3 - lie along the line connecting the two large masses.
- **Stable Lagrange points -** labeled L4 and L5 - form the apex of two equilateral triangles



LAGRANGE POINTS



Significance

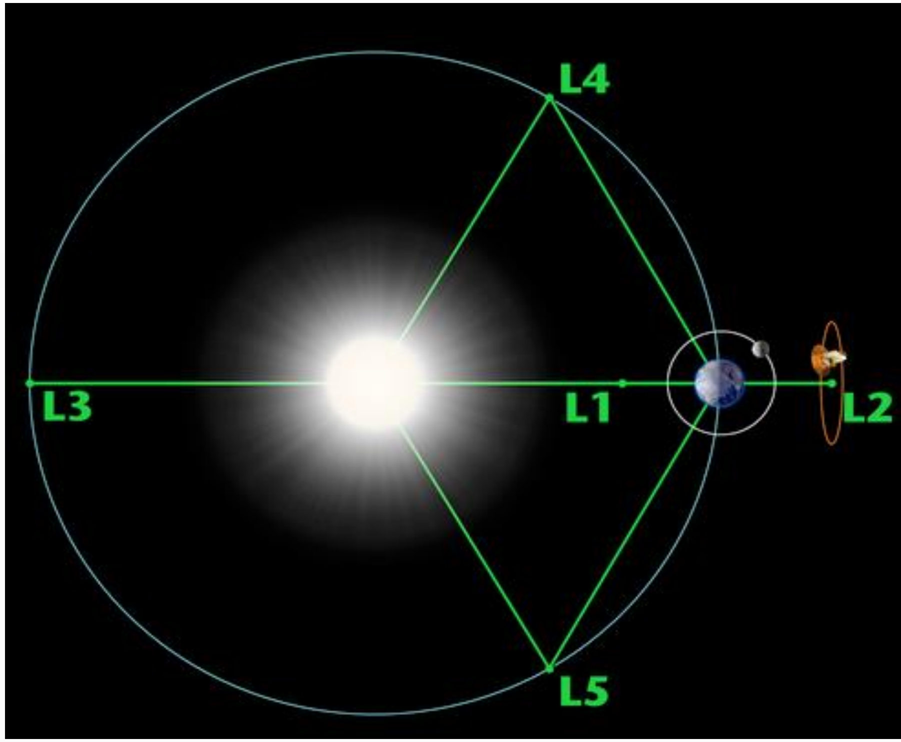
The L1 point

- **Uninterrupted view of the sun** and is currently home to the Solar and Heliospheric Observatory Satellite

The L2 point

- **Ideal for astronomy** because a spacecraft is close enough to readily communicate with Earth, **can keep Sun, Earth and Moon behind**

LAGRANGE POINTS



Significance

The L3 point

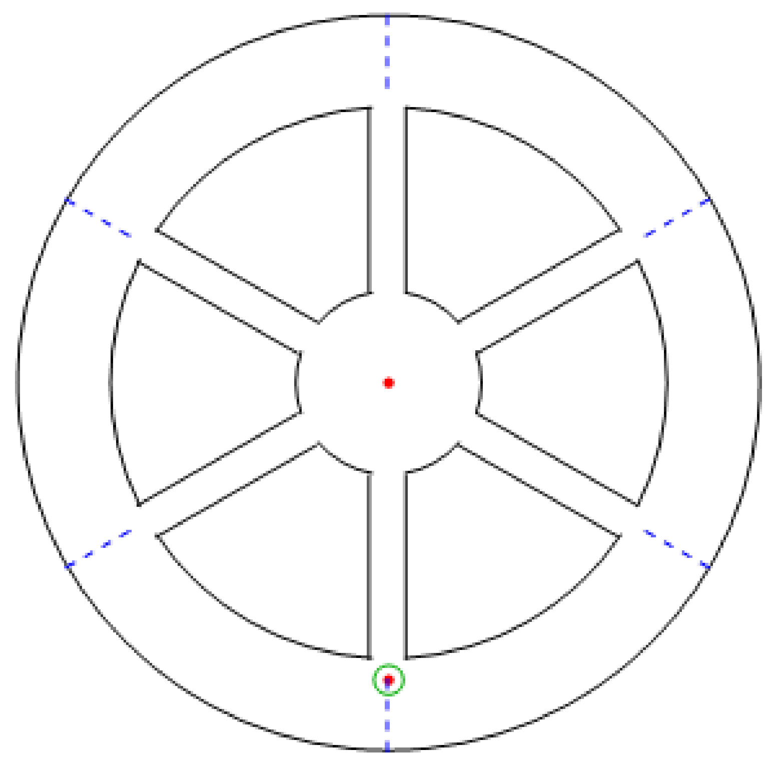
- ❑NASA is unlikely to find any use since it remains hidden behind the Sun at all times

L4 and L5 points

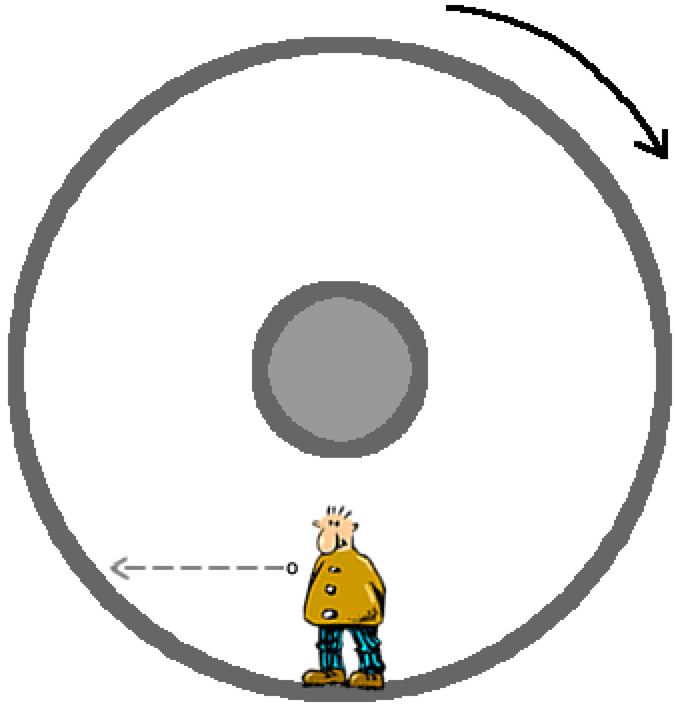
- ❑Are often called **Trojans** after the three large asteroids Agamemnon, Achilles and Hector that orbit in the L4 and L5 points of the Jupiter-Sun system

ARTIFICIAL GRAVITY

- A team from the **University of Colorado** is working on making a device which could create artificial gravity in space
- Artificial gravity is a force that **simulates the effect of gravity in a spaceship.**
- It is **not caused by the attraction to the Earth** but is instead caused by acceleration or centrifugal force.
- Artificial gravity or rotational gravity, is thus the appearance of a centrifugal force in a rotating frame of reference.



ARTIFICIAL GRAVITY

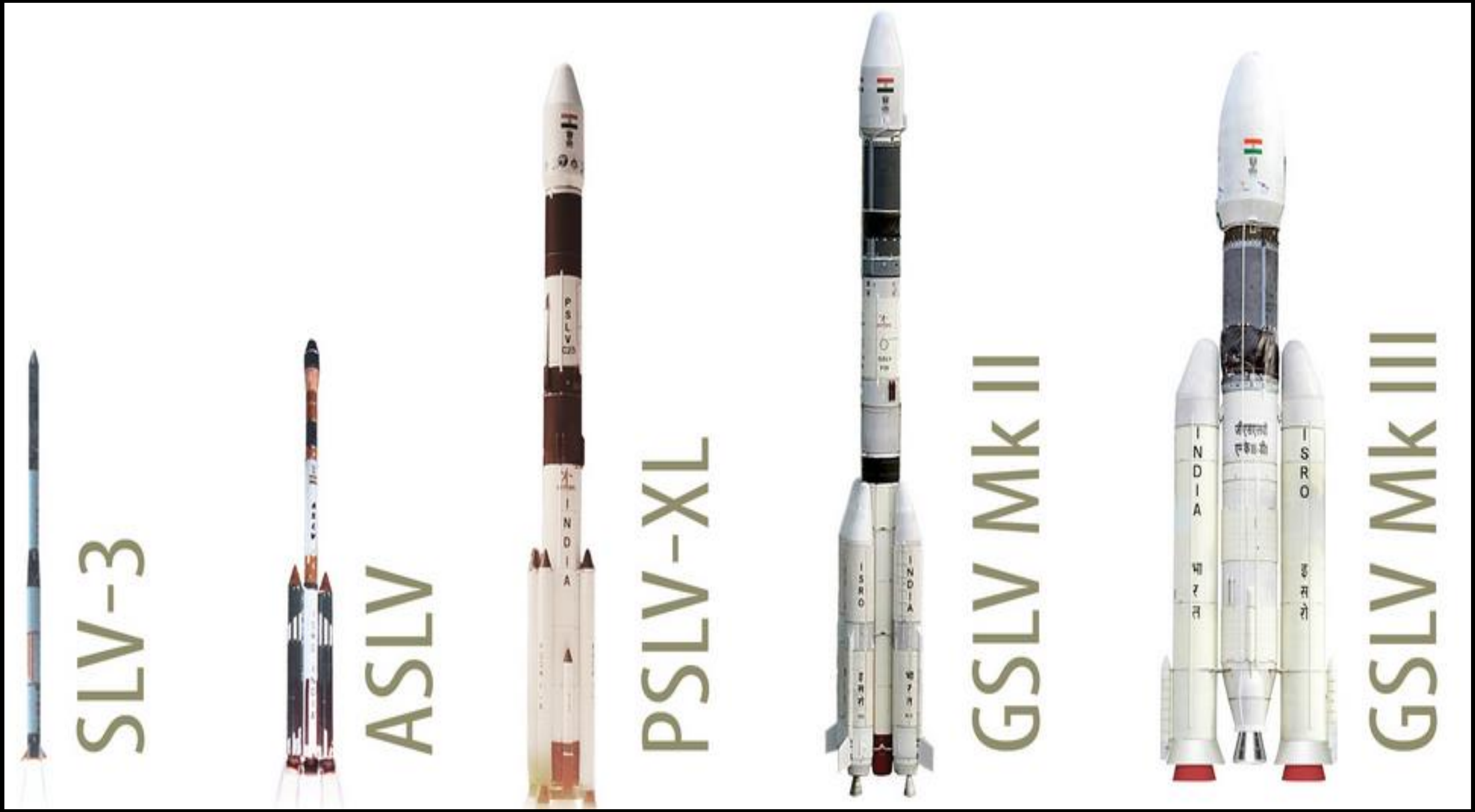


- The research centrifuge is called as **"Human Eccentric Rotator Device"** (HERD) and the device is compact enough to fit into a small room.
- Future astronauts heading into an artificial-gravity room to spend time on a small revolving system.

Significance

- It is built with the aim of counteracting the negative effects of weightlessness

Launch Vehicle



Launch Vehicle

Satellite Launch Vehicle (SLV-3)

- The first Indian **experimental Satellite** Launch Vehicle (SLV-3)
- **Four stage** vehicle (**All solid**)
- SLV-3 was successfully launched on July 18, **1980** from Sriharikota Range (SHAR), when **Rohini satellite, RS-1, was placed in orbit**

Launch Vehicle

Augmented Satellite Launch Vehicle (ASLV)

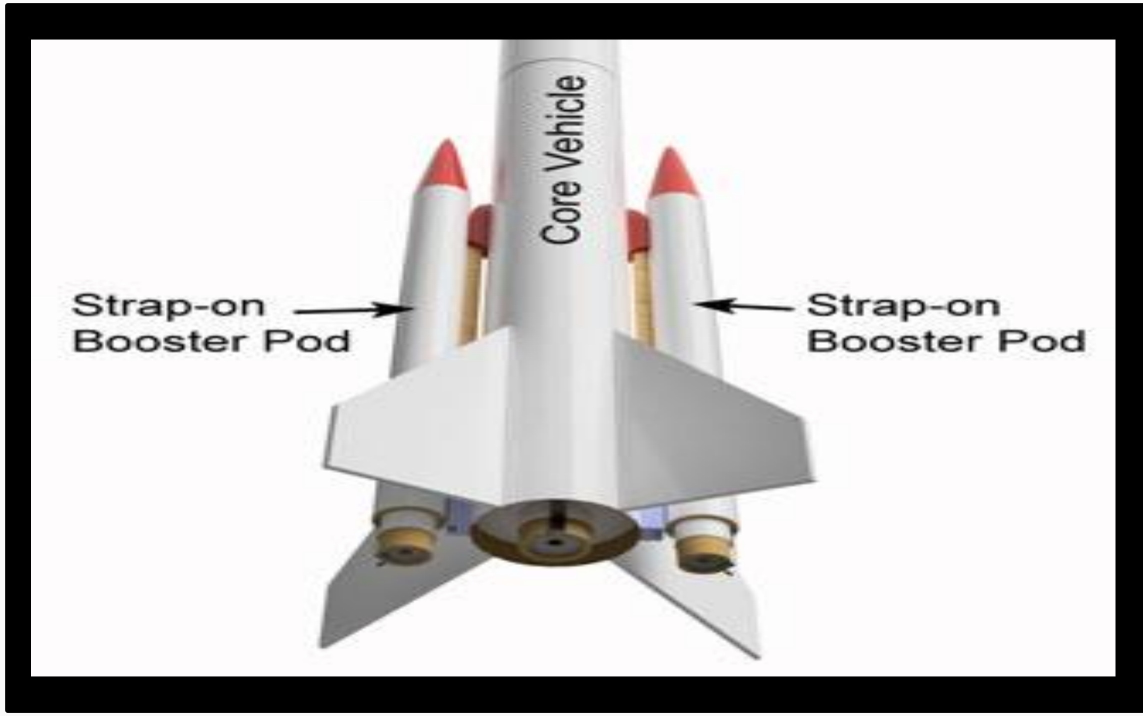
- Was launched successfully in 1992
- **Five stage, all-solid propellant vehicle**, with a mission of orbiting 150 kg class satellites into 400 km circular orbits.

SN	Title	Launch Date	Payload	Remarks
1	ASLV-D4	May 05, 1994	SROSS-C2	
2	ASLV-D3	May 20, 1992	SROSS-C	
3	ASLV-D2	Jul 13, 1988	SROSS-2	Mission Unsuccessful
4	ASLV-D1	Mar 24, 1987	SROSS-1	Mission Unsuccessful

Launch Vehicle

Strap on booster

- Strap-on boosters are attached to the side of a launch vehicle and **burn in parallel with the vehicle's main engines**.
- This allows **the thrust of the vehicle's main engine to be supplemented** by that of the strap-on booster without replacing the stage to be supplemented



Launch Vehicle

Polar Satellite Launch Vehicle (PSLV)

- Third generation launch vehicle of India.
- It is the **first Indian launch vehicle to be equipped with liquid stages**.
- After its first successful launch in **October 1994**, PSLV emerged as the reliable and versatile workhorse launch vehicle of India with 39 consecutively successful missions by June 2017.

Other

- Chandrayaan-1 in 2008
- Mars Orbiter Spacecraft in 2013

Launch Vehicle

Polar Satellite Launch Vehicle (PSLV)

3	PSLV-D3 / IRS-P3	Mar 21, 1996	PSLV-G	SSPO	IRS-P3	
2	PSLV-D2	Oct 15, 1994	PSLV-G	SSPO	IRS-P2	
1	PSLV-D1	Sep 20, 1993	PSLV-G	SSPO		Mission Unsuccessful

Launch Vehicle-PSLV

4 stages

Stage I

- It uses **solid rocket** motor that is augmented by **6 solid strap-on boosters**.
- Burn **hydroxyl-terminated polybutadiene (HTPB)**
- Strap on boosters are used only in G and XL variation

Stage II

- It uses **liquid rocket engine**, known as the **Vikas engine.**
- The second stage ignites after reaching **68.5km**
- **Di-methyl hydrazine fuel** and nitrogen tetroxide oxidiser

Launch Vehicle-PSLV

Stage III

- It uses **solid** rocket motor that provides high thrust after the atmospheric phase of the launch.
- The third stage is ignited at **248km**

Stage IV

- It comprises two **liquid** engines.
- **Monomethylhydrazine fuel and nitrogen tetroxide** oxidiser

Launch Vehicle-PSLV

Capacity –

- 1,750 kg of payload to Sun-Synchronous Polar Orbits
- 1,425 kg of payload to Geosynchronous and Geostationary orbits

Launch Vehicle-GSLV

- It is the 4th generation launch vehicle
- A **three-stage vehicle with four liquid strap-on boosters.**
- GSLV Mk II is the largest launch vehicle developed by India, which is currently in operation.

Stage I

- It uses **solid rocket** motor with **4 liquid strap-ons.**

Launch Vehicle-GSLV

Stage II

- It uses **liquid rocket** engine (similar to vikas engine of PSLV stage II).

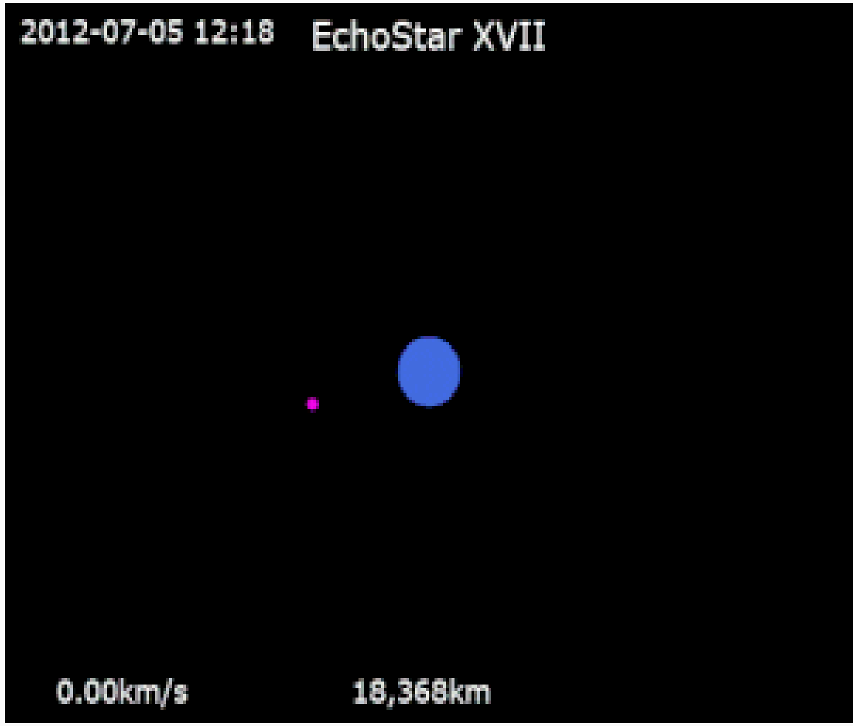
Stage III

- It uses India's **first cryogenic engine** in the upper stage.

Launch Vehicle-GSLV

Capacity

- It can take up to **5000 kg** of pay load to **Low Earth Orbits**
- **2500 kg** of payload to **Geosynchronous Transfer Orbit (GTO)**
- GSLV rockets using the **Russian Cryogenic Stage (CS) are designated as the GSLV Mk I.**
- GSLV rockets using the **indigenous Cryogenic Upper** Stage (CUS) are designated the **GSLV Mk II.**



Launch Vehicle-GSLV

Geosynchronous Satellite Launch Vehicle (GSLV MK III)

- GSLV Mk III is a **three-stage heavy lift launch** vehicle which has two solid strap-ons, a core liquid booster and a cryogenic upper stage.
- It is designed to carry **4000 kg** classes of satellites into Geosynchronous Transfer Orbit (GTO)
- **8000 kg** classes to Low Earth Orbit (LEO), which is about twice the capability of GSLV Mk II.
- It is the designated launch vehicle for India's upcoming moon mission and the first **human space flight** scheduled for 2022

Small Satellite Launch Vehicle

- Recently, **Indian Space Research Organisation (ISRO) launched the first flight of the Small Satellite Launch Vehicle(SSLV),** carrying an Earth observation satellite **EOS-02 and co-passenger students' satellite AzaadiSAT**.
- However, the **mission failed to place the satellites** in their required orbits, and the satellites, as they were already detached from the launch vehicle, were lost.

Small Satellite Launch Vehicle

Detail

- The rocket finally embarked on its first flight, carrying **two satellites**, including an earth observation micro-satellite called EOS-02.
- After a successful lift-off and **separation of its three stages**, the flight deviated from its script.
- ISRO initially said there was **data loss** in the final stages of the flight.
- Later in the afternoon, the space agency elaborated saying that the rocket placed **"the satellites into 356 km x 76 km elliptical orbit instead of 356 km circular orbit", adding that the "satellites are longer be usable"**

Small Satellite Launch Vehicle

What is SSLV?

- The Small Satellite Launch Vehicle (SSLV) is **India's smallest launch vehicle, weighing 110 tonnes.**
- As the name suggests, it is a **smaller launch vehicle compared to the more common PSLV.**
- Even though both are used to launch satellites into Low Earth Orbit, the technical configurations make them **different from each other**.
- While the **PSLV is 44 meters in height, SSLV tops at 34 meters**
- The newly developed rocket has been configured with **three solid stages** as against the **PSLV, which is a four-stage rocket**
- The **SSLV** has been designed to carry objects ranging up to **500 kilograms to a 500-kilometer planar orbit.**
- According to ISRO, **SSLV has a diameter of 2.1 metres** and the liftoff mass of the launch vehicle is approximately **120 tonnes.**
- The SSLV is a **low cost vehicle** due to its low turnaround time, minimal launch infrastructure requirements, and increased production rate from industries.

Small Satellite Launch Vehicle

Why do we need SSLV?

- With a growing market for the global launch services for small satellites, ISRO's **SSLV would make for an attractive option due to its low cost, ability to launch on demand**, and capacity of carrying multiple loads.
- Operating SSLV on smaller and more commercial missions will **free up the massively used Polar Satellite Launch Vehicle (PSLV)** for bigger missions to space.
- The PSLV has successfully conducted over 50 missions depositing not just domestic but also customer satellites into Low Earth Orbit (LEO).

Reusable Launch Vehicle Mission RLV LEX

Recently Indian Space Research Organisation and its partners **successfully demonstrated a precise landing experiment** for a **Reusable Launch Vehicle** at the Aeronautical Test Range (ATR), Chitradurga, Karnataka.

- One of the **first trials of an RLV was announced by ISRO as far back as 2010**, but was put off due **to technical reasons**. Another was hinted at in **2015** but was again grounded over technical issues.
- The **Reusable Launch Vehicle Autonomous Landing Mission** (RLV LEX) test was the **second of five tests that are a part of ISRO's efforts** to develop RLVs, or space planes/shuttles, which can travel to low earth orbits to deliver payloads and return to earth for use again.

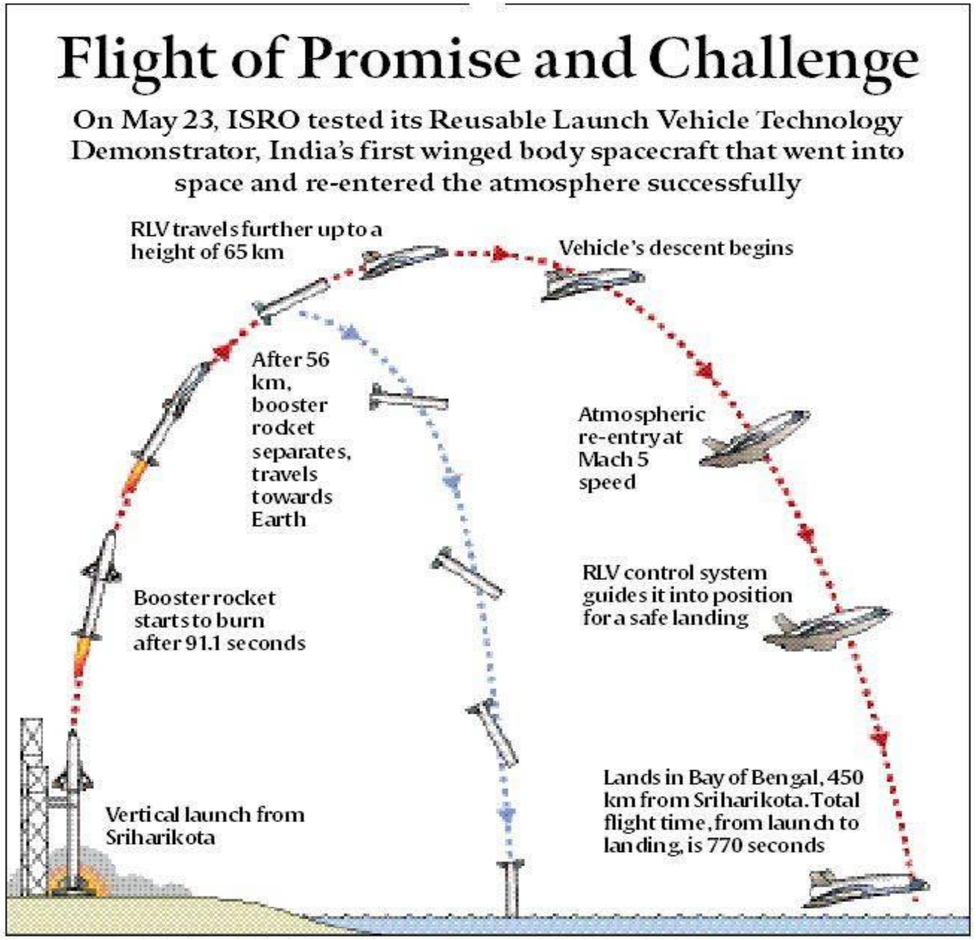
Reusable Launch Vehicle Mission RLV LEX

RLV TD project

- According to ISRO, the series of experiments with the winged RLV-TD are **part of efforts at developing essential technologies for a fully reusable launch vehicle to enable low-cost access to space**.
- The RLV-TD will be used to develop **technologies like hypersonic flight (HEX), autonomous landing (LEX), return flight experiment (REX), powered cruise flight, and Scramjet Propulsion Experiment (SPEX)**.

