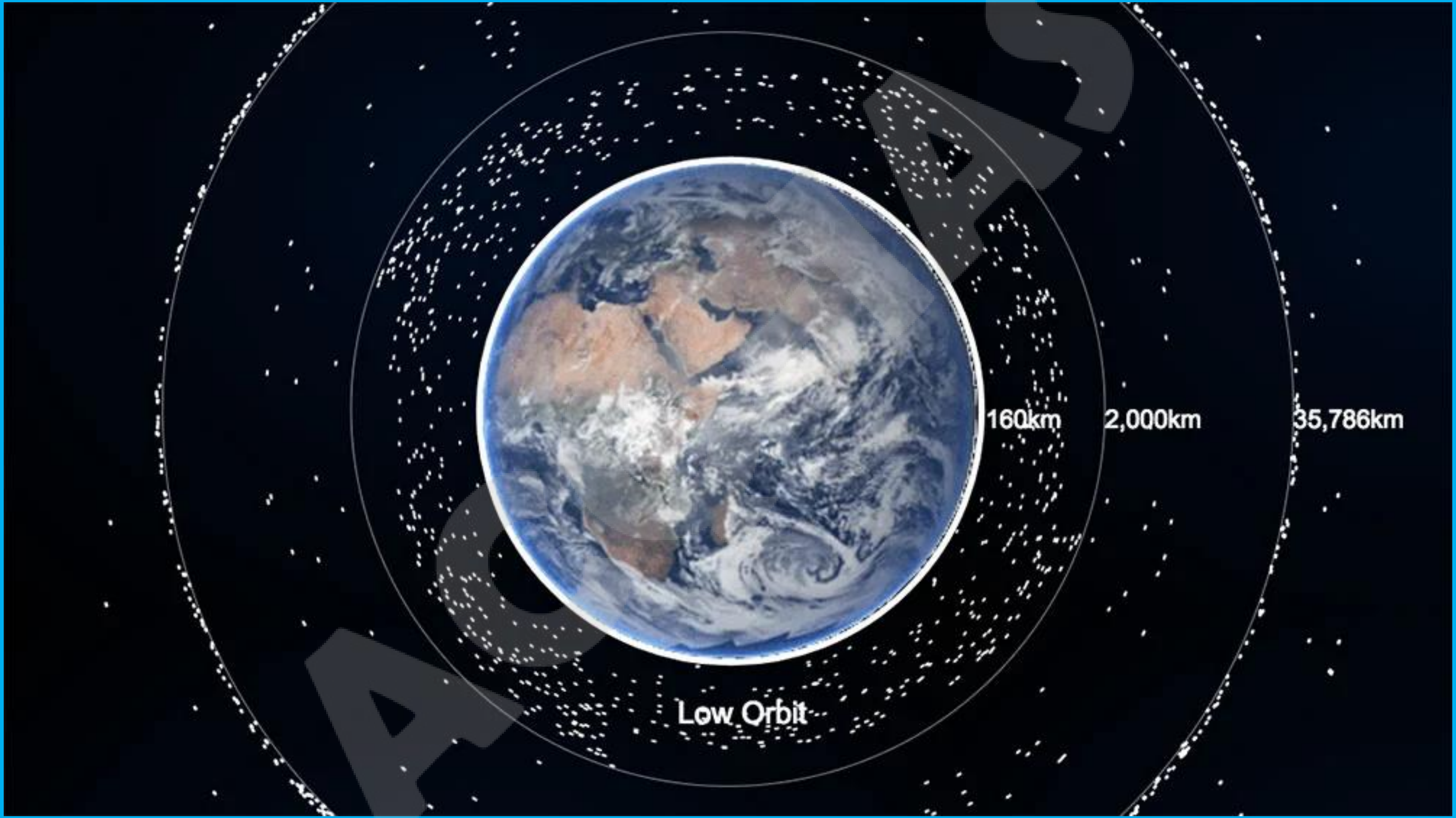