Reusable Launch Vehicle Mission RLV LEX

- ISRO's RLV-TD looks like an **aircraft**. It consists of a fuselage, a nose cap, double delta wings, and twin vertical tails. The 2016 experiment involved sending a winged spacecraft on a rocket powered by a conventional solid booster (HS9) engine used by ISRO into space.
- The spacecraft traveled at a **speed of Mach 5** (five times the speed of sound) when re-entering the earth's orbit and traveled a distance of 450 km before splashdown in the Bay of Bengal.



Reusable Launch Vehicle Mission RLV LEX

What are its advantages?

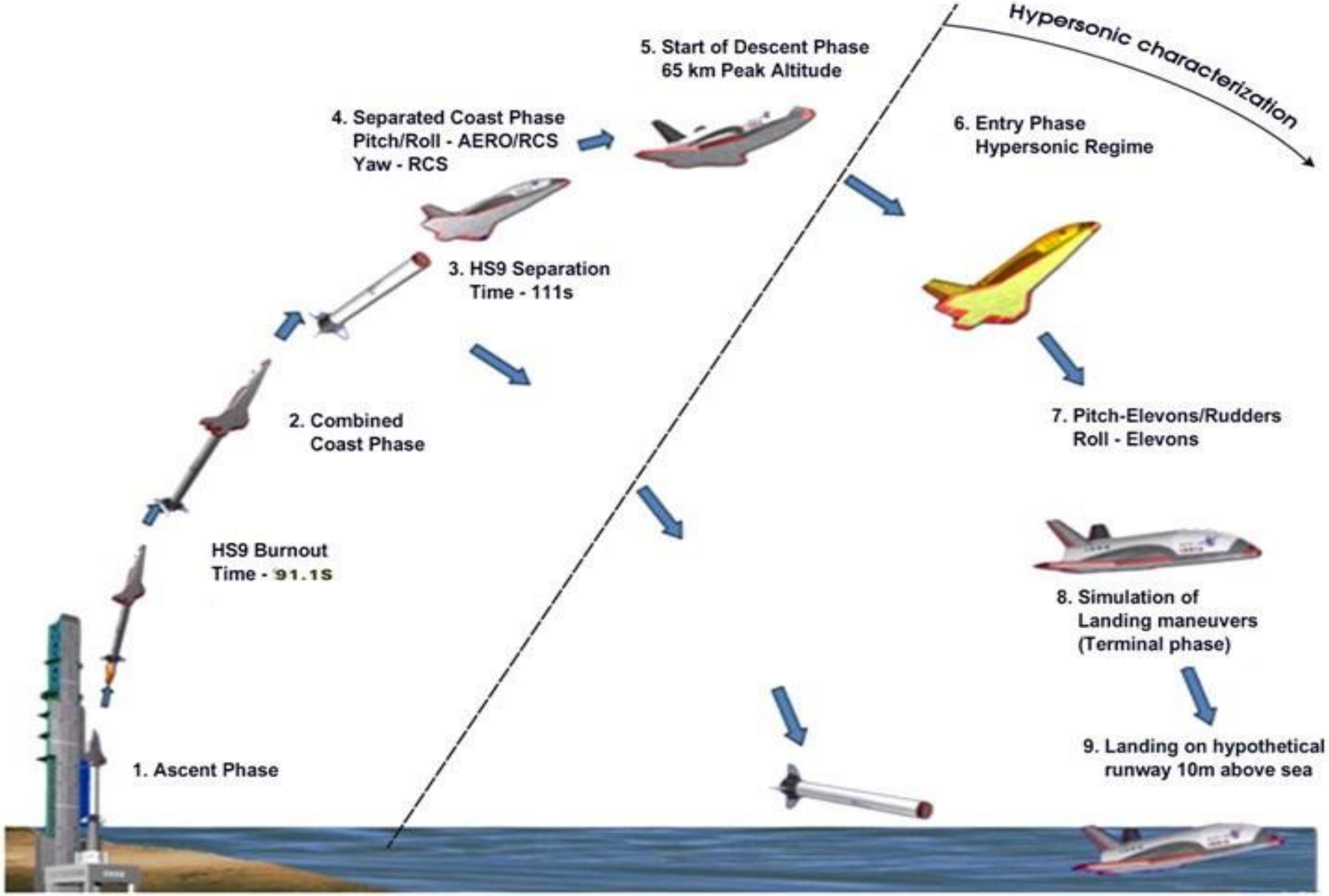
- With the costs acting as a major deterrent to space exploration, a reusable launch vehicle is considered a **low-cost, reliable, and on-demand mode of accessing space.**
- **Nearly 80 to 87 percent of the cost in a space launch vehicle goes into the structure of the vehicle.**
- The **costs of propellants are minimal in comparison**.
- By using RLVs the **cost of a launch can be reduced by nearly 80 percent of the present cost**

Reusable Launch Vehicle Mission RLV LEX

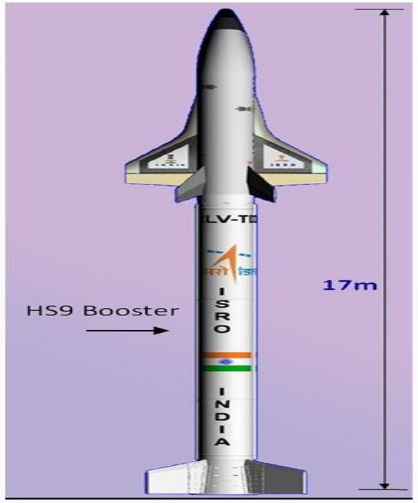
How advanced are RLV technologies globally?

- Reusable space vehicles have been in **existence for a long time with NASA** space shuttles carrying out dozens of human space flight missions.
- The use case for reusable space launch vehicles has revived with the private space launch services provider **Space X** demonstrating partially reusable launch systems with its Falcon 9 and Falcon Heavy rockets since 2017. SpaceX is also working on a fully reusable launch vehicle system called Starship.

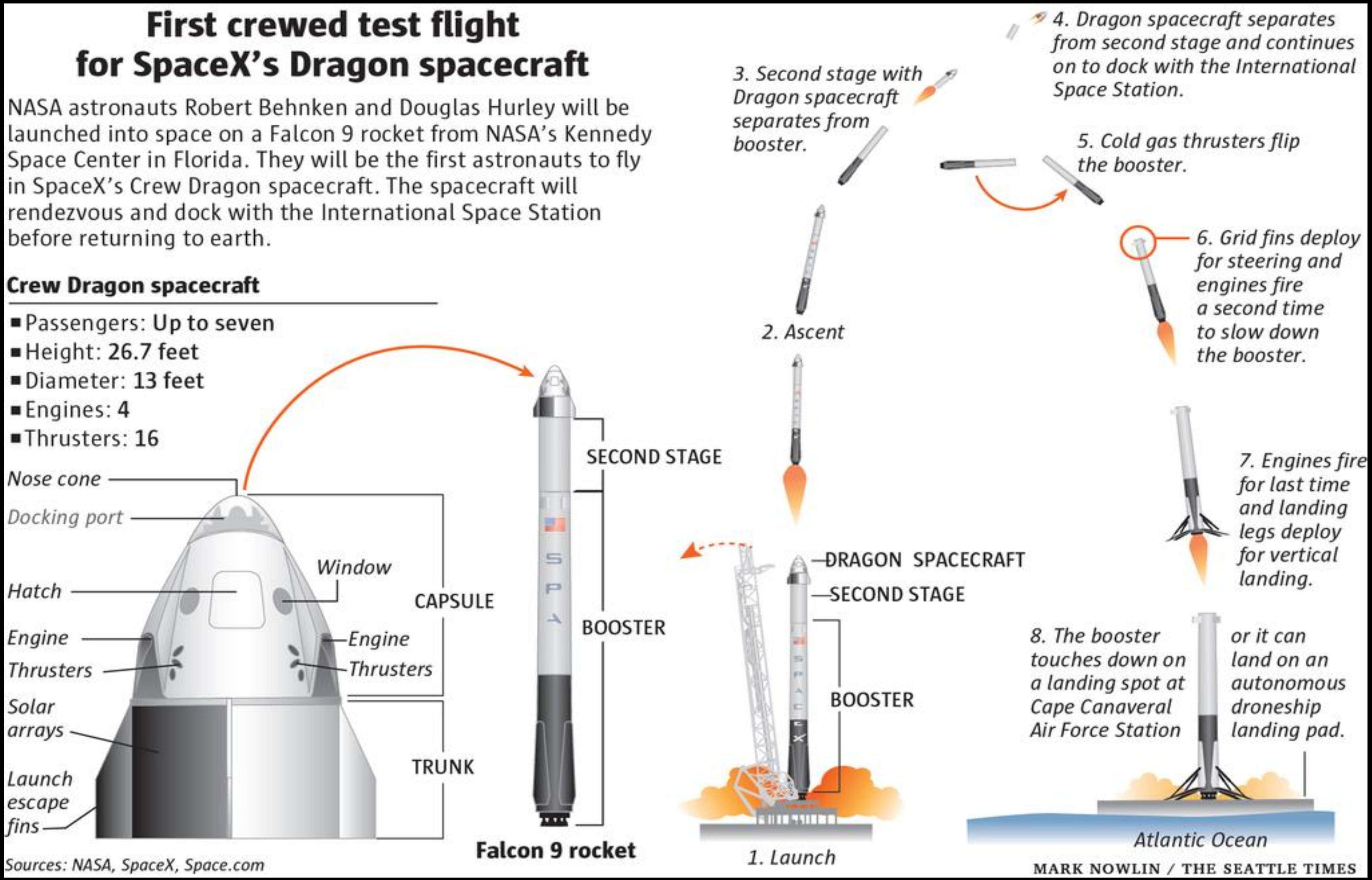
RLV-TD



Hypersonic characterization
5. Start of Descent Phase
65 km Peak Altitude
4. Separated Coast Phase
Pitch/Roll - AERO/RCS
Yaw - RCS
6. Entry Phase
Hypersonic Regime
3. HS9 Separation
Time - 111s
2. Combined
Coast Phase
7. Pitch-Elevons/Rudders
Roll - Elevons
HS9 Burnout
Time - 91.1s
8. Simulation of
Landing maneuvers
(Terminal phase)
9. Landing on hypothetical
runway 10m above sea
1. Ascent Phase



RLV-TD
ISRO
INDIA
17m
HS9 Booster


First crewed test flight for SpaceX's Dragon spacecraft
NASA astronauts Robert Behnken and Douglas Hurley will be launched into space on a Falcon 9 rocket from NASA's Kennedy Space Center in Florida. They will be the first astronauts to fly in SpaceX's Crew Dragon spacecraft. The spacecraft will rendezvous and dock with the International Space Station before returning to earth.
Crew Dragon spacecraft
Passengers: Up to seven
Height: 26.7 feet
Diameter: 13 feet
Engines: 4
Thrusters: 16
Nose cone
Docking port
Window
Hatch
Engine
Thrusters
Engine
Thrusters
Solar arrays
Launch escape fins
CAPSULE
TRUNK
SECOND STAGE
BOOSTER
Falcon 9 rocket
Sources: NASA, SpaceX, Space.com
1. Launch
DRAGON SPACECRAFT
SECOND STAGE
BOOSTER
2. Ascent
3. Second stage with Dragon spacecraft separates from booster.
4. Dragon spacecraft separates from second stage and continues on to dock with the International Space Station.
5. Cold gas thrusters flip the booster.
6. Grid fins deploy for steering and engines fire a second time to slow down the booster.
7. Engines fire for last time and landing legs deploy for vertical landing.
8. The booster touches down on a landing spot at Cape Canaveral Air Force Station
or it can land on an autonomous droneship landing pad.
Atlantic Ocean
MARK NOWLIN / THE SEATTLE TIMES

Next-Gen Launch Vehicle (NGLV)

- The Indian Space Research Organisation (ISRO) is developing a Next-Gen Launch Vehicle (NGLV), which will one day **replace operational systems like the Polar Satellite Launch Vehicle (PSLV)**, ISRO Chairman S. Somanath has said.

Next-Gen Launch Vehicle

- In NGLV, ISRO is understood to be looking at a **cost-efficient, three-stage, reusable heavy-lift vehicle** with a payload capability of **10 tonnes** to **Geostationary Transfer Orbit**.
- NGLV will feature **semi-cryogenic propulsion** (refined kerosene as fuel with liquid oxygen (LOX) as oxidiser) for the booster stages which is cheaper and efficient.
- NGLV will feature a **simple, robust design that allows bulk manufacturing, modularity in systems, sub-systems and stages** and minimal turnaround time.
- Potential uses will be in the areas of **launching communication satellites, deep space missions, future human spaceflight and cargo missions**

Vikram-S rocket

- **India's first privately developed launch vehicle** is set to make its maiden flight from Indian Space Research Organisation's (ISRO) launchpad at Sriharikota between November 12 and 16.

Mission Prarambh

- The mission, of **Hyderabad-based Skyroot Aerospace**, is called '**Prarambh'** (the beginning), and will **carry two Indian and one foreign customer payloads** on the launch vehicle named '**Vikram'.**
- Prarambh will see **Vikram-S carry three customer satellites in a sub-orbital flight**.
- **Sub-orbital flight**, like the ones undertaken by Jeff Bezos and Richard Branson, travel **slower than orbital velocity** — they are fast enough to reach outer space but **not fast enough to stay in orbit around the Earth.**

Vikram-S rocket

Vikram-S rocket

- The Vikram-S rocket is a **single-stage sub-orbital launch vehicle** which will carry three customer payloads and help test and validate technologies in the Vikram series space launch vehicles
- Its launch vehicles have been crafted specially for the small satellite market, and are **named 'Vikram' as a tribute to Vikram Sarabhai**, founder of the Indian space programme. They come in three forms, **Vikram I, II, and III.**
- The leading technology architecture of Vikram vehicles offers **unique capabilities like multi-orbit insertion, interplanetary missions;** while providing customised, dedicated and ride share options covering a wide spectrum of small satellite customer needs

Vikram-S rocket

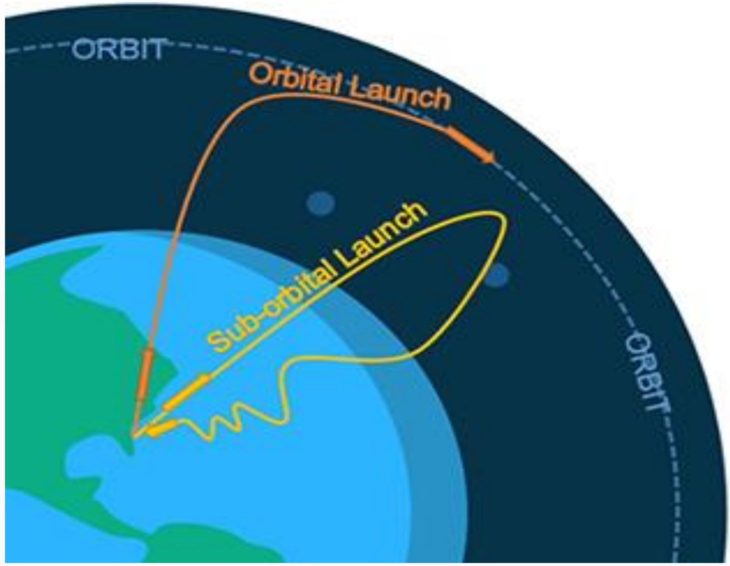
- Skyroot claims a Vikam rocket can be **assembled and launched within 24 hours** from any launch site, and has the "lowest cost in the payload segment"
- Built using an **all-carbon fibre structure**, the **Vikram series rockets** are capable of carrying **up to 800 kg payloads to the Low Earth Orbit (LEO).**

Vikram Series- Skyroot

	Vikram-I	**Vikram-II**	**Vikram-III**
Payload	480 kg to 500 km Low Inclination Orbit 290 kg to 500 km SSPO	595 kg to 500 km Low Inclination Orbit 400 kg to 500 km SSPO	815 kg to 500 km Low Inclination Orbit 560 kg to 500 km SSPO
Architecture	Highly reliable solid propulsion stages	Advanced **Cryogenic** Methalox engine replaces upper stage of Vikram 1 .	An Upgrade to Vikram 2 With Additional low cost Strapped on Solid Rocket Boosters
			

Vikram-S rocket

Sleepy Classes IAS
Awakening Toppers



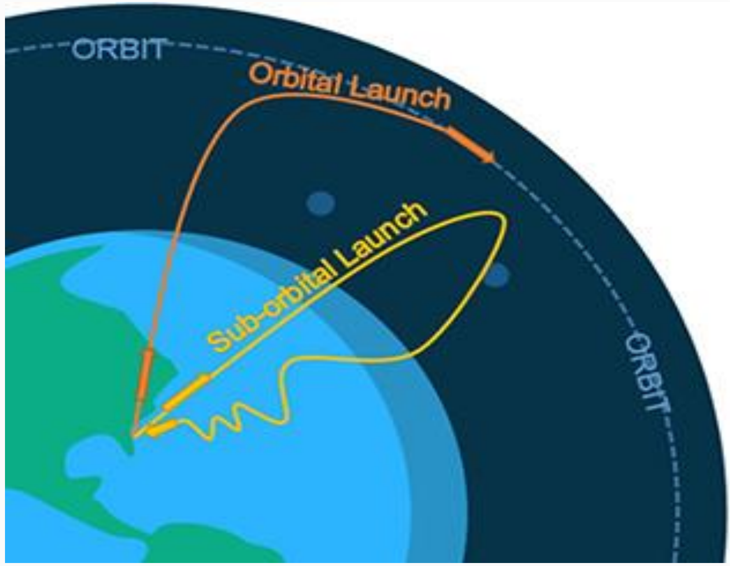
Suborbital flight

- Any object travelling **slower than 28,000 km/hr** must eventually return to Earth.
- These are suborbital flights, because they will **not be travelling fast enough to orbit Earth** once they reach the "edge of space".
- Such a trip allows space travellers to **experience a few minutes of "weightlessness"**
- If an object travels at **40,000 km/hr, it will achieve what is known as "escape velocity"**, and never return to Earth

Vikram-S rocket

Orbital flight

- When an object travels at a horizontal speed of about **28,000 km/hr** or more, it goes into orbit once it is above the atmosphere.
- Satellites need to reach that threshold speed in order to do orbit Earth.
- Such a satellite would accelerating toward the Earth due to gravity.
- However, it moves fast enough that the Earth curves out from under it as fast as it falls, giving it a circular path



Agnibaan SOrTeD rocket

Context-Indian spacetech start-up **AgniKul** one step closer to launching world's first **3D printed** rocket into space

- A successful launch would make **AgniKul the second Indian spacetech start-up to send its launch vehicle** into space after Skyroot Aerospace.

Agnibaan

- AgniKul Cosmos has commenced the process of integrating its cutting-edge Agnibaan SOrTeD rocket at its private launchpad in Sriharikota spaceport
- Agnibaan SOrTeD is a **single-stage launch vehicle** powered by AgniKul's patented **3D printed semi-cryogenic Agnilet engine**
- The rocket is equipped to haul **payloads of up to 100 kilos to a 700 km distance in space** and has been praised for its 'plug-and-play' design

Agnibaan SOrTeD rocket

- Agnibaan SOrTeD is a single-stage launch vehicle powered by AgniKul's patented Agnilet engine, which is an entirely 3D-printed, single-piece, 6 kilonewton (kN) semi-cryogenic engine.
- However, unlike traditional sounding rockets that launch from guide rails, Agnibaan SOrTeD will lift-off vertically and follow a predetermined trajectory to perform a precisely orchestrated set of manoeuvres during flight.
- AgniKul, assisted by the Indian Space Research Organisation (ISRO) and the promotion and regulation body IN-SPACe, has ideated and built the launchpad.

Agnibaan SOrTeD rocket

World's first 3D printed engine

- The Agnibaan rocket, initiated by the **ground-breaking Agnilet cryogenic engine,** is described as a remarkably adaptable, two-stage launch vehicle.
- It is equipped to haul payloads of up to 100 kilos to a 700 km distance in the LEO. Experts have praised the rocket's 'plug-and-play' design that allows for accurate mission configuration.
- The Agnilet engine, which powers the entire operation, is also the first of its kind. It is the **world's sole single-piece 3D-printed engine.**
- Following its initial trial in early 2021, it was verified at the Vikram Sarabhai Space Centre (VSSC) in Thiruvananthapuram.

Green Propellants

- ISRO is developing green propellants for use in future rocket & satellite propulsion systems.
- It has made a beginning by developing an **eco-friendly solid propellant** to eliminate the emission of chlorinated exhaust products from rocket.
- The propellants are **based on Glycidyl Azide Polymer (GAP) as fuel and Ammonium Di-Nitramide (ADN) as oxidizer.**
- ISRO is also carrying out various technology demonstration projects involving green propellant combinations such as **Hydrogen Peroxide (H2O2), Kerosene, Liquid Oxygen (LOX), Liquid Methane etc.**

Green Propellants

- ISRO already used Liquid oxygen and liquid hydrogen combination in cryogenic upper stage of GSLV MK-III.

ISROSENE

- Rocket grade version of **kerosene** as an alternative to conventional hydrazine rocket fuel.

CRYOGENIC ENGINE

- Cryogenics is the science that addresses the production and effects of very low temperatures.
- A cryogenic rocket engine uses a cryogenic fuel or oxidizer, which are gases liquefied and stored at very low temperatures.
- Hydrogen remains liquid at temperatures of -253 degC
- Oxygen remains in a liquid state at temperatures of -183 degC .

CRYOGENIC ENGINE

Challenges

- Amongst all rocket fuels, **hydrogen is known to provide the maximum thrust.**
- But hydrogen, in its **natural gaseous form**, is **difficult to handle**, and, therefore, **not used in normal engines in rockets like PSLV.** However, **hydrogen can be used in liquid form**.
- Creating such a **low-temperature atmosphere in the rocket** is a **difficult proposition**, because it creates problems for other material used in the rocket.

Artemis Mission

NASA made a **third attempt to send its new 322-foot-tall, multi-billion-dollar rocket known as the Space Launch System (SLS),** to the **Moon.**

- The debut flight of the rocket was scrubbed **twice earlier,** on August 29 and September 3, after **technical issues** were detected during the countdown.

Artemis 1

- This mission, known as Artemis 1, is **unmanned**, and is intended to **test the rocket and the Orion space capsule,** in which **astronauts will ride on future missions.**
- The **uncrewed Orion spacecraft successfully completed** a lunar **departure burn on Dec. 1** to begin heading home after successful moon orbits.

Artemis Mission

Why Artemis 1 matters

- It's been a **half century since the six Apollo human Moon landings** between 1969 and 1972.
- Since then, spacecraft have travelled beyond the solar system, exploratory missions have probed Mars, Jupiter, and Saturn, more than 500 astronauts have made return trips to space, and permanent space labs have been set up.
- What **remains to be achieved, however, is the promise of transporting humans to new worlds**, of landing and living on other planets, or maybe meeting aliens.
- **Artemis 1 is seen as the first step into that new space age**. In the missions that will follow, **human beings will go back to the Moon,** explore the possibilities of long lunar stays, and assess the potential of the Moon as a launch pad for explorations into deep space.

Artemis Mission

- While the mission objectives of Artemis 1 itself are **humble — it is only a lunar Orbiter mission even though, unlike most Orbiter missions**, it has a **return-to-Earth target** — it is intended to lay the foundations for more complex and ambitious missions.

Artemis Mission

Artemis II:

- It will take off in **2024.**
- It will have a crew aboard Orion and will be a test mission **to confirm that all of the spacecraft's systems will operate as designed** when it has humans on board.
- But the Artemis II launch will be **similar to that of Artemis I**.
- A **crew of four astronauts** will be aboard Orion as it and ICPS orbit the Earth twice before moving to the direction of the Moon.

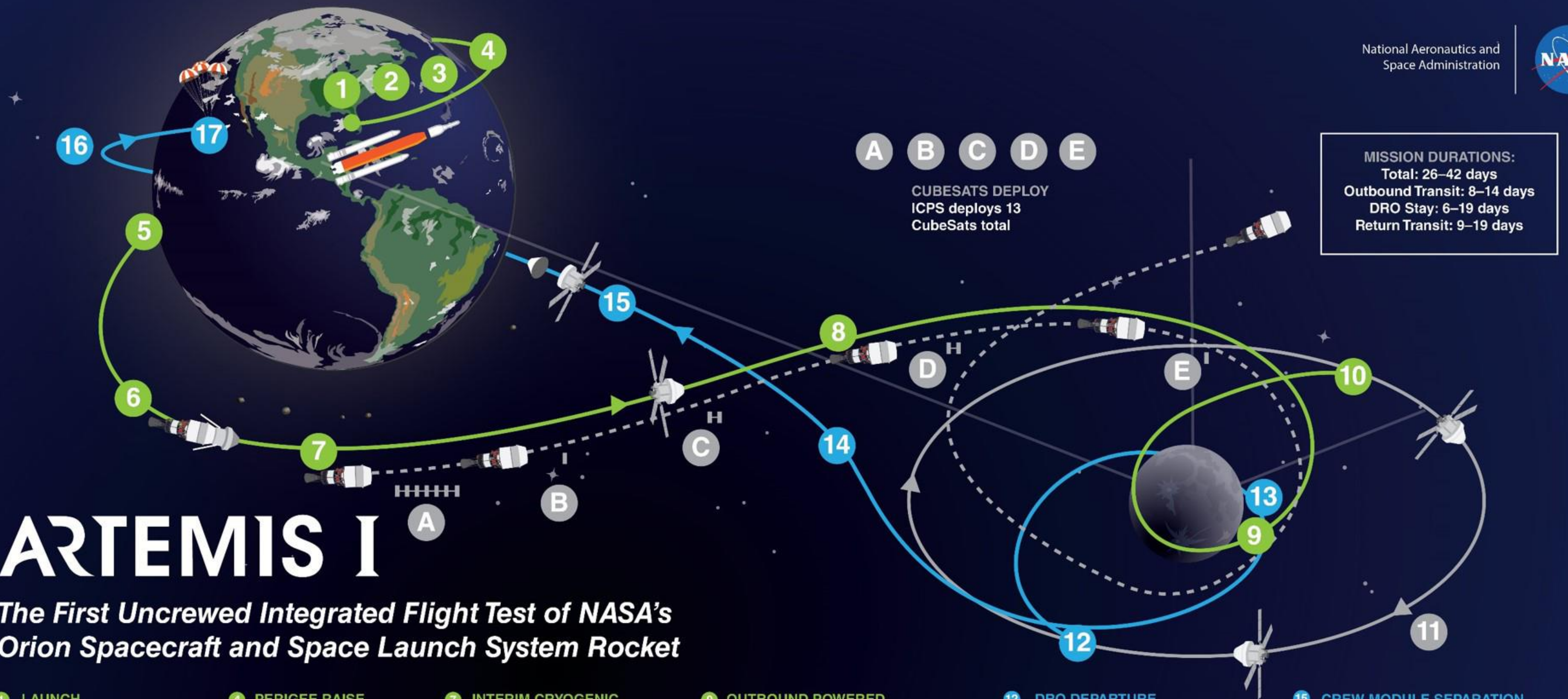
Artemis III:

- It is scheduled for 2025, and is expected to **ferry astronauts to the moon for the first time since the apollo missions.**

National Aeronautics and Space Administration

ARTEMIS I

The First Uncrewed Integrated Flight Test of NASA's Orion Spacecraft and Space Launch System Rocket



1 **LAUNCH**
SLS and Orion lift off from pad 39B at Kennedy Space Center.

2 **JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**

3 **CORE STAGE MAIN ENGINE CUT OFF**
With separation.

4 **PERIGEE RAISE MANEUVER**

5 **EARTH ORBIT**
Systems check with solar panel adjustments.

6 **TRANS LUNAR INJECTION (TLI) BURN**
Maneuver lasts for approximately 20 minutes.

7 **INTERIM CRYOGENIC PROPULSION STAGE (ICPS) SEPARATION AND DISPOSAL**
The ICPS has committed Orion to TLI.

8 **OUTBOUND TRAJECTORY CORRECTION (OTC) BURNS**
As necessary adjust trajectory for lunar flyby to Distant Retrograde Orbit (DRO).

9 **OUTBOUND POWERED FLYBY (OPF)**
60 nmi from the Moon; targets DRO insertion.

10 **LUNAR ORBIT INSERTION**
Enter Distant Retrograde Orbit.

11 **DISTANT RETROGRADE ORBIT**
Perform half or one and a half revolutions in the orbit period 38,000 nmi from the surface of the Moon.

12 **DRO DEPARTURE**
Leave DRO and start return to Earth.

13 **RETURN POWERED FLYBY (RPF)**
RPF burn prep and return coast to Earth initiated.

14 **RETURN TRANSIT**
Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere.

15 **CREW MODULE SEPARATION FROM SERVICE MODULE**

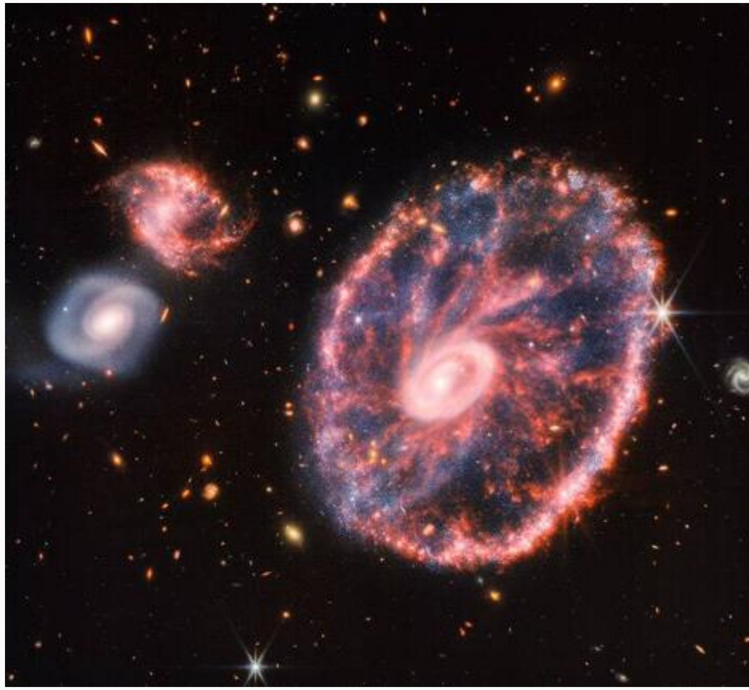
16 **ENTRY INTERFACE (EI)**
Enter Earth's atmosphere.

17 **SPLASHDOWN**
Pacific Ocean landing within view of the U.S. Navy recovery ship.

James Webb Space Telescope (JWST)

Recently James Webb Space Telescope (JWST) has produced the deepest and **sharpest infrared image of the distant universe** that has ever been seen, heralding a major event in astronomy.

- Thousands of galaxies — including the faintest objects ever observed in the infrared — have appeared in Webb's view for the first time, all captured in a relatively small area.



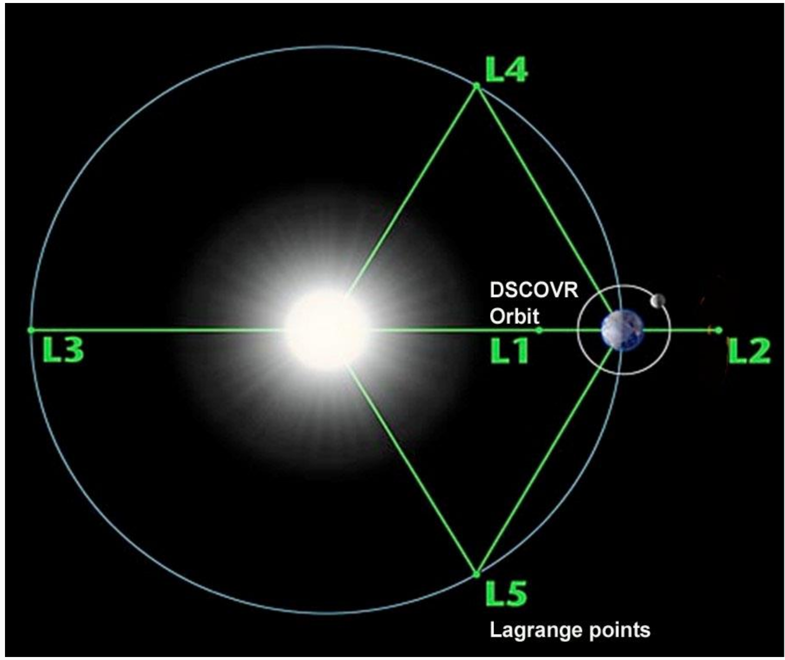
What can be seen in the image?

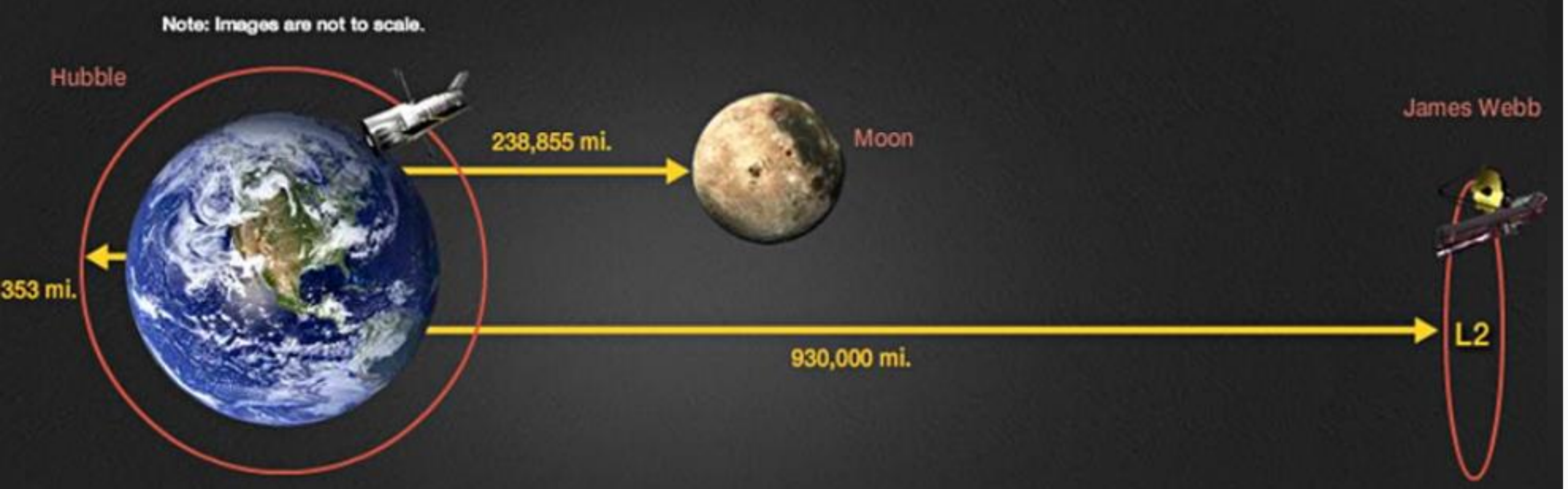
- Calling it "Webb's First Deep Field", NASA said the image shows **galaxies that were once invisible to us**.
- The image shows shining objects packed together in hues of blue and orange. Swirling, faraway galaxies — similar to how the Milky Way looks — are also visible.
- Light travels at 186,000 miles per second. And that light that you are seeing on one of those little specks has been **travelling for over 13 billion years**

James Webb Space Telescope (JWST)

What is NASA's James Webb Telescope?

- The telescope has been in the works for years.
- NASA led its development with the **European Space Agency (ESA) and the Canadian Space Agency.**
- It was launched aboard a rocket on December 25, 2021, and is currently at a point in space known as the **Sun-Earth L2 Lagrange point,** approximately 1.5 million km beyond Earth's orbit around the Sun.
- Lagrange Point 2 is one of the five points in the orbital plane of the Earth-Sun system.
- Named after Italian-French mathematician Josephy-Louis Lagrange, the points are in any revolving two-body system like Earth and Sun, marking where the **gravitational forces of the two large bodies cancel each other out.**





The Hubble Space Telescope orbits around the Earth at an altitude of ~353 miles above it.

Webb will not actually orbit the Earth - instead it will sit at the Earth-Sun L2 Lagrange point, 930,000 miles away. At the L2 point Webb's solar shield will block the light from the Sun, Earth, and Moon. This will help Webb stay cool, which is very important for an infrared telescope. As the Earth orbits the Sun, Webb will orbit with it - but stay fixed in the same spot with relation to the Earth and the Sun. Webb will orbit around the L2 point. It won't stay completely motionless at a fixed spot.

James Webb Space Telescope (JWST)

- Objects placed at these positions are **relatively stable and require minimal external energy or fuel** to keep themselves there, and so many instruments are positioned here.
- L2 is a position directly behind Earth in the line joining the Sun and the Earth. **It would be shielded from the Sun by the Earth as it goes around the Sun, in sync with the Earth**.

James Webb Space Telescope (JWST)

What is the mission of the James Webb Space Telescope?

- NASA says the James Webb Space Telescope will be "a giant leap forward in our quest to understand the Universe and our origins", as it will examine every phase of cosmic history: from the **Big Bang to the formation of galaxies, stars, and planets to the evolution of our own Solar System**

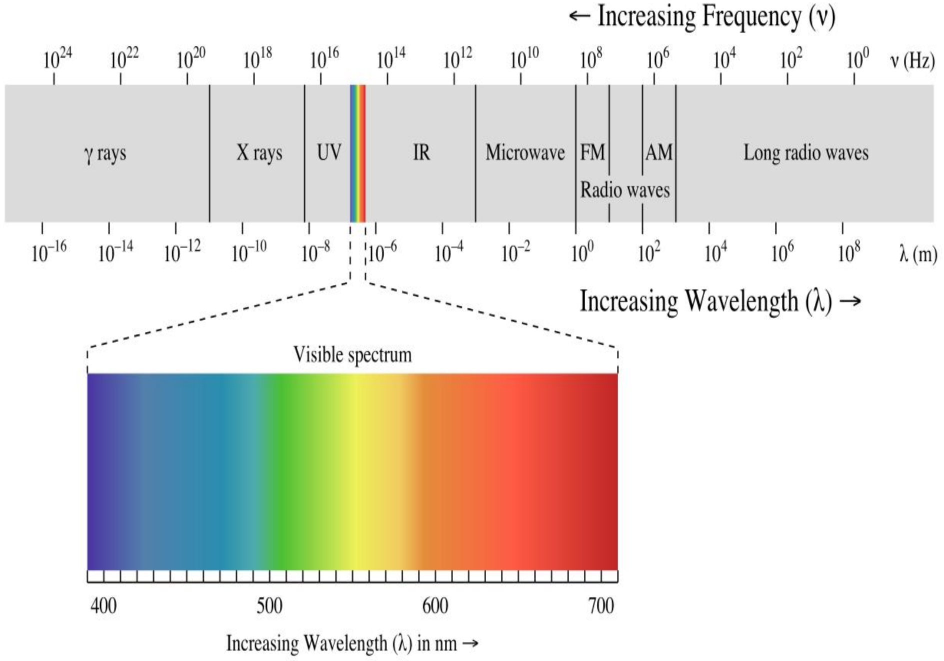
The science goals for the Webb can be grouped into four themes-

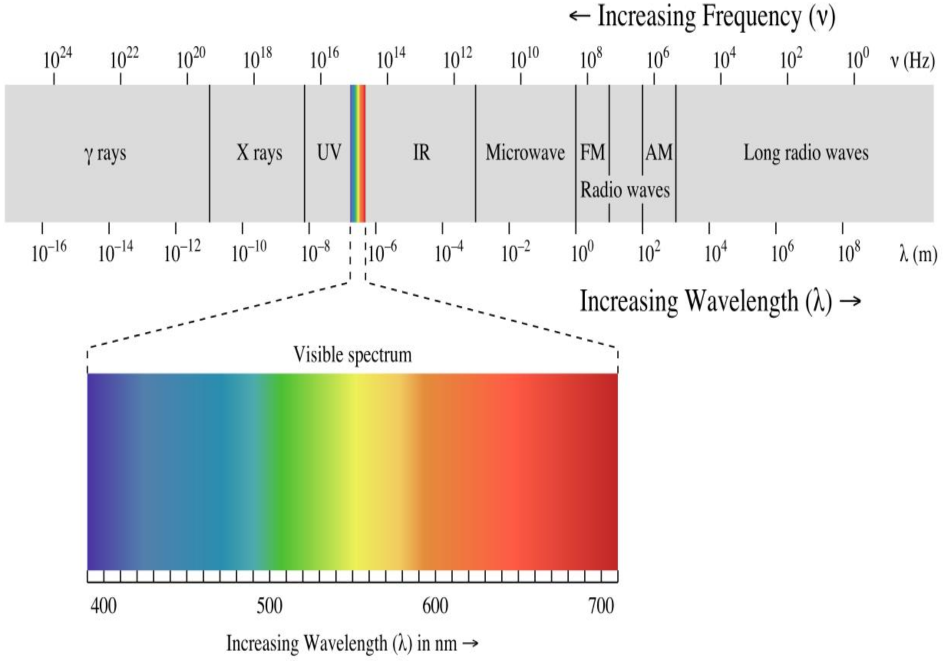
- **The first** is to look back around **13.5 billion years** to see the first stars and galaxies forming out of the darkness of the **early universe**.
- **Second**, to compare the **faintest, earliest galaxies to today's grand spirals** and understand how galaxies assemble over billions of years.
- Third, to see **where stars and planetary systems** are being born. And
- Fourth, **to observe the atmospheres of extrasolar planets** (beyond our solar system), and perhaps find the building blocks of life elsewhere in the universe. The telescope will also study objects within our own Solar System.

James Webb Space Telescope (JWST)

Hubble Vs James web telescope

- The **JWST will be able to see right through and into massive clouds of dust** that are opaque to earlier generation **visible-light observatories like the Hubble Telescope.**
- Another difference is that the Webb is equipped with cameras and other **instruments sensitive to infrared or "heat" radiation, and the Hubble is not.**
- The expansion of the universe causes the light that **would normally be in wavelengths that are visible to be shifted to longer infrared wavelengths**, normally invisible to human eyes




← Increasing Frequency (ν)
10^24 10^22 10^20 10^18 10^16 10^14 10^12 10^10 10^8 10^6 10^4 10^2 10^0 ν (Hz)
γ rays
X rays
UV
IR
Microwave
FM
AM
Radio waves
Long radio waves
10^−16 10^−14 10^−12 10^−10 10^−8 10^−6 10^−4 10^−2 10^0 10^2 10^4 10^6 10^8 λ (m)
Increasing Wavelength (λ) →
Visible spectrum
400
500
600
700
Increasing Wavelength (λ) in nm →

Juice mission

The European Space Agency (ESA) plans to **launch the Jupiter Icy Moons Explorer mission in April 2023**.

About Juice mission

- The Juice mission will complete **35 fly-bys near Jupiter** and will make detailed observations about the gas giant and its three large ocean-bearing moons–**Europa, Ganymede and Callisto.**
- Apart from exploring Jupiter's environment in depth using the ten sensors aboard, the mission will also characterise its moons as both planetary objects and potential habitat.
- The Juice spacecraft will monitor Jupiter's complex environment in depth including its magnetism, radiation and plasma. After it completes its 35 fly-bys near Jupiter and its Moons, it will also become the **first spacecraft to shift its own orbit to another world by moving to Ganymede's orbit.**

Juice mission

- Among the three moons, **Ganymede will be the primary scientific target** of the Juice mission. It is the **largest moon in the Solar System** and is larger than both Pluto and Mercury. It is also the **only moon to have its own intrinsic magnetic field**.
- Mercury and Earth are the only other solid bodies that generate a dipole field like Ganymede.
- Also, Juice will study the **Galilean moons' hidden oceans, magnetism**, heating processes, tidal effects, orbits, surface activity, cores, compositions, atmospheres and space environments to investigate whether the conditions necessary for life could have ever emerged on these three moons. The spacecraft's high-resolution mapping will hunt for biologically essential and important elements like carbon, oxygen, nitrogen, magnesium and iron.

Tiangong space station

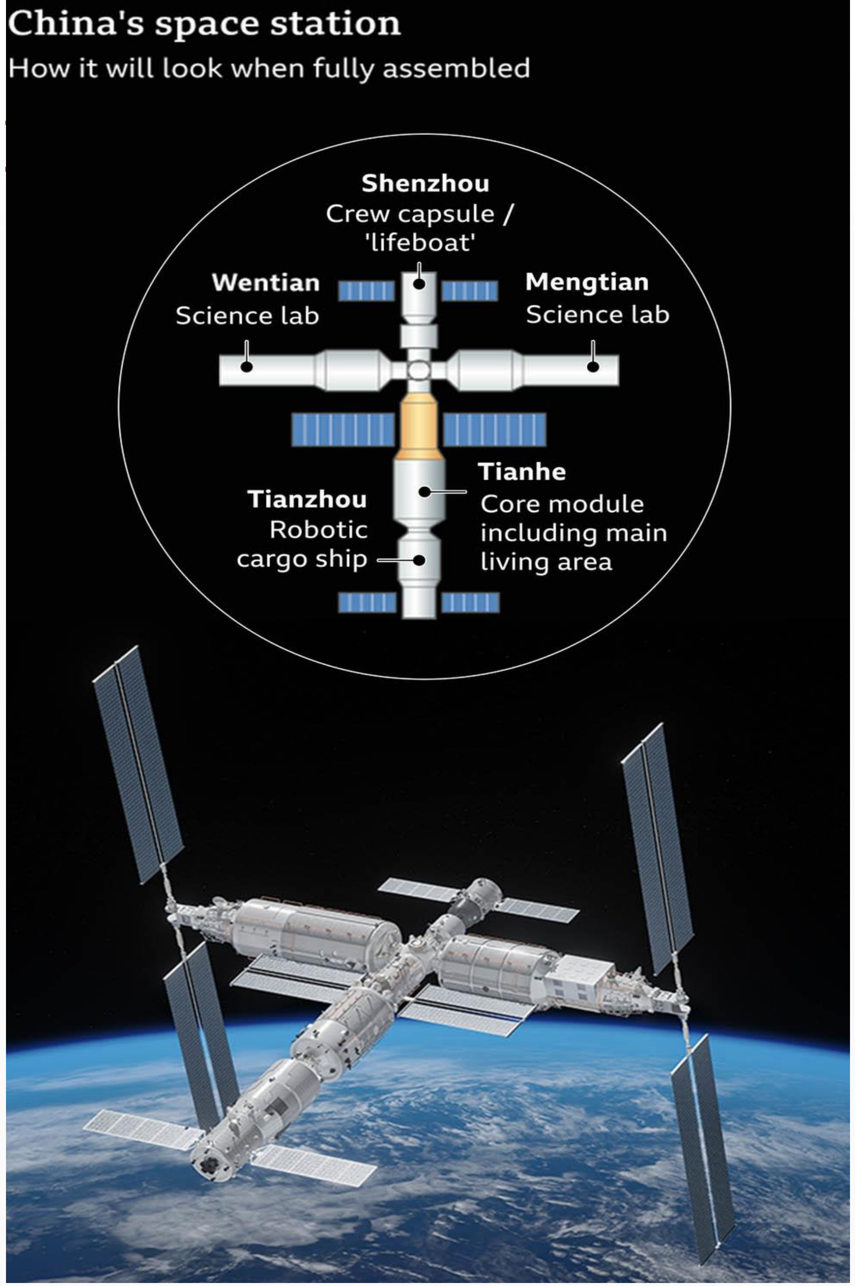
China selects mystery astronauts for 2023 missions to Tiangong space station

About

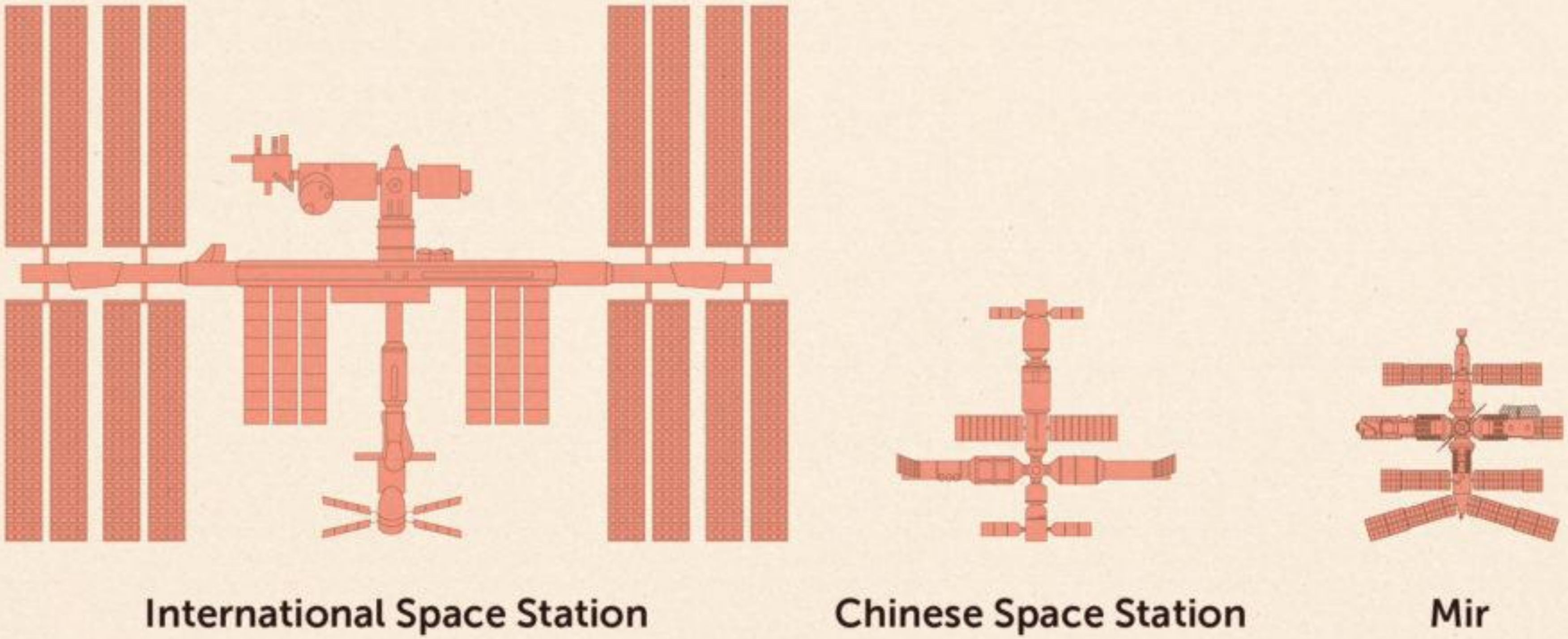
- China will later this year send two crews to the now fully operational Tiangong to spend six months in orbit conducting science experiments and keeping the space station maintained.
- Two three-person crews have been selected for the **Shenzhou 16 mission, due to launch in May, and the following Shenzhou 17 mission**, launching six months later. The missions will lift off atop Long March 2F rockets from Jiuquan in the Gobi Desert
- Tiangong, which means **"Heavenly Palace**," will consist of **Tianhe** the main habitat for astronauts, and two modules dedicated to hosting experiments, **Mengtian and Wentian**
- Tiangong will be much smaller than the International Space Station (ISS)
- Tiangong will also be **lighter than the ISS,** which weighs about 400 tons (450 metric tons)

Tiangong space statio

- China is **only the third country** in history to have put both astronauts into space and to build a space station, after the Russia and the US.



Comparison of Space Stations



	International Space Station	Chinese Space Station	Mir
Maximum Length	109 m	37 m	31 m
Mass	420 metric tons	60 - 70 metric tons	130 metric tons
Lifespan	26 yrs if deorbited in 2024	>10 yrs	15 yrs
Crew Size	6, or 9 short-term	3, or 6 short-term	3, or 6 short-term
Initial Launch Date	1998	2021	1986

ChinaPower CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

Atmospheric Waves Experiment

Context-National Aeronautics and Space Administration (NASA) is set to launch the Atmospheric Waves Experiment (AWE) to study one of the important drivers of Space weather – the Earth's weather.

Atmospheric Waves Experiment

- AWE is a first-of-its-kind NASA experimental attempt aimed at studying the interactions between **terrestrial and Space weather.**
- Planned under NASA's Heliophysics Explorers Program, the $42 million mission will study the links between **how waves in the lower layers of the atmosphere impact the upper atmosphere,** and thus, Space weather.
- AWE will be launched and mounted on the **exterior of the Earth-orbiting International Space Station (ISS).** From the vantage point, it will look down at the Earth and record the colourful light bands, commonly known as airglow.
- The new NASA mission will try to understand the **combination of forces that drive the Space weather in the upper atmosphere.**

Atmospheric Waves Experiment

- AWE could open a new window of study, wherein scientists are attempting to understand if Space weather is affected by terrestrial and bottom-up forces.
- AWE will **measure the airglow at mesopause** (about 85 to 87 km above the Earth's surface), where the atmospheric temperatures dip to minus 100 degrees Celsius. At this altitude, it is possible to capture the faint airglow in the infrared bandwidth, which appears the brightest enabling easy detection.

Atmospheric Waves Experiment

- The health of the ionosphere, whose lower layers sit at the edge of Space, is important for maintaining seamless communication. It is still **not fully understood if the ionosphere is affected by the transient events or intense perturbations resulting from hurricanes or tornadoes.**
- From its original scheduled launch in August 2022, the fresh launch is planned sometime this month.

Atmospheric Waves Experiment

Space weather

- Just like there is weather on the Earth, the environment around the Earth and the other planets remains constantly under the influence of the Sun and its behaviours – solar flares and emissions, along with the kinds of prevailing matter in the Space surroundings.
- During certain days, when the weather over Earth turns rough or extreme, Space weather, too, can suffer extreme events.
- These have a direct impact on vital installations on Earth, like **satellite-based communication, radio communication, and Space-based aircraft orbits** or stations – affecting the smooth operations of the navigation and Global Positioning Systems (GPS) and power grids.
- Apart from influences from the Sun-bound emissions, **Space weather also comes under the impact of terrestrial weather.**

Atmospheric Waves Experiment

Gravity wave

- The simplest way to explain a gravity wave is by considering the example of ripples formed when a pebble is thrown into the calm waters of a pond.
- Close to where the pebble touches the water surface, the waves are concentric and tightly packed whereas they become less defined at a far point from the pebble.
- Similarly, in the atmosphere, there are a wide variety of waves, travelling both horizontally and vertically. Atmospheric **Gravity Waves (AGW) are one such kind of vertical wave.** They are mostly **generated when there is an extreme weather event or a sudden disturbance leading to a vertical displacement of stable air.**
- Natural phenomena like **thunderstorms, hurricanes, tornadoes, regional orography and others have the potential to send out a variety of periodic waves,** including AGWs, in the lower levels of the atmosphere.

Atmospheric Waves Experiment

- A stable atmosphere plays an important role in the generation of gravity waves, that is, when the atmosphere is stable, the temperature difference between the rising air and the atmosphere produces a force that pushes this air to its original position. The air will continuously rise and sink, thus creating a wave-like pattern.
- AGW is a wave that moves through a stable layer of the atmosphere, wherein the upward-moving region is the most favourable for the formation of cloud patterns or streaks. AGWs continue all the way to Space, where they contribute to the Space weather.

Atmospheric Waves Experiment

What will NASA's AWE do?

- AWE will perform focused mapping of the colourful airglows in the Earth's atmosphere.
- Onboard AWE is an **Advanced Mesospheric Temperature Mapper** (ATMT), an instrument that will scan or map the mesopause (a region between the mesosphere and thermosphere).
- Using the four identical telescopes comprising an imaging radiometer, scientists hope to obtain the brightness of light at specific wavelengths.
- This information can then be converted into a temperature map, which could reveal the airglow movement and ultimately, give clues on their role in the upper atmosphere and Space weather.

Space lasers

Context-NASA's Psyche spacecraft, currently over 16 million kilometres away in space, **successfully fired a laser signal at Earth** on November 14.

- The spacecraft is on its way to a unique **metal-rich asteroid**, orbiting the Sun between Mars and Jupiter.
- Scientists believe this **asteroid is the nickel-iron core of an early planet**, studying which could provide unique insights into the impenetrable iron core of our own planet.
- Simultaneously, it will also carry out another mission that might hold the key to future space exploration

Space communication's data rate problem

- Communicating with spacecraft far away from Earth poses many challenges, of which the problem of data rates might be the most critical.
- Like wireless communications on Earth, **spacecraft encode data on various bands of electromagnetic frequencies.**
- Currently, most space communication is carried out **using radio waves** — having the **highest wave lengths but lowest frequencies** in the electromagnetic spectrum

Space lasers

- However, **higher bandwidths (range of frequencies) carry more data per second**.
- Thus, scientists would ideally like to transmit data at the **highest bandwidths possible to increase the rates of data transfer**. But this throws up its own set of challenges.
- Radio waves are more widely used for communication than other electromagnetic waves primarily because of their **desirable propagation properties, stemming from their large wavelength.**
- What this means is that they have the **ability to pass through the atmosphere regardless of weather,** pass through foliage and most building materials, as well as bend around obstructions.
- **Shorter wavelengths tend to scatter** when in contact with any interference.

Space lasers

NASA's revolutionary new technology

- NASA's Deep Space Optical Communications (DSOC) experiment – pioneering the **use of near-infrared laser signals for communication** with spacecraft.
- Much like fibre optics replacing old telephone lines on Earth, NASA says that **DSOC will allow data rates at least 10 times higher than state-of-the-art radio telecommunications systems** of comparable size and power, enabling higher resolution images, larger volumes of science data, and **even streaming video**.
- The **Psyche spacecraft is the first to carry a DSOC transceiver**, and will be testing high-bandwidth optical communications to Earth during the first two years of the spacecraft's journey to the main asteroid belt.
- The tech demo achieved "first light" in the early hours of November 14 after this transceiver locked onto a powerful uplink laser beacon transmitted from the Optical Communications Telescope Laboratory at the NASA's Table Mountain Facility near Wrightwood, California.

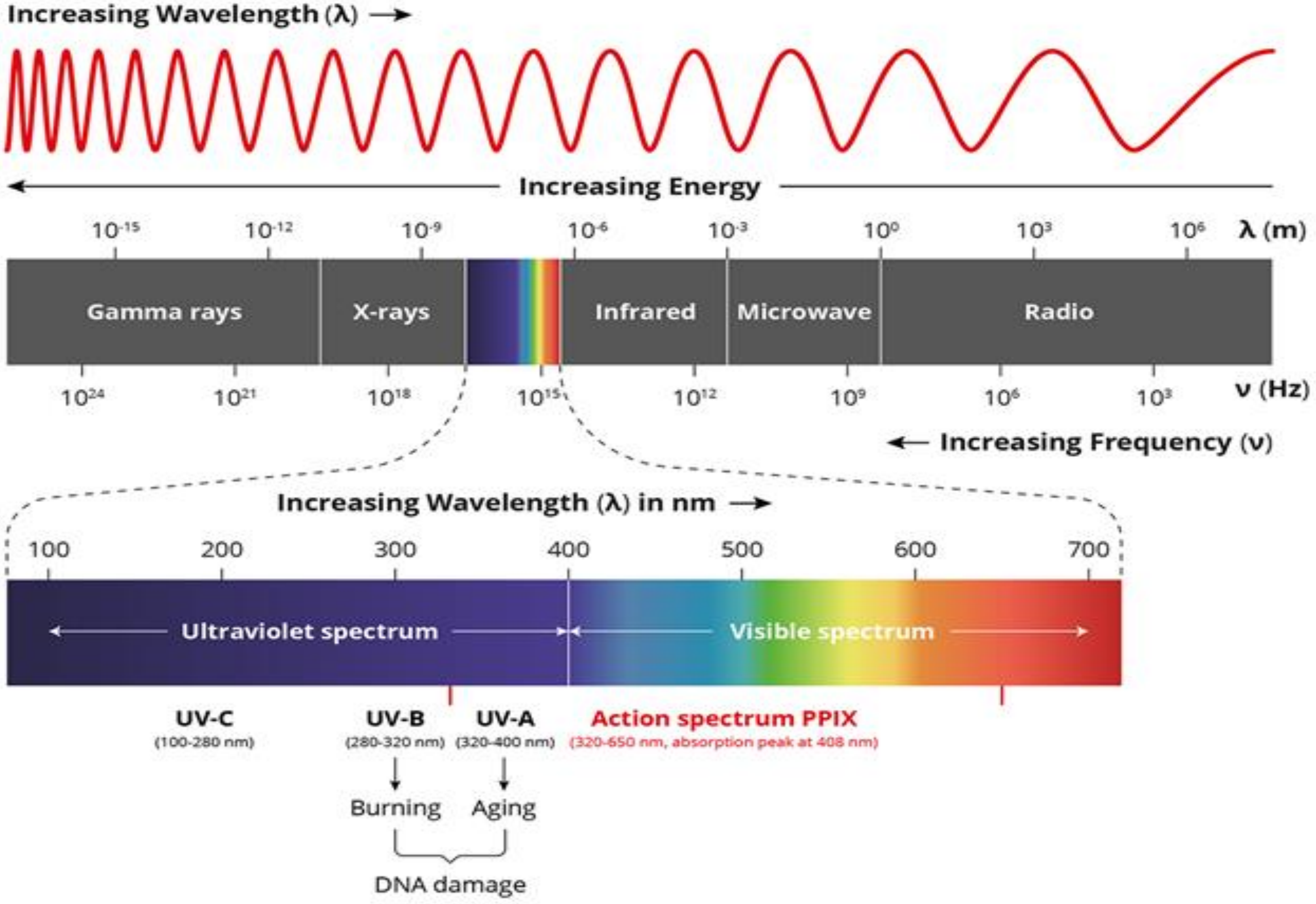
Space lasers

- But given the **limitations on propagation of higher bandwidths**, how does this technology work?
- The flight laser transceiver and ground-based laser transmitter will **need to point with great precision.** Reaching their targets will be akin to hitting a dime from a mile away while the dime is moving," the report says.
- A dime, or a 10 cent coin, is less than 2 cm in diameter.
- To achieve this, the **transceiver aboard the spacecraft needs to be isolated from the craft's vibrations.**
- Moreover, since the positions of Earth and the spacecraft will be constantly changing as the photons travel, the DSOC ground and flight systems will need to compensate, pointing to where the ground receiver and flight transceiver will be when the signal arrives.
- Lastly, given the distance between the spacecraft and Earth, new signal-processing techniques will be utilised to squeeze information out of the weak laser signals transmitted over the vastness of space.

Space lasers

Preparing for the future of space travel

- In 2013, NASA's Lunar Laser Communications Demonstration tested record-breaking uplink and downlink data rates between Earth and the Moon using similar technology.
- DSOC, however, is taking optical communications into deep space, paving the way for high-bandwidth communications far beyond the Moon and over a 1,000 times farther than any optical communications test to date.
- Achieving first light is one of many critical DSOC milestones in the coming months, paving the way toward higher-data-rate communications capable of sending scientific information, high-definition imagery, and streaming video in support of humanity's next giant leap: sending humans to Mars."


Increasing Wavelength (λ) →
Increasing Energy
10^{-15} 10^{-12} 10^{-9} 10^{-6} 10^{-3} 10^{0} 10^{3} 10^{6} λ (m)
Gamma rays
X-rays
Infrared
Microwave
Radio
10^{24} 10^{21} 10^{18} 10^{15} 10^{12} 10^{9} 10^{6} 10^{3} ν (Hz)
← Increasing Frequency (ν)
Increasing Wavelength (λ) in nm →
100 200 300 400 500 600 700
Ultraviolet spectrum
Visible spectrum
UV-C
(100-280 nm)
UV-B
(280-320 nm)
UV-A
(320-400 nm)
Action spectrum PPIX
(320-650 nm, absorption peak at 408 nm)
Burning
Aging
DNA damage

Mission SHAKTI (ASAT)

1960s-Bold orion missile -USA

Anti satellite missile

First interception of a satellite by a missile.

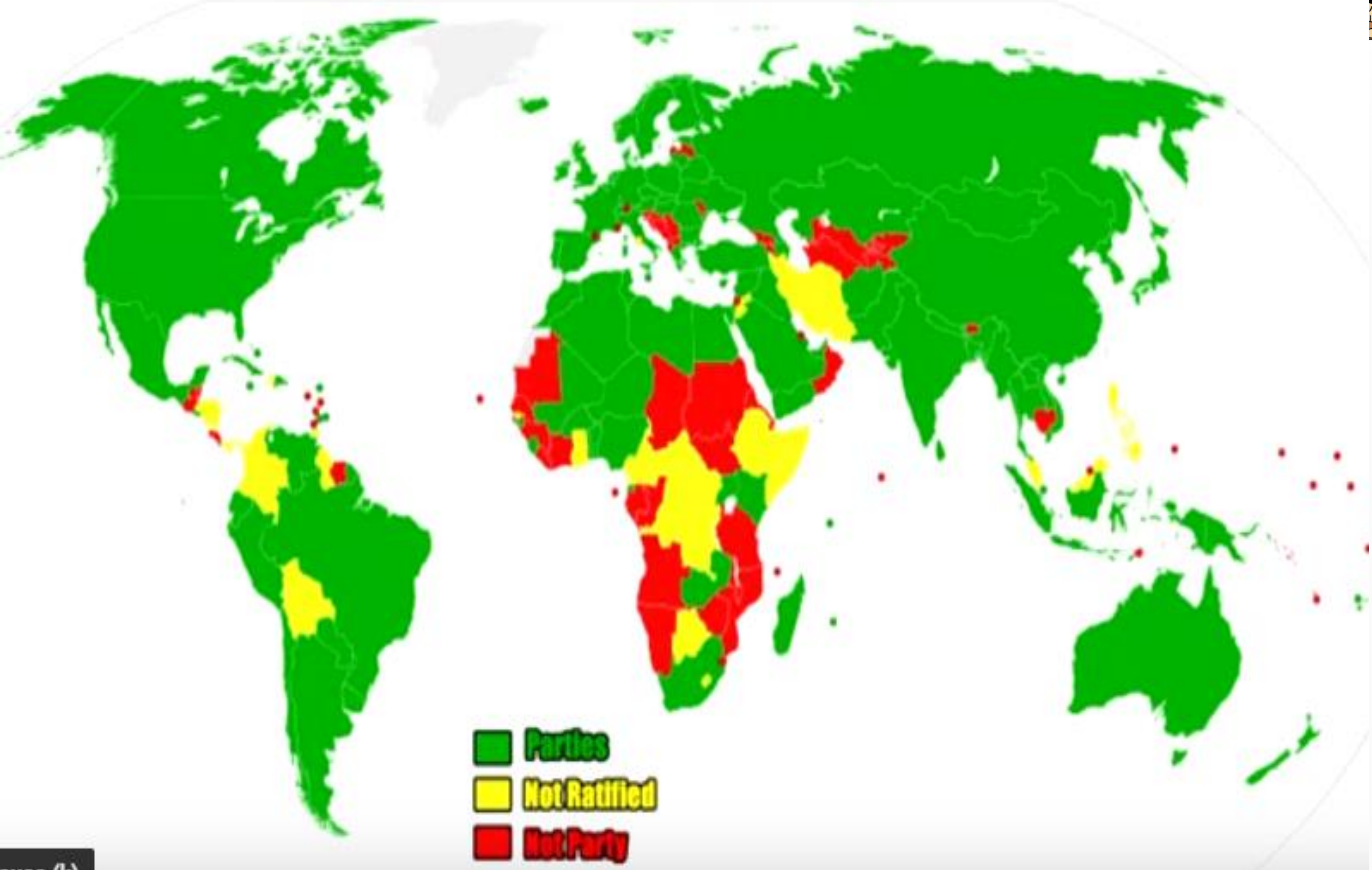
Co-orbital' method (1960-70)

launching a 'killer satellite', which would enter the same orbit as its target and approach it for destruction

1967-By US, UK, SU

Outer space treaty (1967)

- No country can place the weapons of mass destruction in orbit of earth, moon etc
- Makes countries liable for any damages
- Forbids any country from claiming a resource from any celestial body
- Not prohibited launching of ballistic massiles which could be armed with WMD



ause (k)

1980-90-ASAT (electromagnetic energy based)

Very less debris

Not work in poor weather

Soviet –working on laser system

Threat to both-satellite & ballistic missile

2007

China

- China ASAT system-Hit to kill
- Test weather satellite (debris)

2019

India (Mission Shakti)

- ❑Dr abdul kalam island (wheeler)-odisha
- ❑Kinetic kill technology (LEO-300Km)

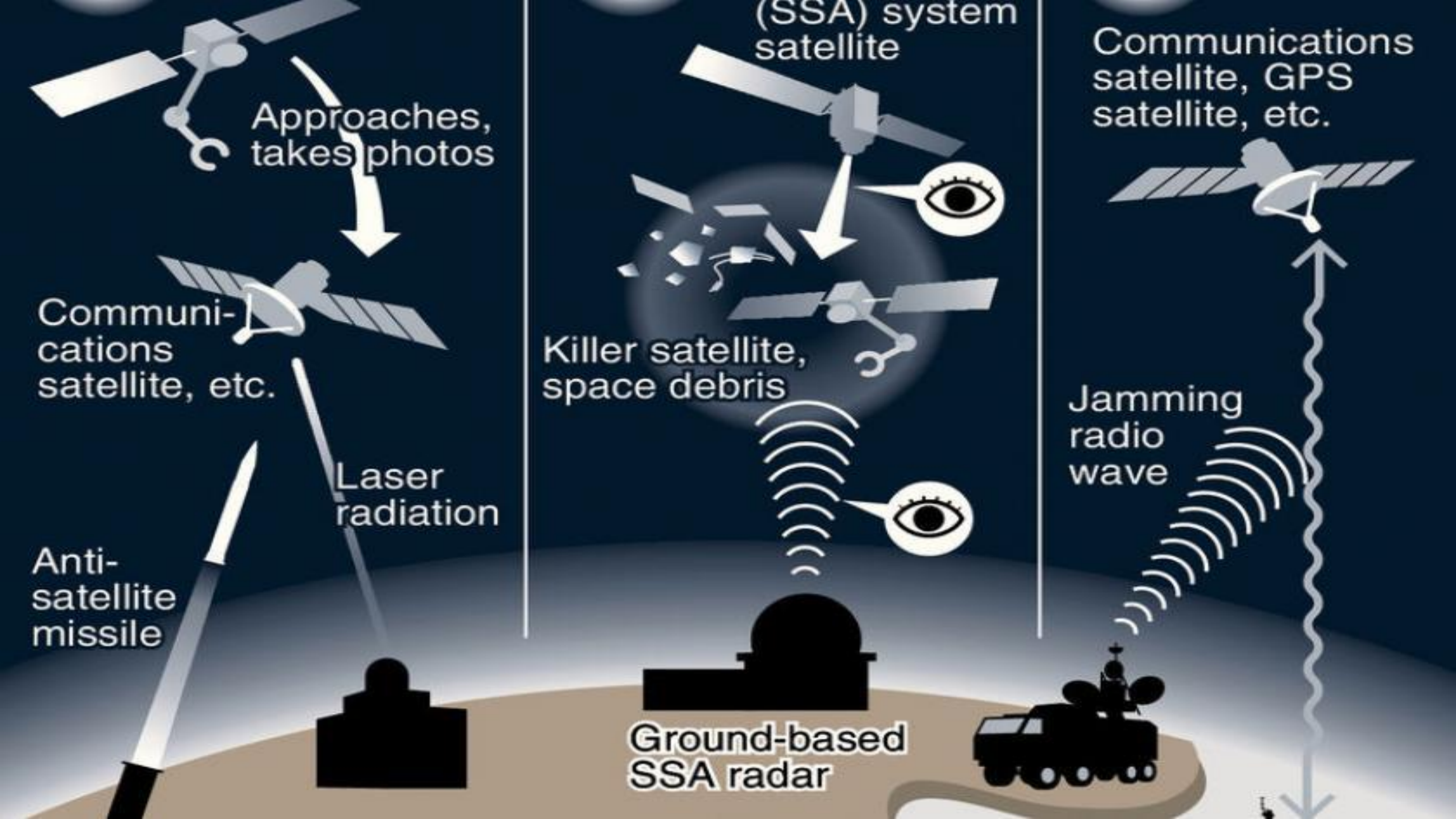
2024

Russia

Anti satellite test

Technologies

- Kinetic Kill
- Satellite jamming
- Satellite Maneuvering
- Ground based laser


(SSA) system
satellite
Communications
satellite, GPS
satellite, etc.
Approaches,
takes photos
Communi-
cations
satellite, etc.
Killer satellite,
space debris
Jamming
radio
wave
Laser
radiation
Anti-
satellite
missile
Ground-based
SSA radar

What is Space Debris?

Natural

consists of small pieces of cometary and asteroidal material called meteoroids.

Artificial

is any non-functional man-made object in space (usually orbiting the Earth).

Space debris

- ESA-23000 objects
- 2007-China ASAT-3300 debris
- 2009-Irradium(US) with Kosmos(R)-2200 debris
- Generally<1mm-no damage

Can they reach earth ?

Yes

Our Protection ?

- Atmosphere-burnt(Except-stainless steel & titanium-High m.pt)
- 3/4th ocean

Where Does Artificial Space Debris Come From?

- Satellites that have reached the end of their life
- **Satellites and spacecraft** that have failed
- Rocket stages that have launched satellites into space
- Solid propellant slag
- Space activity -**human waste**
- Deterioration fragments, eg **peeling paint**
- Fragments from exploding batteries, fuel tanks (not totally empty), etc
- Fragments from collisions, both accidental and deliberate

The RemoveDEBRIS mission

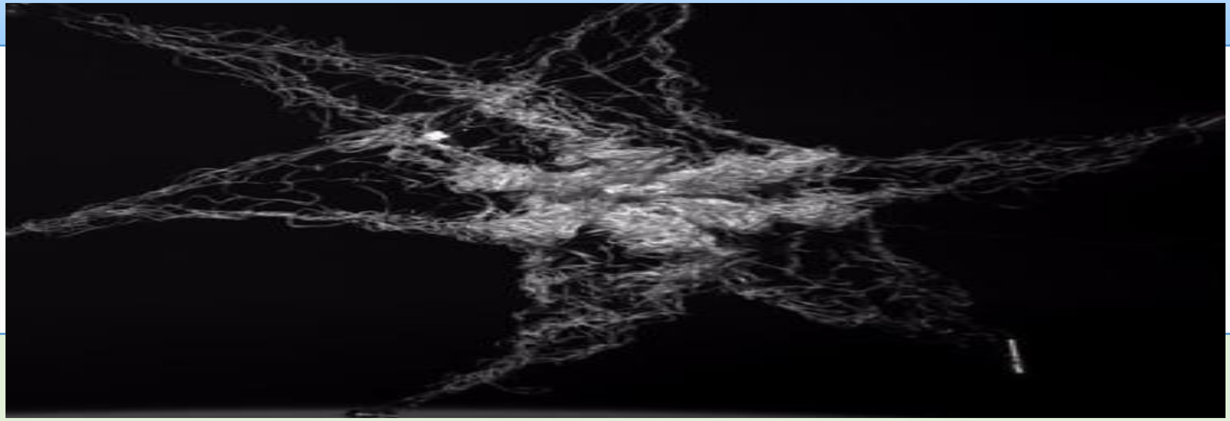
is led by the Surrey Space Centre (SSC) at the University Of Surrey, UK, and is co-funded by **the European Commission and other partners**, including prominent European space companies and institutions.

Kessler syndrome

- also called the Kessler effect, collisional cascading or ablation cascade, is a scenario in which the density of objects in Low Earth Orbit (LEO) is high enough that collisions between objects could cause a cascade where each collision generates space debris that increases the likelihood of further collisions

Remove Debris satellite

First satellite to remove space debris



Orbit (LEO)

Target-two cubesat artificial sat-DebriSAT

- ❑ **Release ,capture,deorbit**
- ❑ **Send data about debris**

ISS (June)

- ❑ **1998**
- ❑ **LEO (330-435Km)**
- ❑ **US,R,J,E,Canada**

April,2018 (Earth)

ASTROSAT

- First dedicated Indian astronomy mission aimed at studying celestial sources in **X-ray, optical and UV spectral bands** simultaneously.
- Into a **650 km orbit** inclined at an angle of 6 deg to the equator by **PSLV-C30** from Satish Dhawan Space Centre, Sriharikota.
- The minimum useful life of the AstroSat mission is expected to be 5 years.

The scientific objectives of AstroSat mission are:

- To understand **high energy processes** in binary star systems containing **neutron stars and black holes**;
- Estimate magnetic fields of **neutron stars**;
- Study star birth regions and high energy processes in **star systems lying beyond our galaxy;**
- Detect new briefly bright **X-ray sources in the sky**;
- Perform a **limited deep field survey** of the Universe in the Ultraviolet region.

Aditya-L1

Context-Aditya-L1 launched from Sriharikota.

- The spacecraft will travel **1.5 million km from the Earth** to the Lagrange 1 or L1 point between the Earth and the Sun.
- This distance is **nearly four times that travelled by the Chandrayaan missions**, but just 1% of the 150 million km between the Earth and the Sun.
- ISRO's **2nd space-based astronomy mission after AstroSat,** which was launched in 2015.
- **Aditya 1** was renamed as Aditya-L1. The Aditya 1 was meant to observe **only the solar corona.**
- The Aditya-L1 mission will see the **Polar Satellite Launch Vehicle (PSLV)** carry the 1,475-kg spacecraft to an elliptical orbit around the Earth. The spacecraft, which will carry seven scientific payloads, is more than two times lighter than the one to the Moon

Aditya-L1

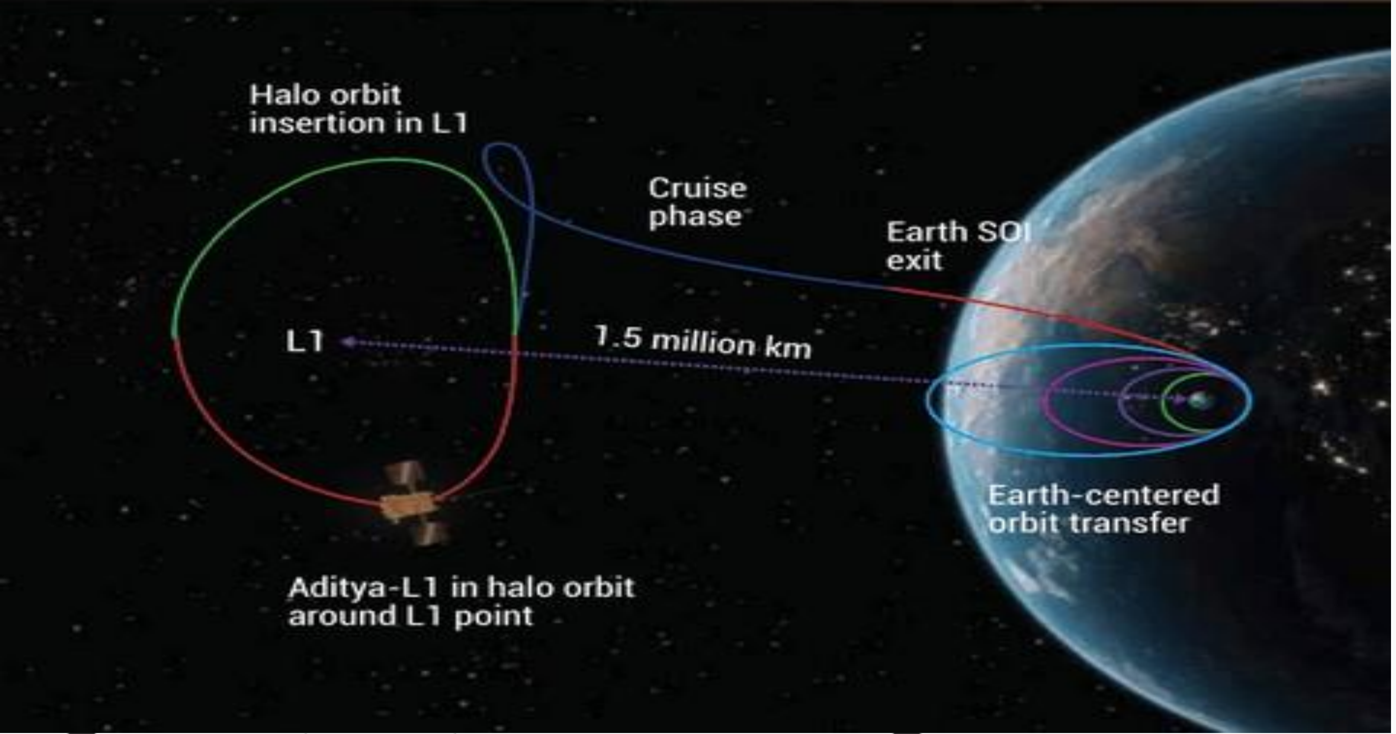
- The distance to L1 point will be covered in nearly **four months.** The spacecraft will then be inserted into a **halo orbit around the L1 point**. It will collect data for five years.
- The L1 point of the Earth-Sun system affords an uninterrupted view of the Sun and is currently home to the **Solar and Heliospheric Observatory Satellite SOHO.**

ADITYA-L1

Trajectory to L1

The Aditya-L1 mission will be launched by ISRO's PSLV XL rocket from Satish Dhawan Space Centre SHAR (SDSC-SHAR), Sriharikota. Initially, the spacecraft will be placed in a Low Earth Orbit. Subsequently, the orbit will be made more elliptical and later the spacecraft will be launched towards the Lagrange point (L1) by using onboard propulsion.

As the spacecraft travels towards L1, it will exit the Earths' gravitational Sphere of Influence (SOI). After exit from SOI, the cruise phase will start and subsequently the spacecraft will be injected into a large halo orbit around L1. The total travel time from launch to L1 would take about four months for Aditya-L1. The Trajectory of Aditya-L1 mission is shown in the figure below.



Aditya-L1

Objectives of Aditya-L1

- The main objective of the mission is to get a **deeper understanding of the star closest to us**, and how its radiation, heat, flow of particles, and magnetic fields affects us.
- The payloads on the mission will **study the upper atmospheric layers of the Sun called chromosphere and corona**.
- They will study the expulsion of plasma and magnetic fields called **coronal mass ejection (CME).** The magnetic field of the corona and the drivers of the space weather will also be studied.
- Importantly, it might provide clues to scientists about a long-standing mystery: **why the not-so-bright corona of the Sun is a million degree C hot**, when the temperature on the surface of the Sun is just about 5,500 degree C.

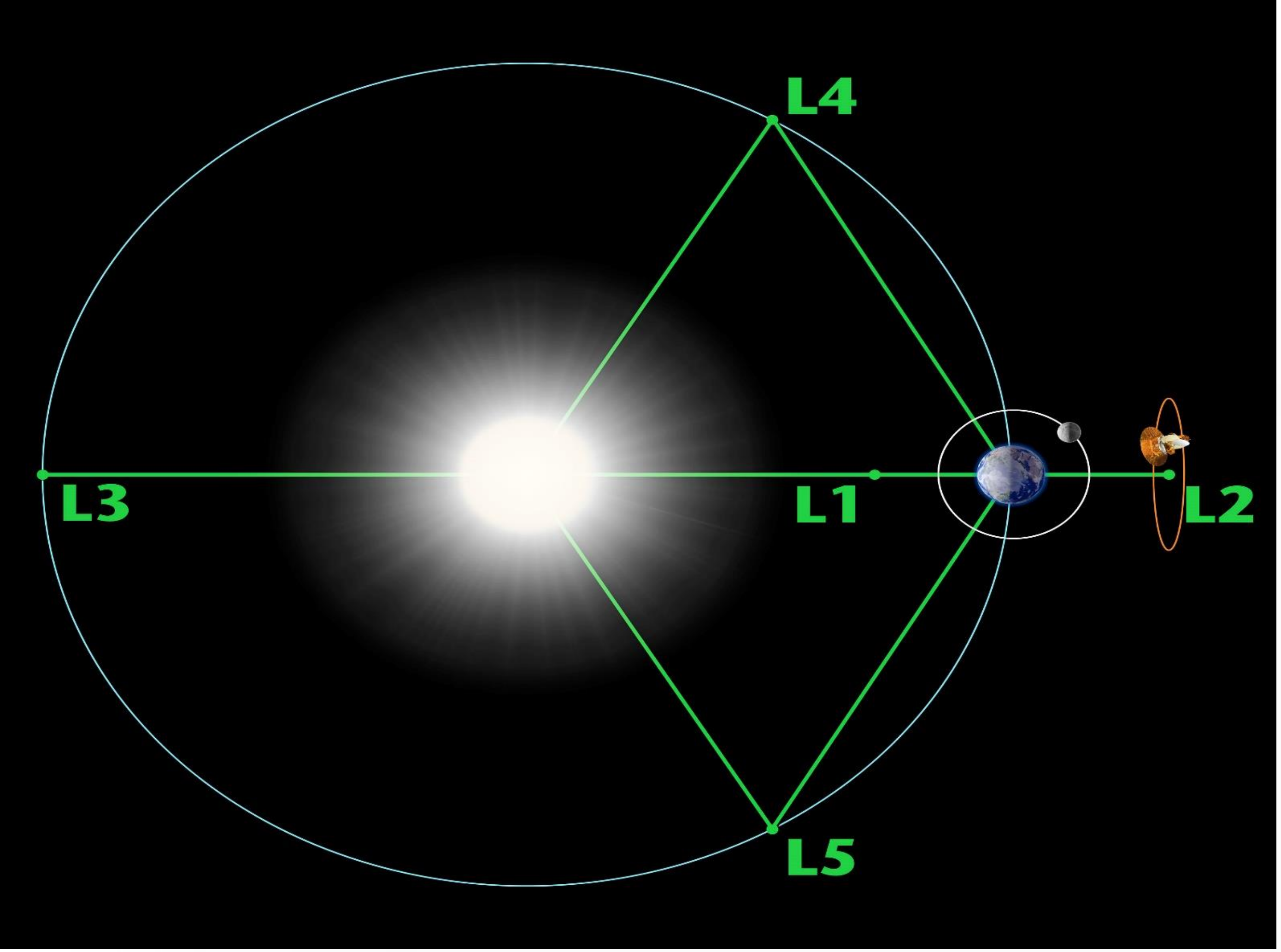
Aditya-L1

What are the payloads?

- The **main payload is the Visible Emission Line Coronagraph** (VLEC), designed by the Indian Institute of Astrophysics, which will help study the solar corona from the lowermost part upwards. The VELC can image the solar corona down to 1.05 times the solar radius, the closest any such payload has imaged.
- The instruments of Aditya-L1 are tuned to observe the solar atmosphere mainly the chromosphere and corona.
- **In-situ instruments** will observe the local environment at L1.
- There are total seven payloads on-board with **four of them carrying out remote sensing** of the Sun and **three of them carrying in-situ observation**.

Aditya-L1

Type	Sl. No.	Payload	Capability
Remote Sensing Payloads	1	Visible Emission Line Coronagraph(VELC)	Corona/Imaging & Spectroscopy
	2	Solar Ultraviolet Imaging Telescope (SUIT)	Photosphere and Chromosphere Imaging- Narrow & Broadband
	3	Solar Low Energy X-ray Spectrometer (SoLEXS)	Soft X-ray spectrometer: Sun-as-a-star observation
	4	High Energy L1 Orbiting X-ray Spectrometer(HEL1OS)	Hard X-ray spectrometer: Sun-as-a-star observation
In-situ Payloads	5	Aditya Solar wind Particle Experiment(ASPEX)	Solar wind/Particle Analyzer Protons & Heavier Ions with directions
	6	Plasma Analyser Package For Aditya (PAPA)	Solar wind/Particle Analyzer Electrons & Heavier Ions with directions
	7	Advanced Tri-axial High Resolution Digital Magnetometers	In-situ magnetic field (Bx, By and Bz).


L4
L3
L1
L2
L5

Halo-Orbit Insertion

- Halo-Orbit Insertion (HOI) of its solar observatory spacecraft, Aditya-L1 was accomplished on January 6, 2024 (IST).

About

- The orbit of Aditya-L1 spacecraft is a periodic **Halo orbit** which is located roughly 1.5 million km from earth on the continuously **moving Sun – Earth line** with an **orbital period of about 177.86 earth days.**
- This Halo orbit is a **periodic, three-dimensional orbit** at L1 involving Sun, Earth and a spacecraft.
- This specific halo orbit is selected to ensure a **mission lifetime of 5 years**, minimising station-keeping manoeuvres and thus fuel consumption and ensuring a continuous, unobstructed view of sun.

Aditya-L1

Significance

- First, going to Lagrange 1 places the spacecraft at a point **beyond the Moon** between the Earth and the Sun. This offers the spacecraft an **unobstructed view of the Sun even during phenomena like an eclipse.**
- Second, with the mission covering only 1% of the distance between the Earth and Sun, the payloads will be able to **look directly at the Sun**.
- Third, the L1 point makes the mission **fuel-efficient**.

Chandrayaan

Chandrayaan-1 was India's first lunar probe.

- It was launched by the Indian Space Research Organisation in **October 2008**, and operated until August 2009.
- The mission included a lunar orbiter and an impactor. It was launched from Satish Dhawan Space Centre, Sriharikota, by the **PSLV C-11** on 22 October 2008.
- The spacecraft was orbiting around the Moon at a **height of 100 km** from the lunar surface for chemical, mineralogical and photo-geologic mapping of the Moon.
- The spacecraft carries **11 scientific instruments** built in India, USA, UK, Germany, Sweden and Bulgaria.

Chandrayaan-1

Key Findings

- **Confirmed presence of lunar water**
- **Evidence of lunar caves** formed by an ancient lunar lava flow
- **Past tectonic activity** were found on the lunar surface.
- The faults and fractures discovered could be features of past interior tectonic activity coupled with meteorite impacts

Chandrayaan-2

Comprising of an Orbiter of the Moon, Vikram (after Vikram Sarabhai) the lander and **Pragyan (wisdom) the rover**

The Orbiter

- Orbit from 100 km away , would remain in orbit for a year.

Lander (Vikram)

- Remain stationary after touching down, study the moon's atmosphere. It will also look out for seismic activity.

Chandrayaan-2

Rover (Pragyan)

- Six-wheeled solar-powered vehicle, detach itself and slowly crawl on the surface, making observations and collecting data.

- **Study the composition of the surface near the lunar landing site,** and determine the abundance of various elements.

Chandrayaan-2

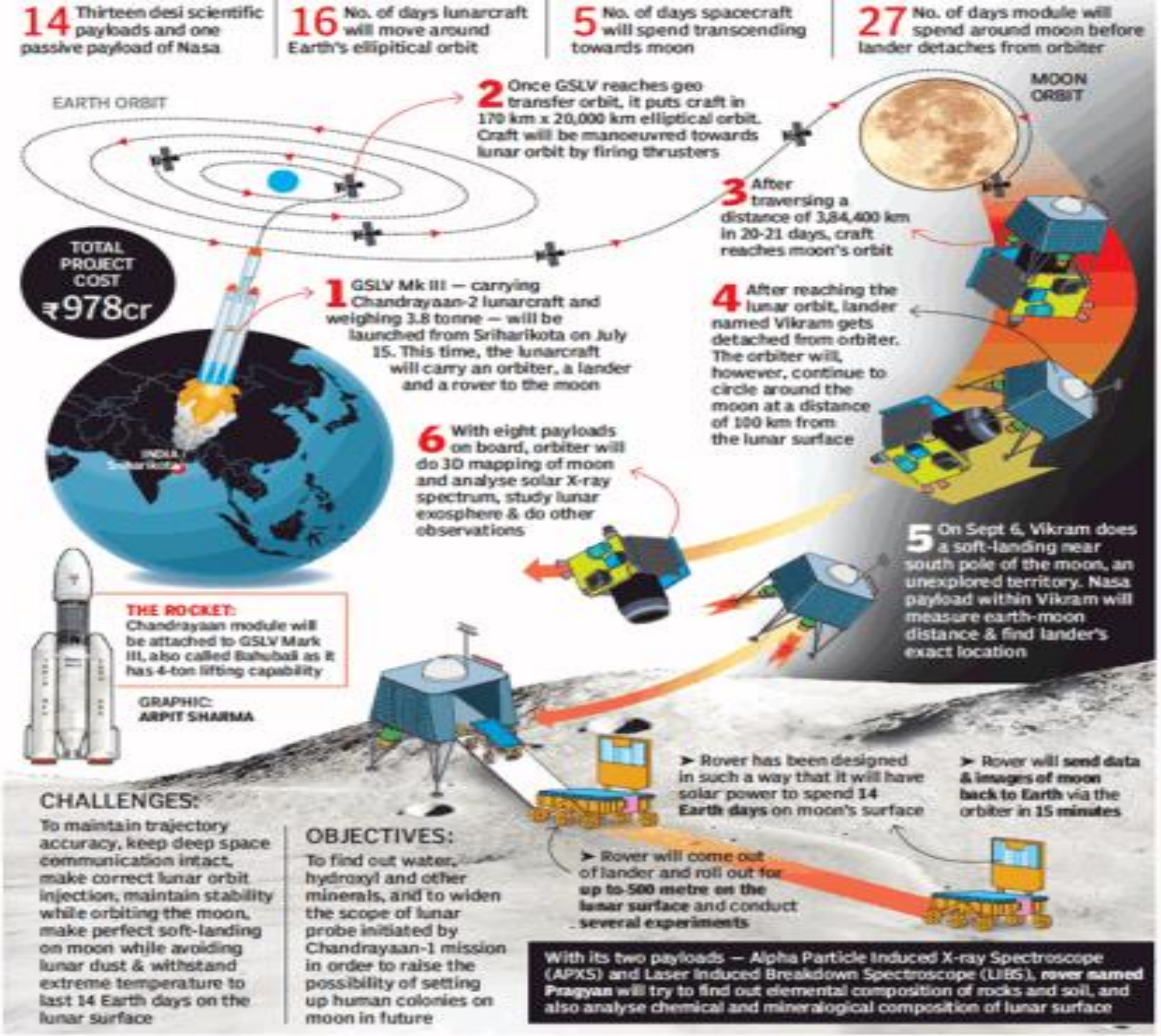
Objectives

- **Primary objective** is to demonstrate the **ability to soft-land** on the lunar surface and operate a robotic rover on the surface.
- **Scientific goals** include studies of lunar topography, **mineralogy, elemental abundance, the lunar exosphere**, and signatures of hydroxyl and water ice.
-
- .

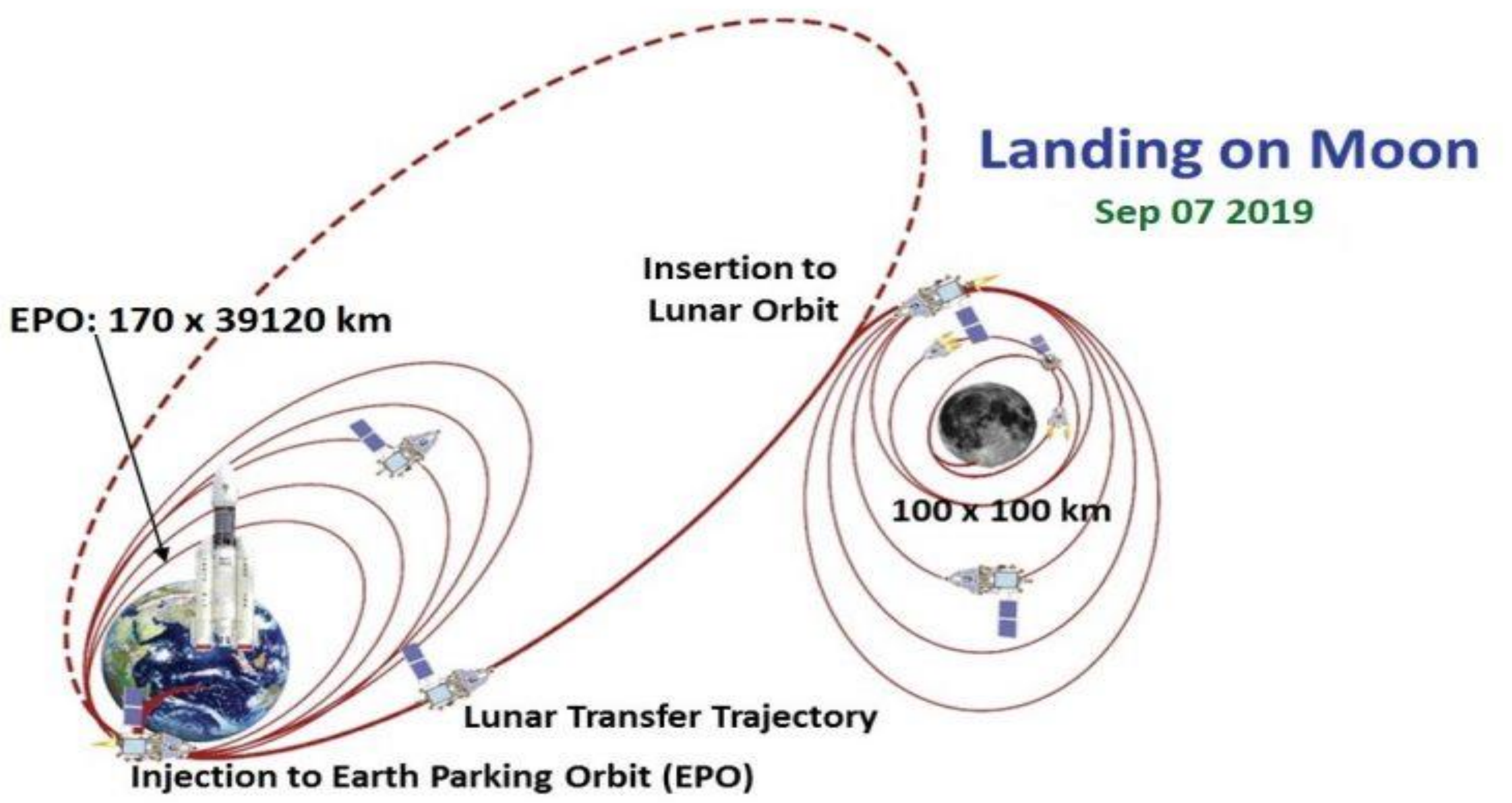
Chandrayaan-2

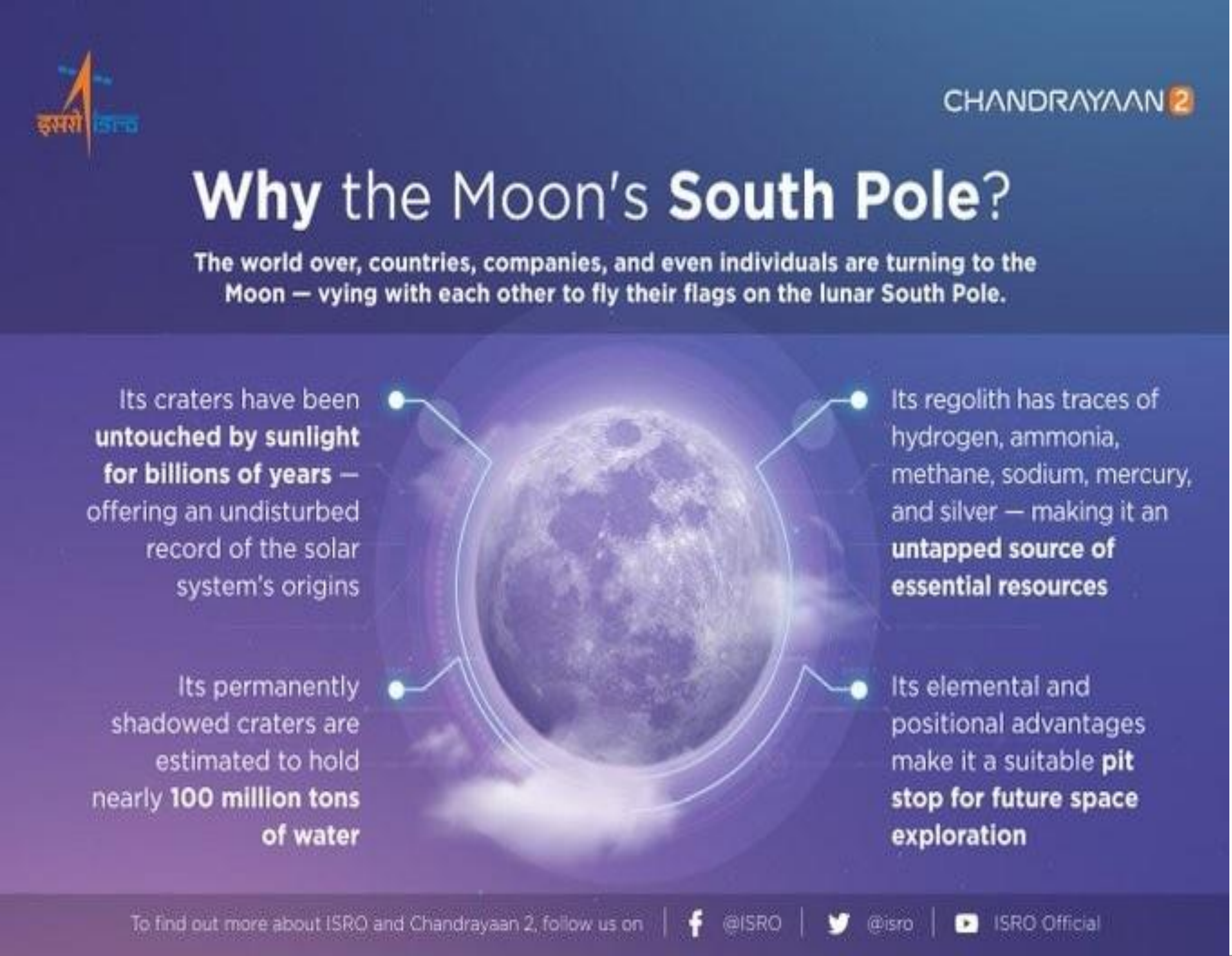
Other objectives

1. To identify minerals and indicators of hydroxyl and **water molecules.**
2. To study the **surface of the moon.**
3. To study the **density of the electrons in the Moon's ionosphere** that is the uppermost part of the atmosphere that is ionised by radiation.


14 Thirteen desi scientific payloads and one passive payload of Nasa
16 No. of days lunarcraft will move around Earth's elliptical orbit
5 No. of days spacecraft will spend transcending towards moon
27 No. of days module will spend around moon before lander detaches from orbiter
EARTH ORBIT
MOON ORBIT
2 Once GSLV reaches geo transfer orbit, it puts craft in 170 km x 20,000 km elliptical orbit. Craft will be manoeuvred towards lunar orbit by firing thrusters
3 After traversing a distance of 3,84,400 km in 20-21 days, craft reaches moon's orbit
TOTAL PROJECT COST ₹978cr
1 GSLV Mk III — carrying Chandrayaan-2 lunarcraft and weighing 3.8 tonne — will be launched from Sriharikota on July 15. This time, the lunarcraft will carry an orbiter, a lander and a rover to the moon
4 After reaching the lunar orbit, lander named Vikram gets detached from orbiter. The orbiter will, however, continue to circle around the moon at a distance of 100 km from the lunar surface
INDIA
Sriharikota
6 With eight payloads on board, orbiter will do 3D mapping of moon and analyse solar X-ray spectrum, study lunar exosphere & do other observations
5 On Sept 6, Vikram does a soft-landing near south pole of the moon, an unexplored territory. Nasa payload within Vikram will measure earth-moon distance & find lander's exact location
THE ROCKET: Chandrayaan module will be attached to GSLV Mark III, also called Bahubali as it has 4-ton lifting capability
GRAPHIC: ARPIT SHARMA
➤ Rover has been designed in such a way that it will have solar power to spend 14 Earth days on moon's surface
➤ Rover will send data & images of moon back to Earth via the orbiter in 15 minutes
CHALLENGES:
To maintain trajectory accuracy, keep deep space communication intact, make correct lunar orbit injection, maintain stability while orbiting the moon, make perfect soft-landing on moon while avoiding lunar dust & withstand extreme temperature to last 14 Earth days on the lunar surface
OBJECTIVES:
To find out water, hydroxyl and other minerals, and to widen the scope of lunar probe initiated by Chandrayaan-1 mission in order to raise the possibility of setting up human colonies on moon in future
➤ Rover will come out of lander and roll out for up to 500 metre on the lunar surface and conduct several experiments
With its two payloads — Alpha Particle Induced X-ray Spectroscope (APXS) and Laser Induced Breakdown Spectroscope (LIBS), rover named Pragyan will try to find out elemental composition of rocks and soil, and also analyse chemical and mineralogical composition of lunar surface

Chandrayaan-2




इसरो isro
CHANDRAYAAN 2
Why the Moon's South Pole?
The world over, countries, companies, and even individuals are turning to the Moon — vying with each other to fly their flags on the lunar South Pole.
Its craters have been untouched by sunlight for billions of years — offering an undisturbed record of the solar system's origins
Its regolith has traces of hydrogen, ammonia, methane, sodium, mercury, and silver — making it an untapped source of essential resources
Its permanently shadowed craters are estimated to hold nearly 100 million tons of water
Its elemental and positional advantages make it a suitable pit stop for future space exploration
To find out more about ISRO and Chandrayaan 2, follow us on
@ISRO
@isro
ISRO Official

Chandrayaan-3

India has **landed its Chandrayaan-3 spacecraft on the moon**, becoming only the fourth nation ever to accomplish such a feat.

- India became **first country in the world to make a soft landing near the Moon's South Pole**
- India also became **only the fourth country to make a soft landing on the Moon** after Russia, US and China.
- With the success of Chandrayaan-3, **India became the second country to land a spacecraft on the moon in the 21st century after China**, which has put three landers on the lunar surface since 2013 — including the first to touch down on the moon’s far side

Chandrayaan-3

Chandrayaan-3

- Chandrayaan-3, India's **third lunar exploration mission**, was launched on **GSLV Mark 3 (LVM 3**) heavy-lift launch vehicle successfully from the Satish Dhawan Space Centre in Andhra Pradesh's Sriharikota on July 14.
- According to Isro officials, the **Chandrayaan-3** will reach the lunar orbit almost a month after its launch, and its lander, Vikram, and rover, Pragyaan, are likely to **land on the Moon on August 23.**
- Chandrayaan-3, which **weighs 3,900kg and cost 6.1bn rupees** ($75m; £58m).
- The **lander (called Vikram**, after the founder of Isro) weighs about 1,500kg and carries within its belly **the 26kg rover which is named Pragyaan,** the Sanskrit word for wisdom.

Chandrayaan-3

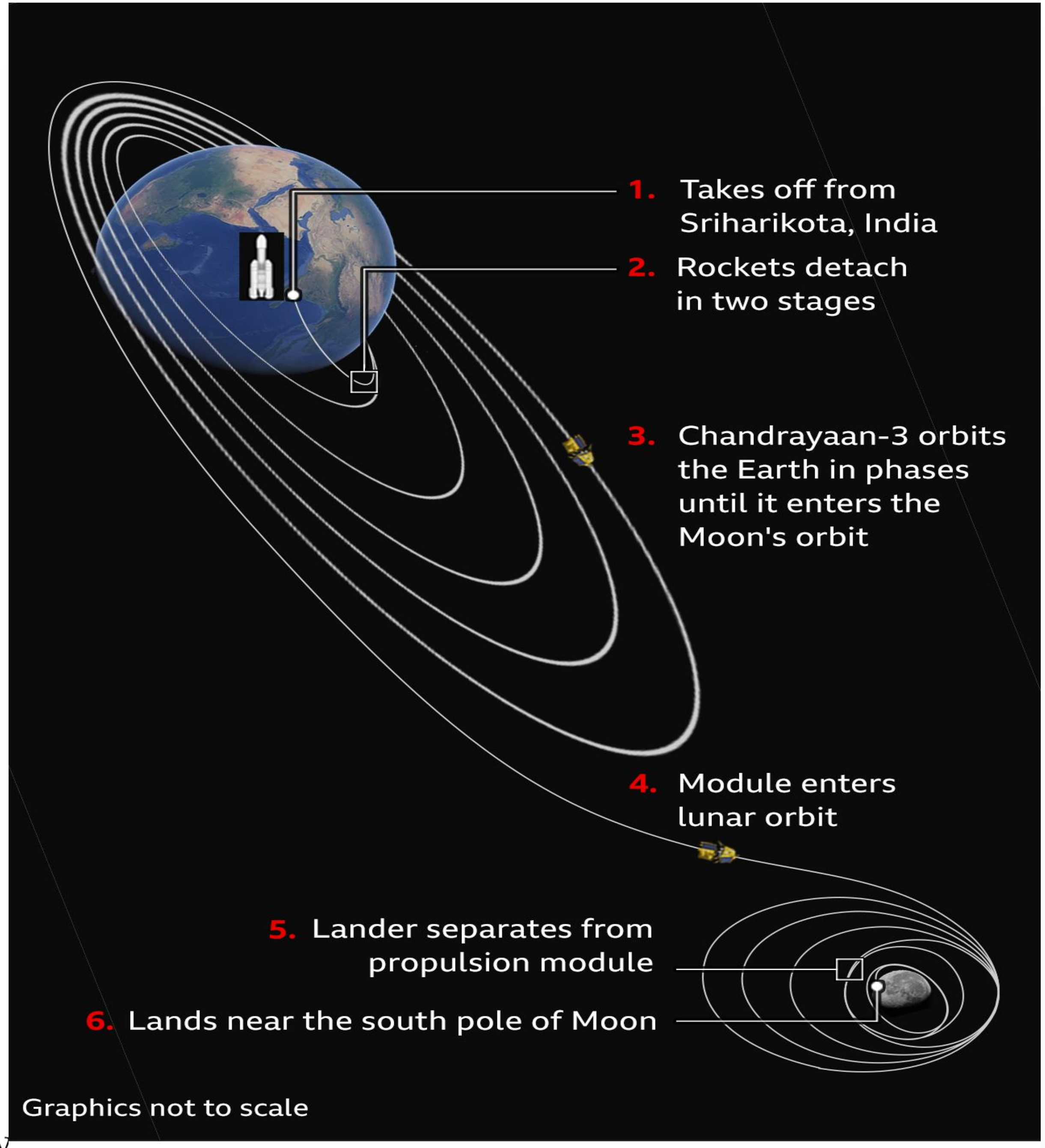
- Notably, the **landing site of the latest mission is more or less the same** as the **Chandrayaan-2**: near the south pole of the moon at 70 degrees latitude. If everything goes well, the Chandrayaan-3 will become the **world's first mission to soft-land near the lunar south pole**
- All the **previous spacecraft** to have landed on the Moon have landed in the **equatorial region**, a few **degrees latitude north or south** of the lunar equator.
- The furthest that any spacecraft has gone from the equator was **Surveyor 7, launched by NASA,** which made a moon landing way back on January 10, 1968. This spacecraft landed **near 40 degrees south latitude**.
- It will also become **only the fourth to achieve a soft landing on the Moon after the US, the former Soviet Union and China.**
- Mission Life (Lander & Rover)- **One lunar day (~14 Earth days**)

Chandrayaan-3

Component

- Unlike Chandrayaan-2, it will **not have an orbiter** and its propulsion module will behave like a communications relay satellite.
- Chandrayaan-3 consists of an indigenous **Lander module (LM), Propulsion module (PM) and a Rover** with an objective of developing and demonstrating new technologies required for Inter planetary missions.

How India's Chandrayaan-3 will reach the Moon



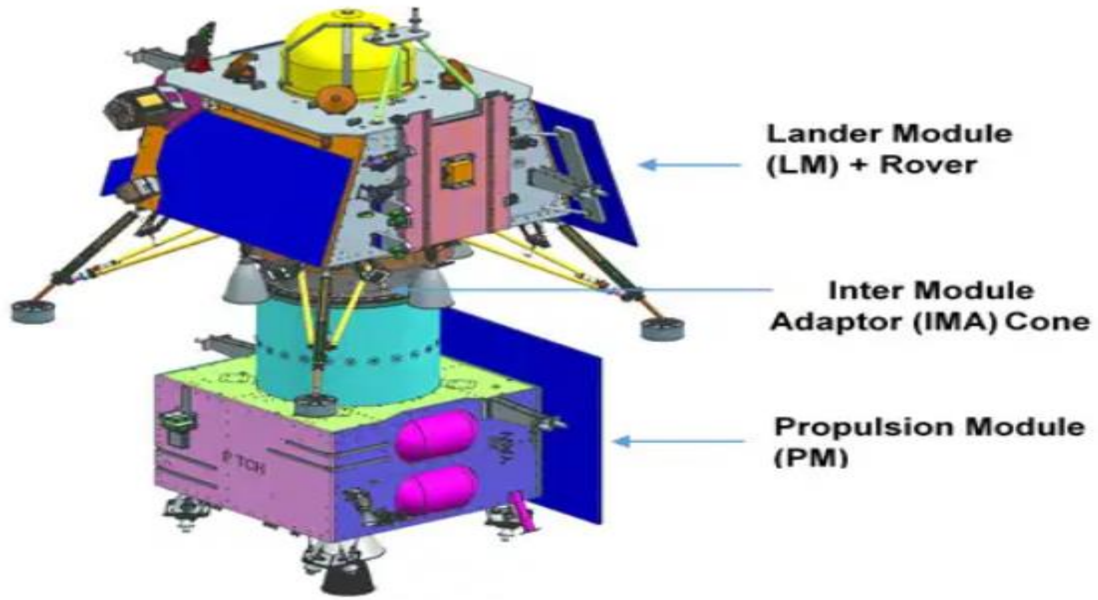
Source: Indian Space Research Organisation

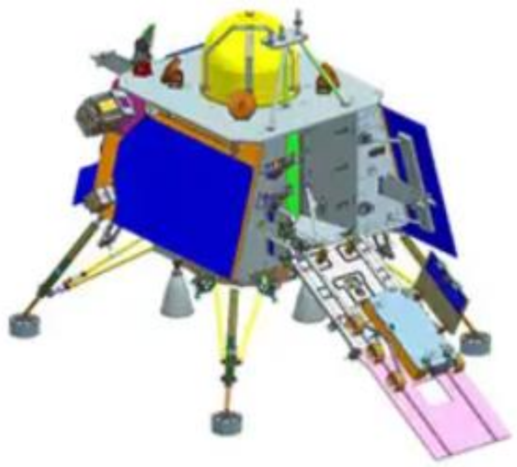
BBC

Chandrayaan-3

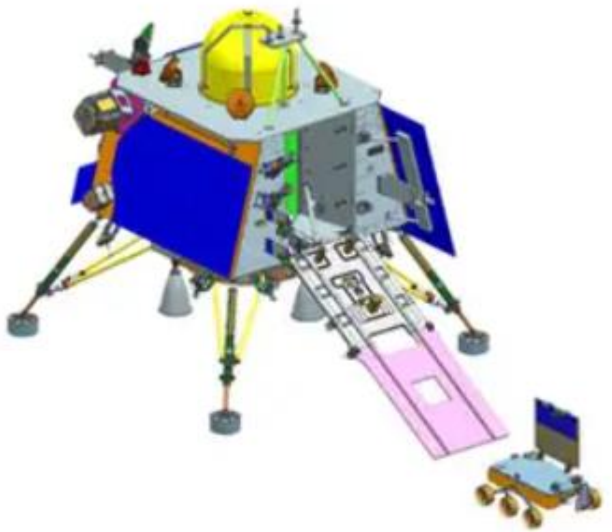
The mission objectives of Chandrayaan-3 are:

1. To demonstrate Safe and Soft Landing on Lunar Surface
2. To demonstrate Rover roving on the moon and
3. To conduct in-situ scientific experiments.

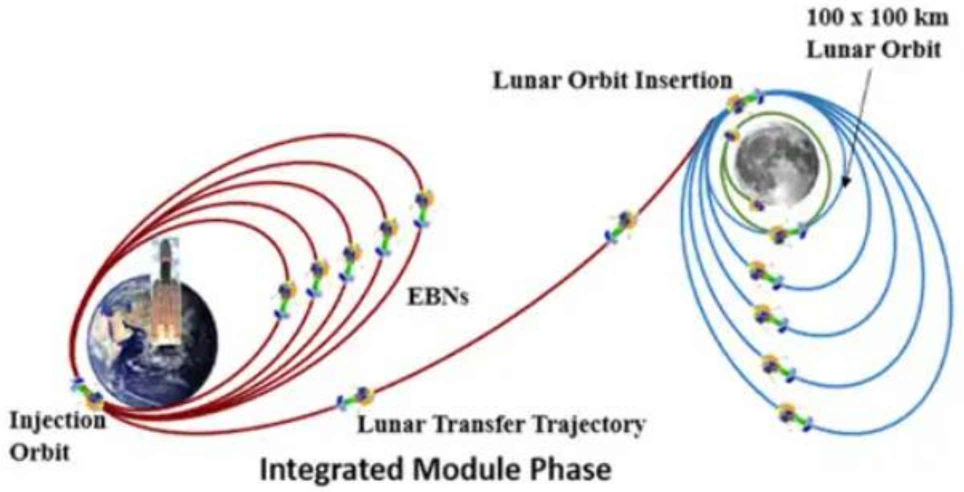


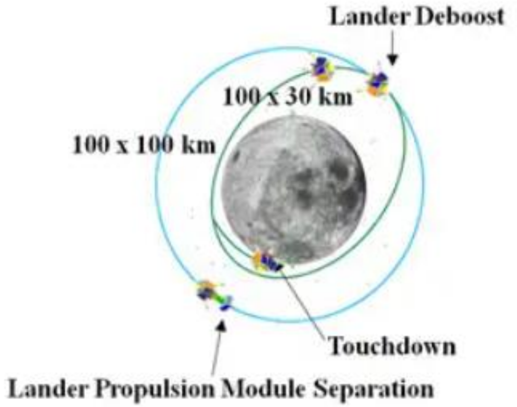


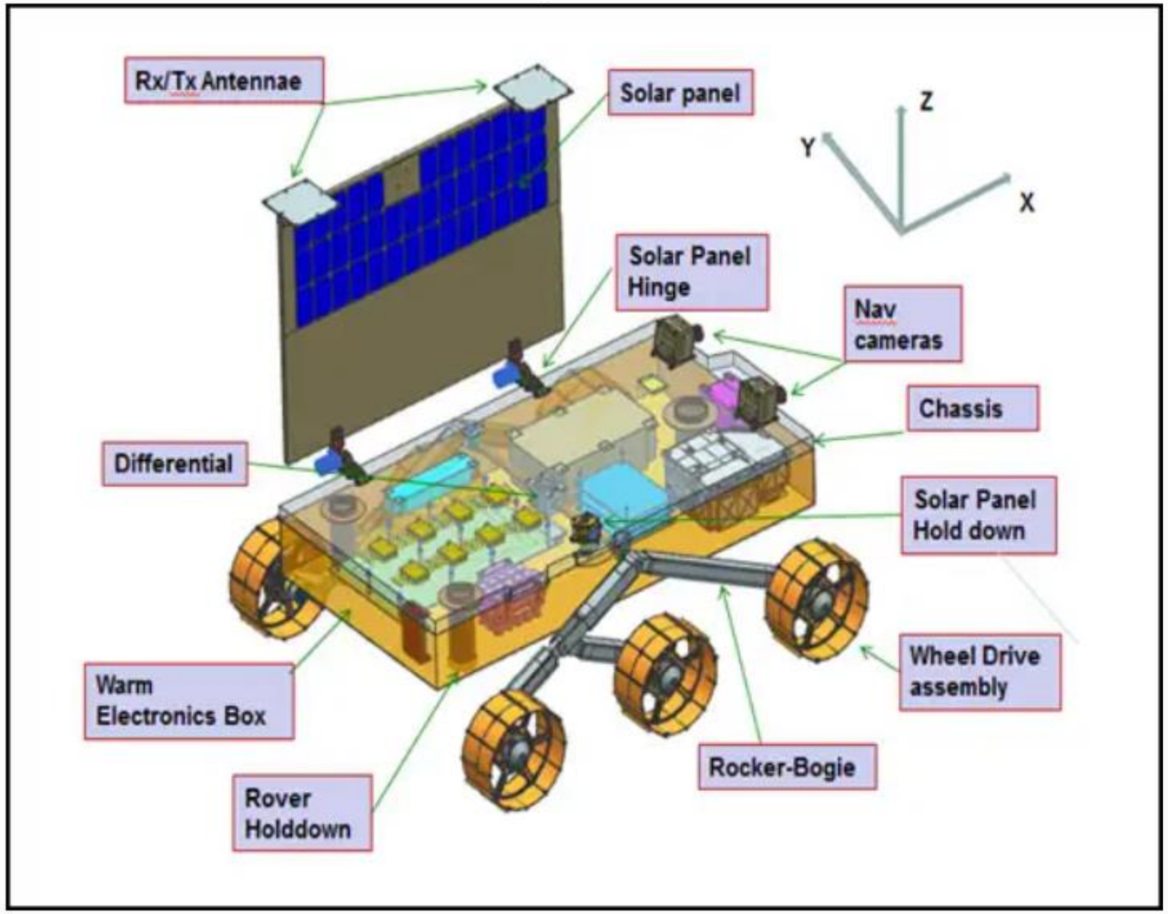
Rover on Ramp



Rover Deployed from Lander







Chandrayaan-3 Rover

Sl. No	Lander Payloads	Objectives	
1.	Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA)	Langmuir probe (LP)	To measure the near surface plasma (ions and electrons) density and its changes with time
2.	Chandra's Surface Thermo physical Experiment (ChaSTE)	To carry out the measurements of thermal properties of lunar surface near polar region.	
3.	Instrument for Lunar Seismic Activity (ILSA)	To measure seismicity around the landing site and delineating the structure of the lunar crust and mantle.	
4.	LASER Retroreflector Array (LRA)	It is a passive experiment to understand the dynamics of Moon system.	

Sl. No	Rover Payloads	Objectives
1.	LASER Induced Breakdown Spectroscope (LIBS)	Qualitative and quantitative elemental analysis & To derive the chemical Composition and infer mineralogical composition to further our understanding of Lunar-surface.
2.	Alpha Particle X-ray Spectrometer (APXS)	To determine the elemental composition (Mg, Al, Si, K, Ca,Ti, Fe) of Lunar soil and rocks around the lunar landing site.

Sl. No	Propulsion Module Payload	Objectives
1.	Spectro-polarimetry of HAbitable Planet Earth (SHAPE)	Future discoveries of smaller planets in reflected light would allow us to probe into variety of Exo-planets which would qualify for habitability (or for presence of life).

Sleepy Classes IAS
Awakening Toppers

How the two attempts stack up

CHANDRAYAAN-3

Jul 14 Chandrayaan-3 Launch

Aug 23 Probable landing

LUNA-25

Aug 10 Luna-25 Launch

Aug 21-22 Probable landing

	Chandrayaan-3	Luna-25
Lift-off mass	3,900 kg	1,750 kg
Landing site	69.36°S, 32.34°E	69.54°S, 43.54°E
Mission life	14 days	1 year

LIGHTER

Luna-25 does not carry a rover. Chandrayaan-3 has a rover capable of moving around 500 metres

PAYLOADS

CHANDRAYAAN-3

LANDER:

- RAMBHA to study properties of electrons and ions such as temperature and density
- ChaSTE to study the thermal properties of the lunar surface near the polar region

ROVER:

- APXS to determine the composition of elements such as Magnesium, Aluminium, Silicon, etc.
- LIBS to determine the chemical and mineral composition of the lunar surface

LUNA-25

- ADRON-LR, a spectrometer to study the surface
- ARIES-L detects charged particles in the polar exosphere
- LIS-TV-RPM, an infra-red spectrometer, measures surface water and OH
- The LASMA-LR mass spectrometer will measure composition of soil samples
- The PML detector will study dust in the polar exosphere
- STS-L is a panoramic and local imaging system

Chandrayaan-3

Why hasn't any spacecraft ever landed near the lunar south pole?

- There is a very good reason why all the landings on the Moon so far have happened in the equatorial region. Even **China's Chang'e 4**, which became the first spacecraft to land on the **far side of the moon** — the side that does not face the earth — landed near the 45-degree latitude.
- It is **easier and safer to land near the equator**. The **terrain and temperature are more hospitable** and conducive for a long and sustained operation of instruments.
- The **surface here is even and smooth, very steep slopes are almost absent**, and there are fewer hills or craters.
- **Sunlight is present in abundance**, at least on the side facing the earth, thus offering a regular supply of energy to solar-powered instruments.

Chandrayaan-3

- The **polar regions of the Moon, however, are a very different**, and difficult, terrain. Many parts lie in a completely **dark region** where sunlight never reaches
- **Lack of sunlight and extremely low temperatures** create difficulty in the operation of instruments. In addition, there are **large craters all over the place**, ranging from a few centimetres in size to those extending to several thousands of kilometres.

Chandrayaan-3

Why do scientists want to explore the lunar south pole?

- Due to their rugged environment, the polar regions of the Moon **have remained unexplored.** But several Orbiter missions have provided evidence that these regions could be very interesting to explore.
- There are **indications of the presence of ice molecules** in substantial amounts in the deep craters in this region — India's 2008 Chandrayaan-1 mission indicated the presence of water on the lunar surface with the help of its two instruments onboard.
- In addition, the extremely cold temperatures here mean that anything **trapped in the region** would **remain frozen in time, without undergoing much change.** The rocks and soil in **Moon's north and south poles could therefore provide clues to the early Solar System.**

Why don't some parts of the lunar polar regions receive any sunlight?

- Unlike the Earth, whose **spin axis is tilted with respect to the plane of the Earth's solar orbit by 23.5 degrees,** the Moon's axis tilts **only 1.5 degrees**. Because of this unique geometry, sunlight never shines on the floors of a number of craters near the lunar north and south poles. These areas are known as Permanently Shadowed Regions, or PSRs.

Chandrayaan-3

Why was Chandrayaan-2 unable to land correctly, and what has changed since then?

- **Chandrayaan-2 lost control over its descent around 7.2 km from the surface** of the Moon. Its communications system relayed data of the loss of control up to around 400 m above the surface. The **Lander had slowed down to about 580 km/hr when it crashed.**
- A Lander does not have wheels; it has stilts, or legs, which are supposed to touch down on the lunar surface, the **legs of Chandrayaan-3** **have been strengthened to ensure that it would be able to land, and stabilise**, even at a speed of 3 m/sec, or 10.8 km/hour.
- The prospective **landing site had its range increased**, this time. **Instead of trying to reach a specific 500mx500m patch** for landing as targeted by **Chandrayaan-2, the current mission was given instructions to land safely anywhere in a 4kmx2.4km area**.
- The **Chandrayaan-3 Lander carried** **more fuel** **than Chandrayaan-2**. This was done to ensure that the Lander is able to make a last-minute change in its landing site if it needs to.

Chandrayaan-3

- The **Chandrayaan-3 Lander has solar panels on four sides**, instead of only two in Chandrayaan-2. This was to ensure that the Lander continued to draw solar power, even if it landed in a wrong direction, or tumbled over. At least one or two of its sides would always be facing the Sun, and remain active.

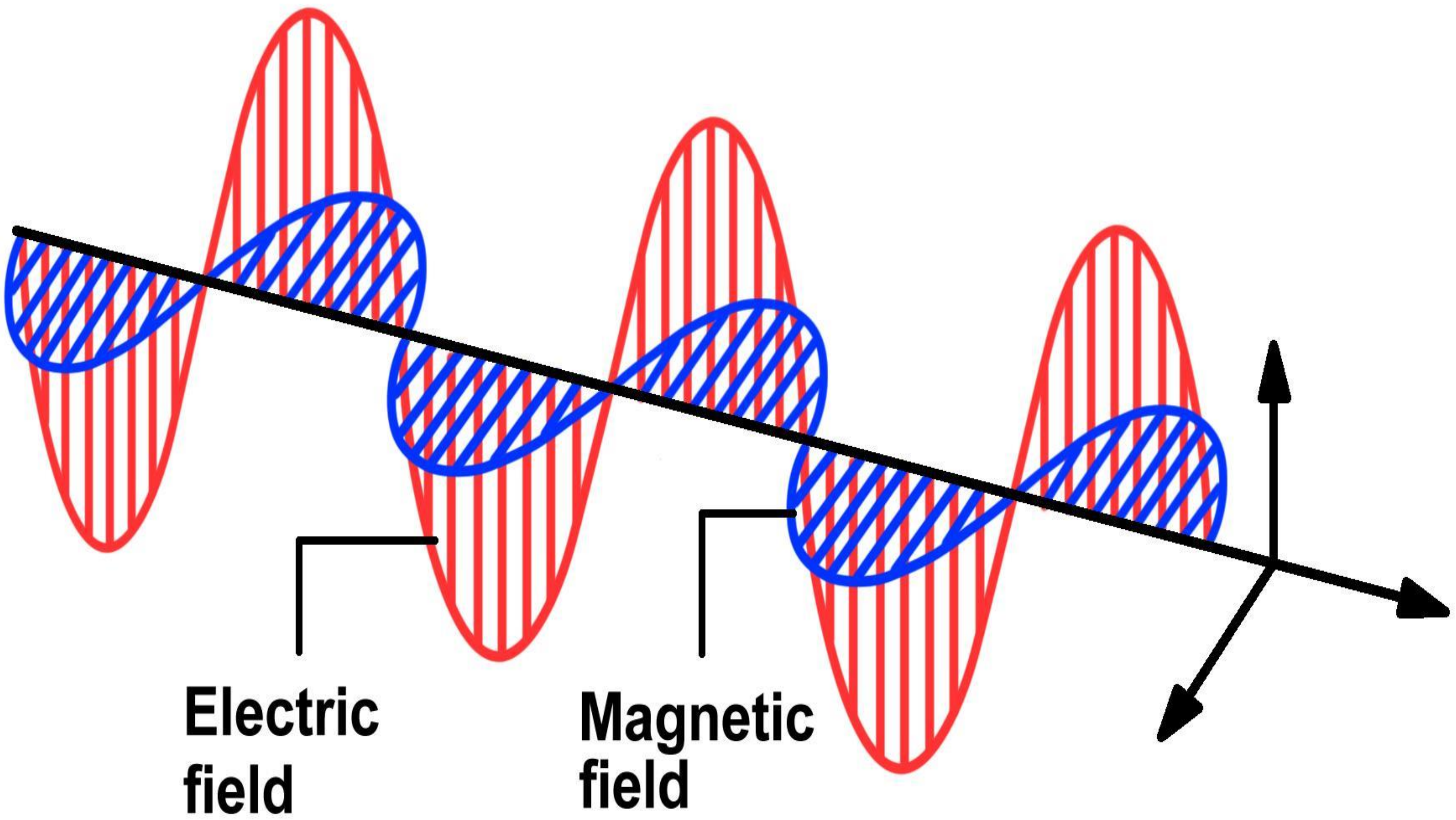
X-ray Polarimeter Satellite (XpoSat)

Context-The Indian Space Research Organisation (ISRO) began the new year with the launch of its **first X-ray Polarimeter Satellite** (XpoSat)

The PSLV-C58 rocket, with primary payload XPoSat and 10 other satellites to be deployed in **low-earth orbits**

XpoSat

- It is a space-based observatory to study **X-ray polarisation and its cosmic sources** – celestial bodies including black holes, neutron stars and magnetars.
- XpoSat is only the **world's second such mission**. In 2021, NASA had launched Imaging X-ray Polarimetry Explorer (IXPE) to operate and perform X-ray polarisation measurements within the soft X-ray band, whereas XPoSat will operate within the medium X-ray band.
- XPoSat will become the country's third space-based observatory after the recently launched solar mission Aditya-L1, and AstroSat launched in 2015.


Electric field
Magnetic field

X-ray Polarimeter Satellite (XpoSat)

Payloads

- It will carry two payloads – POLIX (Polarimeter Instrument in X-rays) and XSPECT (X-ray Spectroscopy and Timing).
- POLIX is expected to observe about 40 bright astronomical sources of different categories
- XSPECT will study the electromagnetic spectrum generated by different matter.

X-ray Polarimeter Satellite (XpoSat)

X-ray polarisation

- It serves as a crucial diagnostic tool for examining the radiation mechanism and geometry of celestial sources.
- The insights derived from X-ray polarisation measurements on celestial objects like black holes, neutron stars and active galactic nuclei, hold the potential to significantly improve the understanding of their physics.

Indian Space Policy 2023

The government recently approved the **Indian Space Policy 2023** that seeks to **institutionalise the private sector participation in the space sector**, with ISRO focusing on research and development of advanced space technologies.

Indian space policy 2023

- It delineated the roles and responsibilities of **ISRO,** space sector PSU **NewSpace India Limited (NSIL)** and **Indian National Space Promotion and Authorization Center (IN-SPACe).**
- The policy will **allow the private sector** to take part in end-to-end space activities that include building satellites, rockets and launch vehicles, data collection and dissemination

Indian Space Policy 2023

What does the policy say about what private space players can do?

- In its essence, the policy allows **NGEs to take up end-to-end activities in the space sector** by establishing **operations of objects in space** (such as satellites etc), ground-based assets and so on.
- Their operations will be **subject to guidelines prescribed by the Indian Space Promotion and Authorisation Centre (IN-SPACe),** which, in the couple of years since its establishment, has turned out to be a focal point for interactions between the government and private players when it comes to space activities.
- Private players **can use Indian orbital resources** to establish space objects for communication services; establish and operate remote sensing satellites within and outside India; and manufacture and operate space transportation systems, including launch vehicles etc

Indian Space Policy 2023

Non-Governmental Entities

- NGEs can engage in **commercial recovery of an asteroid or a space resource**.
- Any NGE engaged in such a process shall be entitled to **possess, own, transport, use and sell any such asteroid resource or space resource** obtained in accordance with applicable law, including the international obligations of India.
- NGE shall mean (i) a company incorporated under the **Companies Act, 2013** or (ii) a partnership firm established under the **Limited Liability Partnership Act, 2008**, (iii) Trusts under the **Indian Trusts Act 1882** (iv) Association of persons or body of individuals incorporated under **relevant statutes in India**.

Indian Space Policy 2023

What does the policy say about ISRO's role?

- In what is being welcomed by stakeholders in the space industry, the policy states that the nation's premier space organisation's **primary focus would be on research and development of new space technologies and applications**.
- The organisation would **transition from the existing practice of manufacturing operational space systems**. From now on, the policy says, those **systems will be transferred to industries and "ISRO shall focus on R&D in advanced technology proving newer systems of space objects for meeting national prerogatives"**

Indian Space Policy 2023

IN-SPACe

- Established in 2020, **In-SPACE is a single-window autonomous agency under the Department of Space**.
- Although it has turned out to be crucial for space tech start-up players in all things related to permissions, integrations, launches and so on, industry players have often highlighted the **lack of a legislative mandate of IN-SPACe**.
- Now, they have a reason to rejoice as the space policy **clarifies the responsibilities of this bod**y. Although other aspects such as **organisation structure, appointments, tenure etc is still not clear.**

Indian Space Policy 2023

IN-SPACe's responsibilities

- IN-SPACe will provide **authorisations to both government bodies and NGEs for space activities,** such as establishment and/or operation of space objects, launch of rockets, establishment of launchpads, planned re-entry of space objects, and so on.
- **On the promotion side**, it will work with space sector-centric industry clusters, work towards establishing India as a preferred service provider for foreign requirements of products and services, work with academia to enable industry-academia linkages, and so on.
- It will also **define frameworks for developing space industry standards**, based on global standards. IN-SPACe will authorise the use of space objects for communication/broadcast services in coordination with the departments concerned.

Indian Space Policy 2023

- IN-SPACe will **ensure a level playing field for the utilisation of all facilities created** using public expenditure, by prioritising their use among Government entities and NGEs. For this, IN-SPACe will **formulate appropriate procedures** for prioritisation, and the decisions of IN-SPACe shall be binding on the operators of such facilities.
- Apart from that, the policy states that the body will **incentivise NGEs that acquire new orbital resources** through filings in the UN's International Telecommunication Union (ITU), and so on.

Indian Space Policy 2023

What will the Department of Space do?

- The policy states that the department will be **responsible for implementation of the Indian Space Policy.**
- It will also ensure **different stakeholders mentioned in the policy are empowered to take on their responsibilities** without overlapping into others' domains.
- Importantly, the DoS will also be **responsible for ensuring sustenance of existing and future satellite constellations and ground segments**. It will also establish **framework to ensure safe and sustainable space operation**, in compliance with relevant international space debris mitigation guidelines.

Indian Space Policy 2023

NewSpace India Limited NSIL

As the **Public Sector Undertaking under DOS**, shall:

1. Be responsible for **commercialising space technologies** and platforms created through public expenditure.
2. **Manufacture, lease, or procure space components**, technologies, platforms and other assets from private or public sector, on sound commercial principles.
3. Service the **space-based needs of users**, whether Government entities or NGEs, on sound commercial principles

LIGO project

Seven years after an in-principle approval, the government's final go-ahead to the **LIGO project** paves the way for **construction to begin on India's largest scientific facility** that will bolster global efforts to probe the universe through the detection and study of gravitational waves.

LIGO, or Laser Interferometer Gravitational-Wave Observatory

- It is an **international network of laboratories** meant to detect **gravitational waves** — the ripples in space-time produced by the movement of large celestial bodies like stars and planets.
- **First discovered in 2015 by two LIGOs based in the United States**
- Two years later, in 2017, this experimental verification of the century-old theory received the Nobel Prize in Physics
- Besides the United States (in **Hanford and Livingston**), such gravitational wave observatories are currently operational in **Italy (Virgo) and Japan (Kagra).**

LIGO project

LIGO-India

- It is **part of the plan to expand the network of gravitational wave observatories** in order to increase the chances of detecting these waves from anywhere in the observable universe and improve the accuracy and quality of information gleaned from them.
- Until now, at least 10 events producing gravitational waves have been detected.
- Besides the United States, such gravitational wave observatories are currently operational in Europe and Japan. **LIGO-India will be the fifth, and possibly the final, node of the planned network.**
- To be located in **Hingoli district of Maharashtra**, about 450 km east of Mumbai, LIGO-India is scheduled to begin its scientific runs from 2030. The final approval, involving a budget of Rs 2,600 crore, has taken several years in coming.
- The LIGO detector in India would be **similar to the two that are located in the United States – in Hanford and Livingston.**

LIGO project

Gravitational Waves

- Gravitational waves are **'ripples' in space-time caused by some of the most violent and energetic processes in the Universe**.
- **Albert Einstein** predicted the existence of gravitational waves in 1916 in his general theory of relativity.
- Einstein's mathematics showed that **massive accelerating objects (such as neutron stars or black holes orbiting each other) would disrupt space-time in such a way that 'waves' of undulating space-time** would propagate in all directions away from the source. These cosmic ripples would travel at the speed of light, carrying with them information about their origins, as well as clues to the nature of gravity itself.
- The **strongest gravitational waves are produced by cataclysmic events** such as colliding black holes, supernovae (massive stars exploding at the end of their lifetimes), and colliding neutron stars.
- Other waves are predicted to be caused by the rotation of neutron stars that are not perfect spheres, and possibly even the remnants of gravitational radiation created by the Big Bang.

LIGO project

Sources and Types of Gravitational Waves

- **Every massive object that accelerates produces gravitational waves**. This includes **humans, cars, airplanes etc**., but the **masses and accelerations of objects on Earth are far too small** to make gravitational waves big enough to detect with our instruments. To find big enough gravitational waves, we have to look far outside of our own solar system.
- It turns out that the Universe is filled with incredibly massive objects that undergo rapid accelerations that by their nature, generate gravitational waves that we can actually detect.
- Examples of such things are orbiting pairs of **black holes and neutron stars, or massive stars blowing up at the ends of their lives**.

NISAR Mission

ISRO-NASA built NISAR satellite ready to be shipped to India for launch

About NISAR

- An **earth-observation satellite jointly developed by NASA and ISRO** that will help study **Earth's land and ice surfaces in greater detail**
- This mission will be a powerful demonstration of the **capability of radar as a science tool and help us study Earth's dynamic land and ice surfaces** in greater detail than ever before
- **ISRO and NASA joined hands in 2014 to** build the 2,800 kg satellite. In March 2021, **ISRO sent its S-Band SAR payload** developed in India to NASA for integration with the L-Band payload built by JPL (NASA's Jet Propulsion Laboratory)
- This marks an important milestone in our shared journey to better understand planet Earth and our changing climate. NISAR will **provide critical information on Earth's crust, ice sheets, and ecosystems**

NISAR Mission

- NISAR will gather radar data with a drum-shaped reflector antenna almost 12 meters in diameter. It will use a signal-processing technique called interferometric synthetic aperture radar, or InSAR, to observe changes in Earth's land and ice surfaces down to fractions of an inch.
- The satellite will help researchers detect slow-moving variations of a land surface that can precede earthquakes, landslides, and volcanic eruptions.

NISAR Mission

Benefits

- Data about such movements could help communities **prepare for natural hazards such as the Joshimath land subsidence**.
- Measurements of **melting sea ice and ice sheets will improve understanding of the pace** and impacts of climate change, including sea level rise.
- Over the course of its three-year prime mission, the satellite will observe nearly the **entire planet every 12 days**, making observations day and night, in all weather conditions

Dark Sky Reserve

- India established the **country's first Dark Sky Reserve in the cold desert regions of Ladakh**

What is a Dark Sky Reserve?

- A Dark Sky Reserve is **public or private land** with a distinguished nocturnal environment and starry nights that has been developed **responsibly to prevent light pollution**.
- According to the **International Dark Sky Association** (IDSA) website, these reserves "**consist of a core area meeting minimum criteria for sky quality and natural darkness, and a peripheral area that supports dark sky preservation in the core**."
- These reserves, it said, are formed through a "partnership of multiple land managers who have recognized the value of the natural nighttime environment through regulations and long-term planning".

Dark Sky Reserve

How does a site become a 'Dark Sky Reserve'?

- **Individuals or groups can nominate** a site for certification to the International Dark Sky Association (IDSA). There are five designated categories, namely International **Dark Sky parks, communities, reserves, sanctuaries and Urban Night Sky Places.**
- The certification process is **similar to that of a site being awarded the UNESCO** World Heritage Site tag or getting recognised as a Biosphere Reserve.
- Between 2001 and January 2022, there have been **195 sites recognised as International Dark Sky Places globally, the IDSA** said.

Dark Sky Reserve

Criteria

- The **IDSA considers a piece of land suitable for dark sky** place only if it is **either publicly or privately owned**; is accessible to the public partially or entirely during the year; the land is **legally protected for scientific, natural, educational, cultural, heritage and/**or public enjoyment purposes; the core area of the land provides an exceptional dark sky resource relative to the communities and cities that surround it and the land **offers prescribed night sky brightness** either for a reserve, park or sanctuary.
- India is still in the process of filing its nomination to IDSA.

Dark Sky Reserve

Who is developing India's first Dark Sky Reserve?

- The **Ladakh Union Territory administration** is leading the efforts in establishing the country's first Dark Sky Reserve.
- To be situated at a height of 4,500 metres above sea level, the Hanle Dark Sky Reserve (HDSR) will come up within the **Changthang Wildlife Sanctuary**.

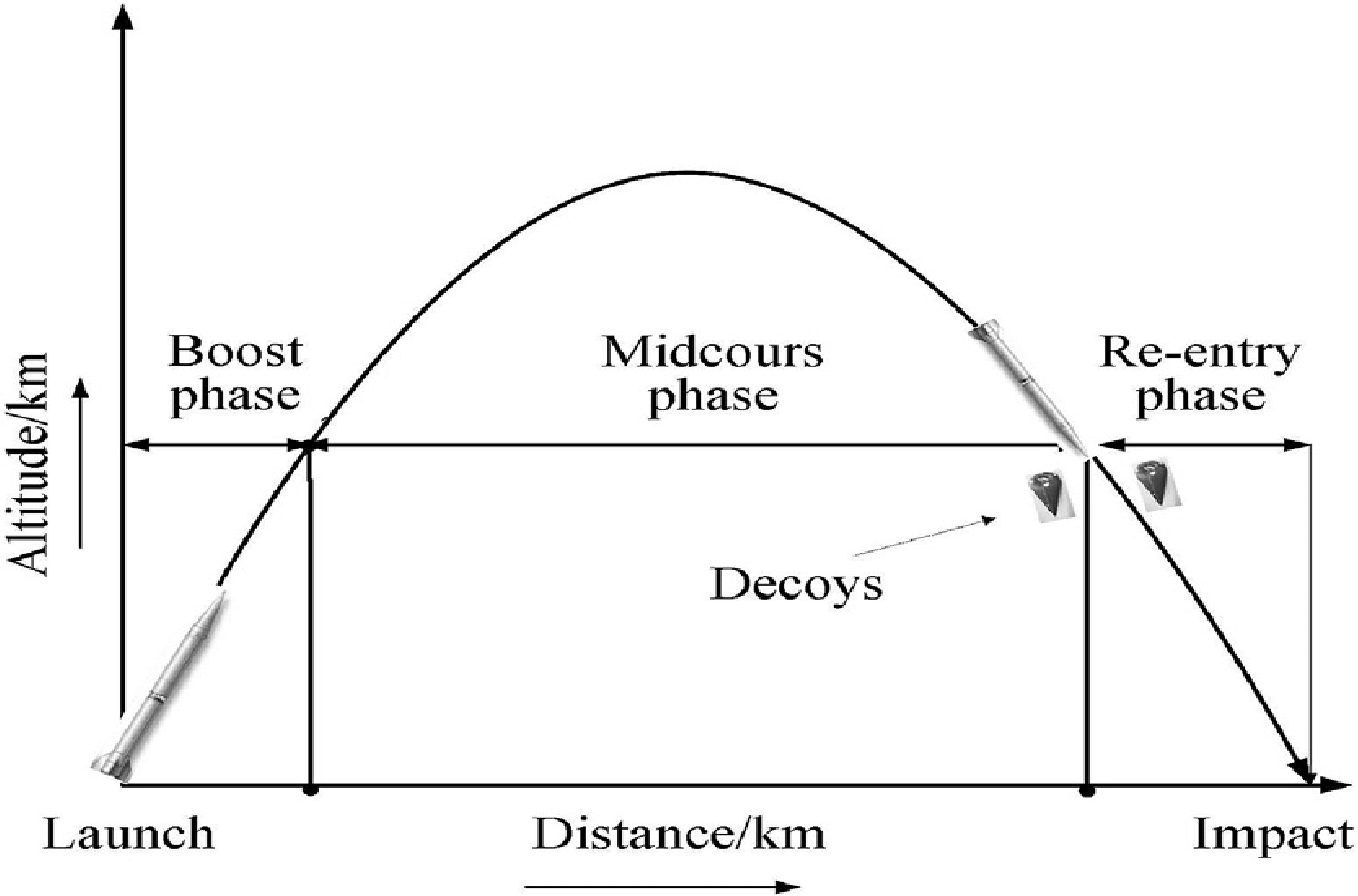
Dark Sky Reserve

Why was Ladakh chosen for the project?

- Ladakh is a **unique cold desert** located about 3,000 metres above sea level with high mountainous terrains.
- Long and harsh winters with minimum temperatures dropping to minus 40 degrees Celcius make large parts of the UT **highly inhabitable.**
- This aridity, limited vegetation, high elevation and **large areas with sparse populations** – all make it the perfect setting for long-term astronomical observatories and dark sky places.
- But the primary objective of the proposed Dark Sky Reserve is to **promote astronomy tourism** in a sustainable and environment-friendly manner. Scientific methods will be used here **to preserve the night sky from ever-increasing light pollution.**
- With metros, cities and peripheral areas experiencing light pollution and remaining constantly lit up, there are diminishing areas that offer a view of clear skies on cloudless nights, experts have noted.

Missile system of India

Ballistic Missile stages



Ballistic Missile stages

Boost Phase	• Begins at launch and lasts until the rocket engine(s) stops firing and the missile begins unpowered flight. • Depending on the missile, boost phase **can last three to five minutes**. Most of this phase takes place in the atmosphere.
Midcourse Phase	• Begins after the rocket(s) stops firing. • The missile continues to ascend toward the highest point in its trajectory, and then begins to descend toward Earth. • This is the longest phase of a missile's flight
Terminal Phase	• Begins when the detached warhead(s) **reenter the Earth's atmosphere** and ends upon impact or detonation. • During this phase, which can **last for less than a minute**, strategic warheads can be traveling at speeds greater than 3,200 kilometers per hour

Ballistic Vs Cruise missile

Ballistic Missile	Cruise Missile
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.
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 generally small (below 500 km) as it needs to be constantly propelled to hit the target with high precision.
Prithvi , Agni	**Brahmos missile**

Integrated Guided Missile Development Programme (IGMDP)-DRDO

- IGMDP was started in 1983 (Dr APJ Abdul Kalam)
- To attain self-sufficiency in the field of missile technology.

Missiles

- Prithvi Missile
- Akash
- Trishul
- Nag
- Agni

Missile	Type	Range	
Agni I	SRBM	700-1000 Km	Single stage Solid Nuclear
Agni II	MRBM	2000-2500	Two stage solid fuel Nuclear warhead
Agni III	IRBM	2500-3500	Two solid stage Nuclear
Agni IV	IRBM	3500-4000	Two solid stage Nuclear
Agni V	ICBM	>5000	Three stage solid Nuclear Warhead

Agni-6

- The DRDO is reportedly in the early stages of developing Agni-6 and the missile is expected to have a range between 9,000 to 12,000 kms with a 3-tonne nuclear payload.

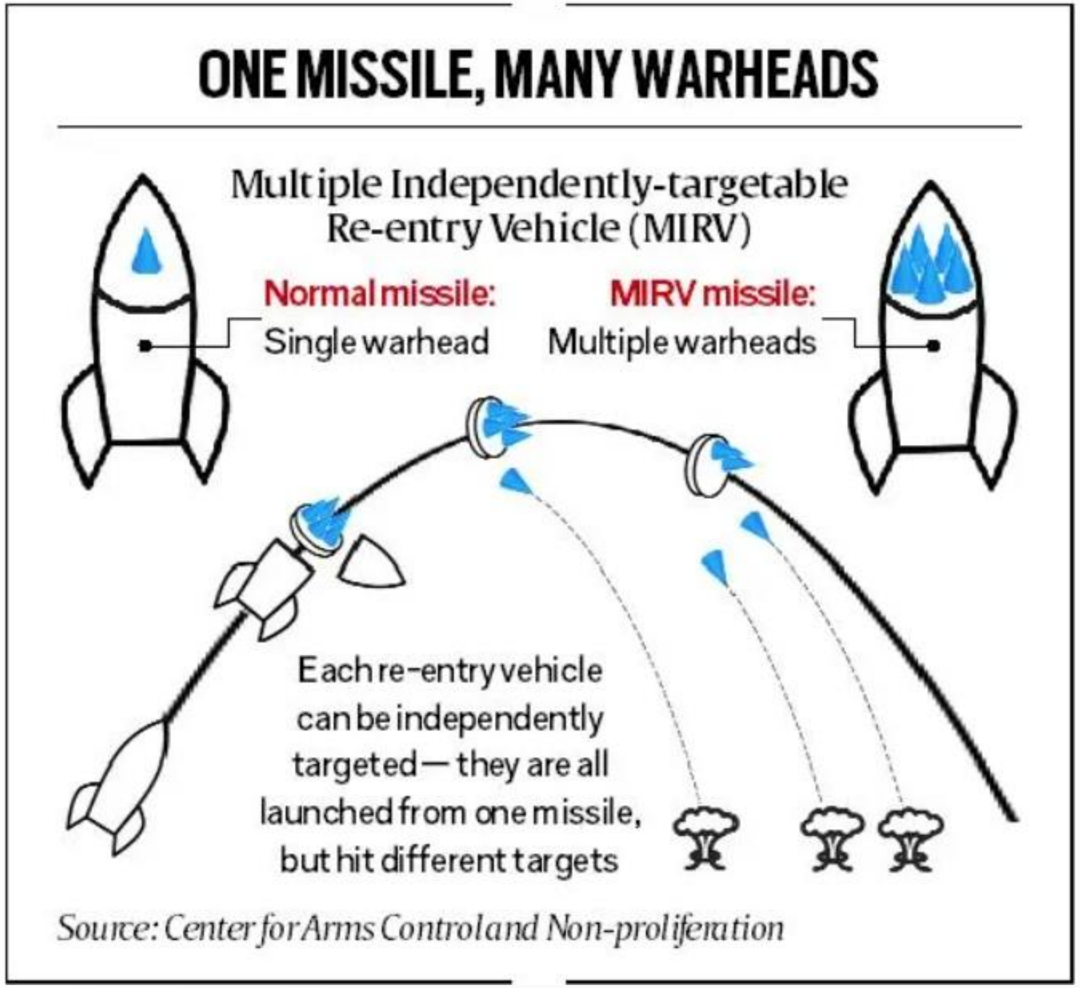
Mission Divyastra

- India test-fires Agni-V ballistic missile with multiple warhead technology under Mission Divyastra
- This ability to carry multiple warheads on a single missile, called MIRV or Multiple Independently Targetable Re-entry Vehicle

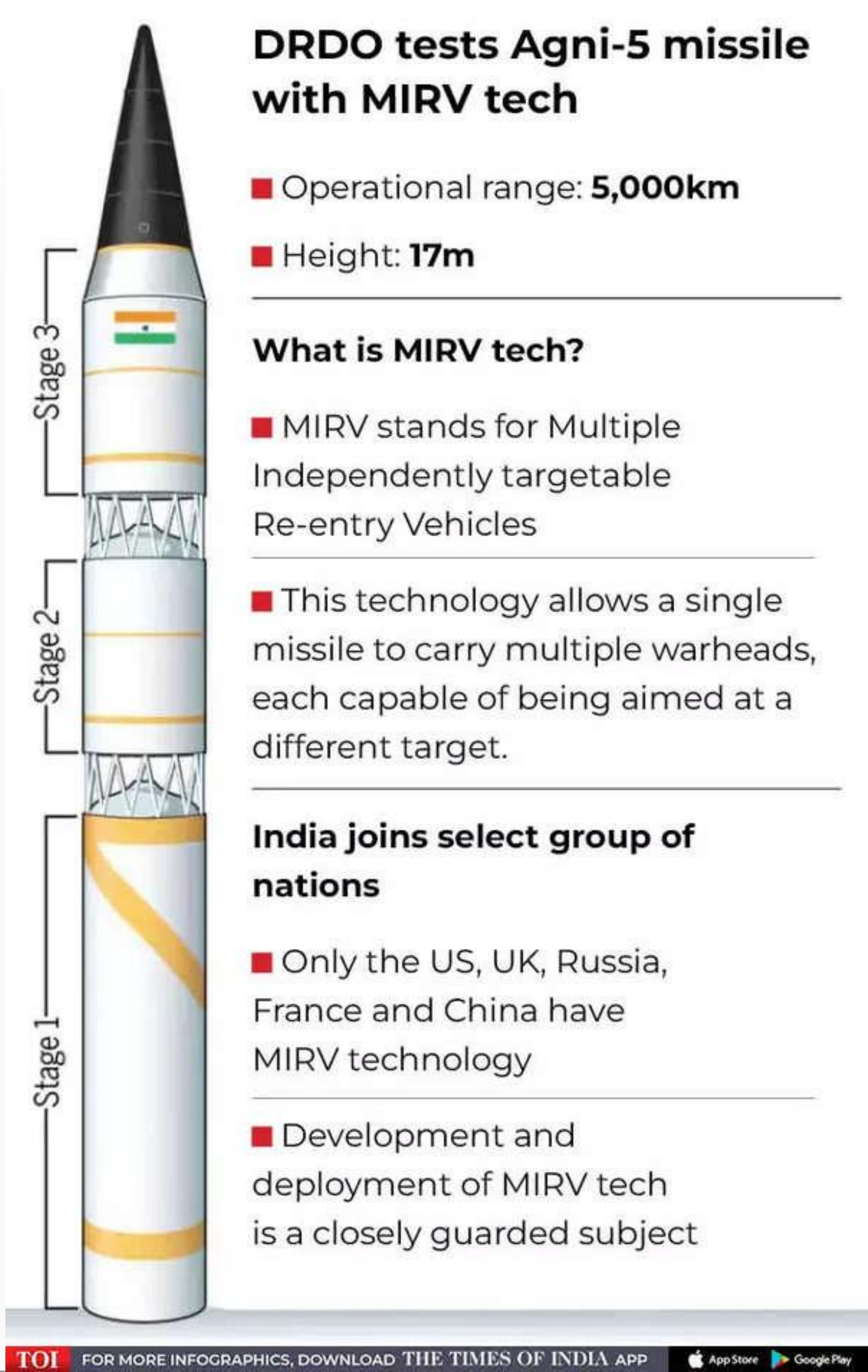
MIRV or Multiple Independently Targetable Re-entry Vehicle

- It is a technology that originated five decades ago, but is in possession of only a handful of countries – the **United States, Russia, China, United Kingdom and France.**
- Last year, Pakistan also claimed to have tested a MIRV-equipped missile
- Missiles equipped with MIRV technology can aim multiple targets that can be located hundreds of kilometres apart.
- Agni-5, which can carry nuclear warheads and hit targets more than 5,000 km away, is aimed mainly at thwarting the challenge from China.
- It uses a three-stage solid-fuelled engine.

The advantage of these warheads is that they are smart and intelligent and could be controlled to hit multiple specific targets, thus covering a larger area of influence. Thus, it is a force multiplier.



- The US was the first country to develop MIRV technology, deploying a MIRVed Intercontinental Ballistic Missile (ICBM) in 1970 and a MIRVed Submarine-Launched Ballistic Missile (SLBM) in 1971.
- The Soviet Union caught up quickly and developed their own MIRV-enabled ICBM and SLBM technology by the end of the 1970s.
- Besides these two countries, the UK, France and China have MIRV technology.



Agni-P missile

A new-generation nuclear-capable ballistic missile, **Agni-P (Prime) was successfully test-fired** by the Defence Research and Development Organisation (DRDO)

Agni-P

High accuracy

- Many advanced technologies including composites**, propulsion systems, innovative guidance and control mechanisms** and state-of-the-art navigation systems have been introduced.
- The Agni-P missile **would further strengthen India's credible deterrence capabilities**
- There is a complete technology upgrade in every way.

Shot in the arm

- Agni-P's range of 1,000-2,000 km is too short to reach targets in China's mainland, but can cover all of Pakistan's territory
- Being a canisterised missile, it can be transported easily and fired at very short notice
- It will replace the Prithvi, Agni-1 and Agni-2 missiles in India's arsenal that were built two decades ago with tech now considered obsolete
- It will enter service as a two-stage, solid propellant missile. Both stages will have composite rocket motors and guidance systems with electro-mechanical actuators
- Agni-P and Agni-5 originate from the Integrated Guided Missile Development Programme launched by then DRDO chief Dr APJ Abdul Kalam in the early 1980s

Submarines

Submarine

- any naval vessel that is capable of propelling itself beneath the water as well as on the water's surface.
- Submarines are essentially of two types:
- conventional and nuclear.

Submarines

Conventional submarines

- Use a diesel-electric engine, and must surface for oxygen for fuel combustion.

Advantage

- Smaller - easier to maneuver in shallow waters and harder to detect
- Ease and quietness of operation

Submarines

Conventional submarines

Disadvantage

- Diesel-electric submarines require to come to the surface frequently **to charge their batteries, their underwater endurance time is less**
- **Risk of detection** by enemy radar

Submarines

Air Independent Propulsion (AIP)

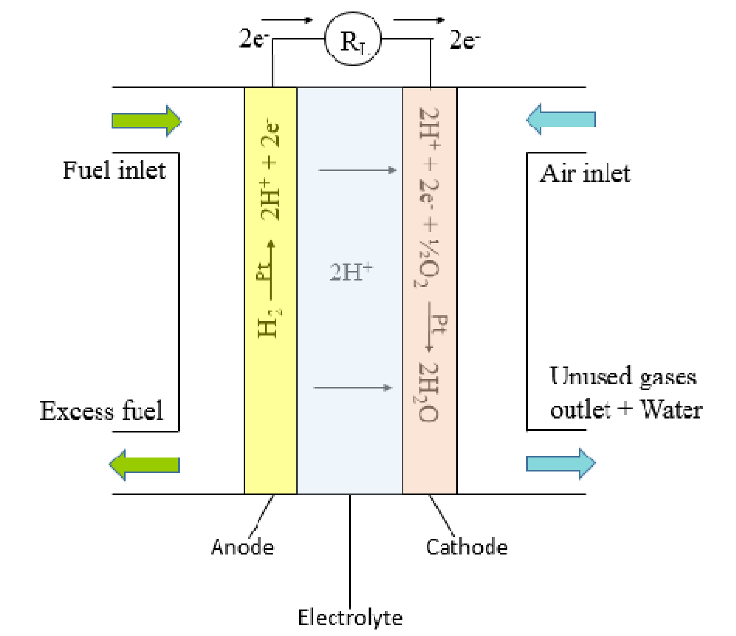
- Technology which allows a non-nuclear submarine to operate without much need to access atmospheric oxygen

Submarines

Air Independent Propulsion (AIP)

Fuel cell AIP

- An electrolytic fuel cell releases energy by combining hydrogen and oxygen, with only water as the waste product.
- The cells are highly efficient, and **do not have moving parts**, thus ensuring that the submarine has a low acoustic signature



Submarines

Basics

Electrolysis

- When each water molecule **splits into its components**: two parts hydrogen and one part oxygen. That process is called **electrolysis.**

Fuel cell (Reverse electrolysis)

- What takes place inside a fuel cell is electrolysis in reverse: **Combine hydrogen and oxygen, and you get water and electricity**

Submarines

Air Independent Propulsion (AIP)

- Fuel cell technology-based AIP generates power through the **reverse electrolysis of oxygen and hydrogen**. In this process, the two elements chemically combine, thereby generating electricity to charge the submarine's batteries. This process **does not need air, but requires storage of highly inflammable hydrogen on board**

Submarines

DRDO's AIP

Innovative Phosphoric Acid Fuel Cell technology

- This process is more tolerant of fuel impurities, **offers longer life and efficiency**, and is much safer, since it **does not require hazardous Hydrogen** to be stored on board.

Submarines

- The DRDO's AIP system, once ready, will from 2024-25 onward, be "retrofitted" into six **Scorpene submarines that are being built in India under Project 75**
- As per various reports the **six Project-75I submarines will be powered by AIP systems that the foreign vendor**

Submarines

Nuclear Submarine

- Not required to be refueled and brought to the surface again

Disadvantage

- The **reactor needs to be cooled** even when the submarine is not moving
- The nuclear fission generates enormous amounts of the **harmful radiation** that if it is leaked , It can damage both the human and the marine life.

Submarines

Disadvantage

- The **reactor is cooled by using the surrounding sea water**, So, the nuclear submarine moves ahead leaving behind huge amounts of **warm water**
- The warm water layer rises to the surface and it creates the **thermal wake** (turbulence) which can be easily detected by the thermal imaging system.
- The nuclear submarines **cost a lot of money**

Submarines

INS Arihant

- Nuclear submarines are those that are powered by onboard nuclear reactors whereas conventional submarines generate energy by burning diesel, which requires air
- **indigenously-built nuclear-propelled submarine.**
- Capable of carrying submarine-launched **ballistic missiles** having a range of over 700 km.
- It can **dive to 300 metres**
- It is its **most dependable platform for a second-strike** as the other options i.e land-based and air-launched, are easier to detect.

Submarines

Sleepy Classes IAS
Awakening Toppers

INS Arihant

- Marked the completion of India's **nuclear triad.**

Nuclear triad

- Refers to the nuclear weapons delivery via **land, air and sea** i.e. land-based intercontinental ballistic missiles (ICBMs), strategic bombers, and submarine-launched ballistic missiles (SLBMs).

Submarines

INS Chakra

- It belongs to Akula-class **nuclear powered Submarine**.
- It was **taken from Russia** on a 10 year lease period.
- It carries **only conventional weapons and not nuclear tipped missiles.**
- It is the second nuclear submarine after the indigenously built INS Arihant.
- INS Chakra 1 was inducted into Indian Navy in the year 1998.
- INS Chakra 2 was inducted into Indian Navy in the year 2012.

SONAR stands for **Sound Navigation and Ranging.**

- SONAR is a process of communicating or detecting objects underwater.
- It is generally used by ships, submarines to detect underwater objects like rocks, icebergs which causes serious risk to the ships.

The Speed of Sound

- A sound wave is a pressure disturbance that travels through a medium by means of particle-to-particle interaction.
- As one particle becomes disturbed, it exerts a force on the next adjacent particle, thus disturbing that particle from rest and transporting the energy through the medium
- The speed of sound in a medium depends on **temperature of the medium.**
- The speed of sound decreases when we go from solid to gaseous state. In any medium as we increase the temperature, the speed of sound increases.
- For example, the speed of sound in air is **331 m s–1 at 0°C and 344 m s–1 at 22 °C**

Medium

$\mathbf{v_{solids} > v_{liquids} > v_{gases}}$

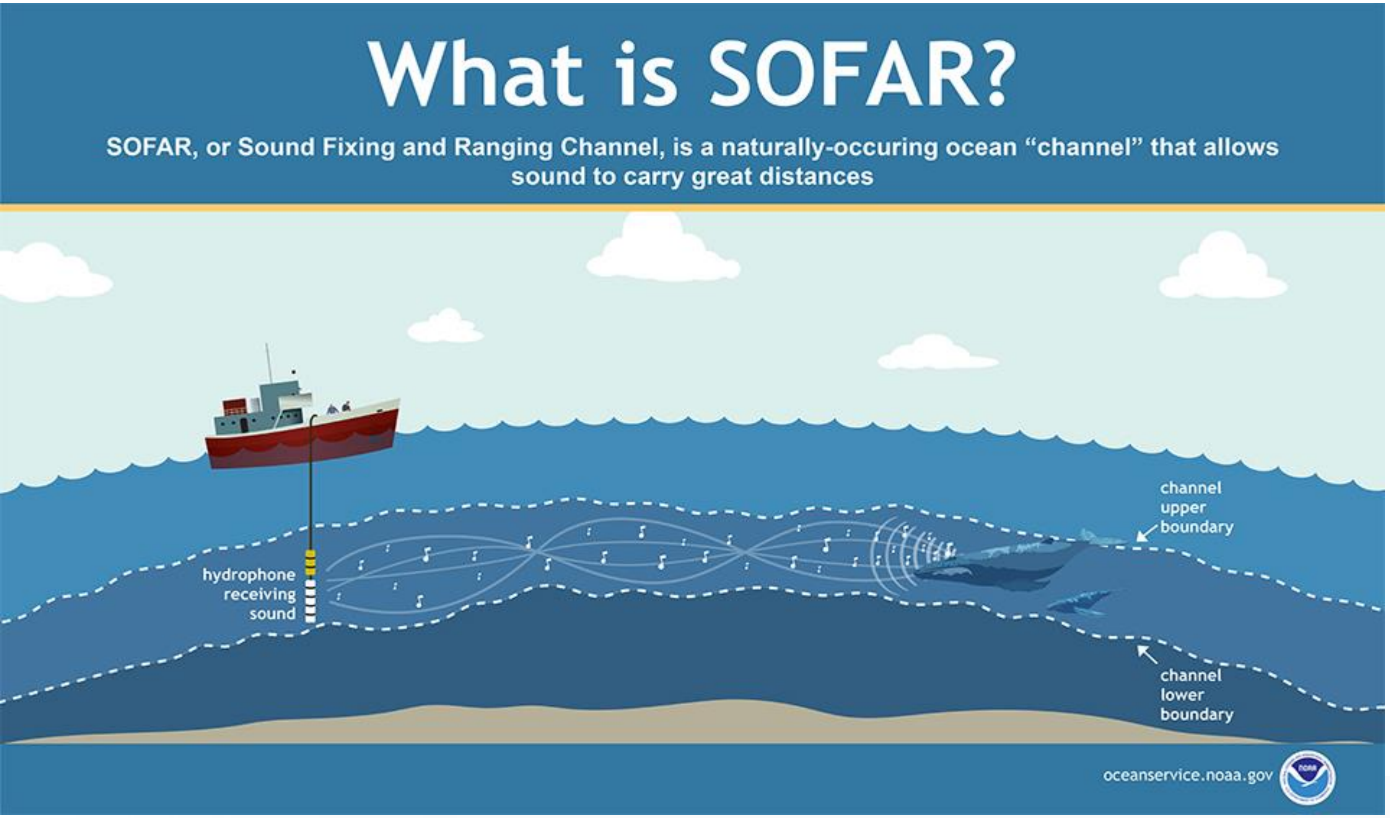
Sound in water

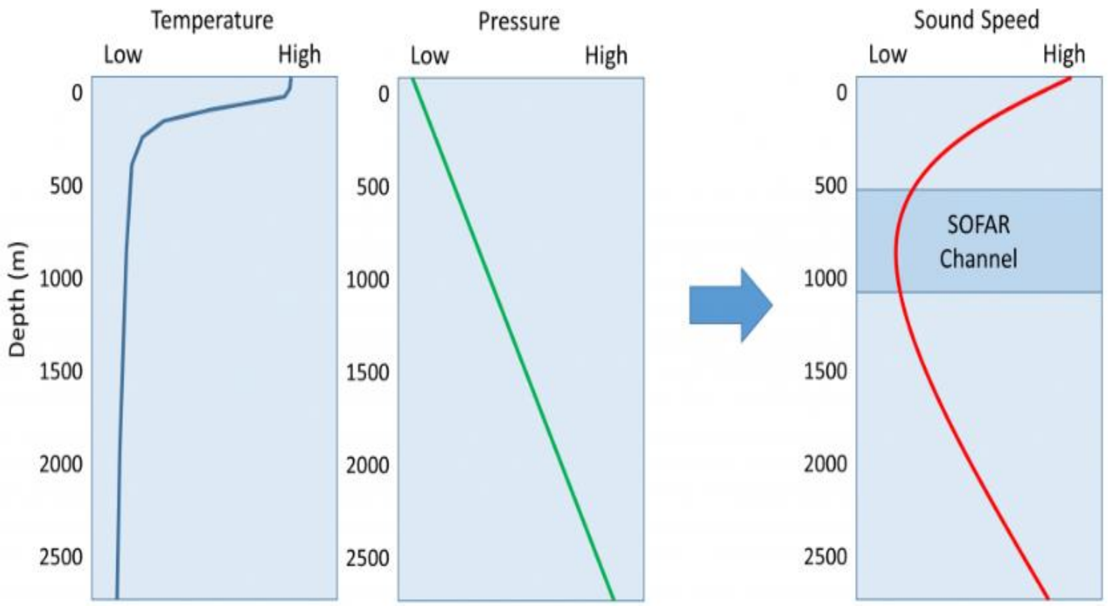
- Sound travels **much more slowly than light** through water but can travel much further, and so is used for remote sensing and communication in the oceans.
- Sound travels faster through denser materials. Since water is much denser than air, the **speed of sound in water** (about 1500 m/s) is approximately five times faster than the speed in air (around 330 m/s).
- This helps explain why we sometimes have **difficulty localizing the source of a sound** that we hear underwater.
- We **localize sound sources when our brains detect the tiny differences in the time of arrival of sounds** reaching our ears.
- A sound coming from our left will reach our left ear a fraction of a second before reaching our right ear.
- Our brains can process that small difference in time of arrival to recognize the direction from which the sound came.
- **In water**, the sound is so much faster that the **difference in arrival time between our ears becomes too small for us to interpret**, and we lose the ability to localize the source.

Sleepy Classes IAS
Awakening Toppers

SOFAR or Sound Fixing and Ranging Channel

- It is a **naturally-occurring ocean "channel"** that allows sound to carry great distances.
- The SOFAR channel is important because sounds produced in that region can be **propagated over very long distances** with little attenuation (loss of energy).
- Sound waves produced in the channel radiate out in all directions. Waves that travel into shallower or deeper water outside of the sound channel are entering a region of faster sound transmission.
- As we saw with seismic waves, when these sound waves encounter a region of differing transmission speed, the waves tend to **be refracted or bent back towards the region of lower speed.**
- As a result, sound waves moving from **the SOFAR channel into shallower water will be refracted back towards the channel**


What is SOFAR?
SOFAR, or Sound Fixing and Ranging Channel, is a naturally-occuring ocean "channel" that allows sound to carry great distances
channel upper boundary
hydrophone receiving sound
channel lower boundary
oceanservice.noaa.gov


Temperature
Low
High
Pressure
Low
High
Sound Speed
Low
High
Depth (m)
0
500
1000
1500
2000
2500
SOFAR Channel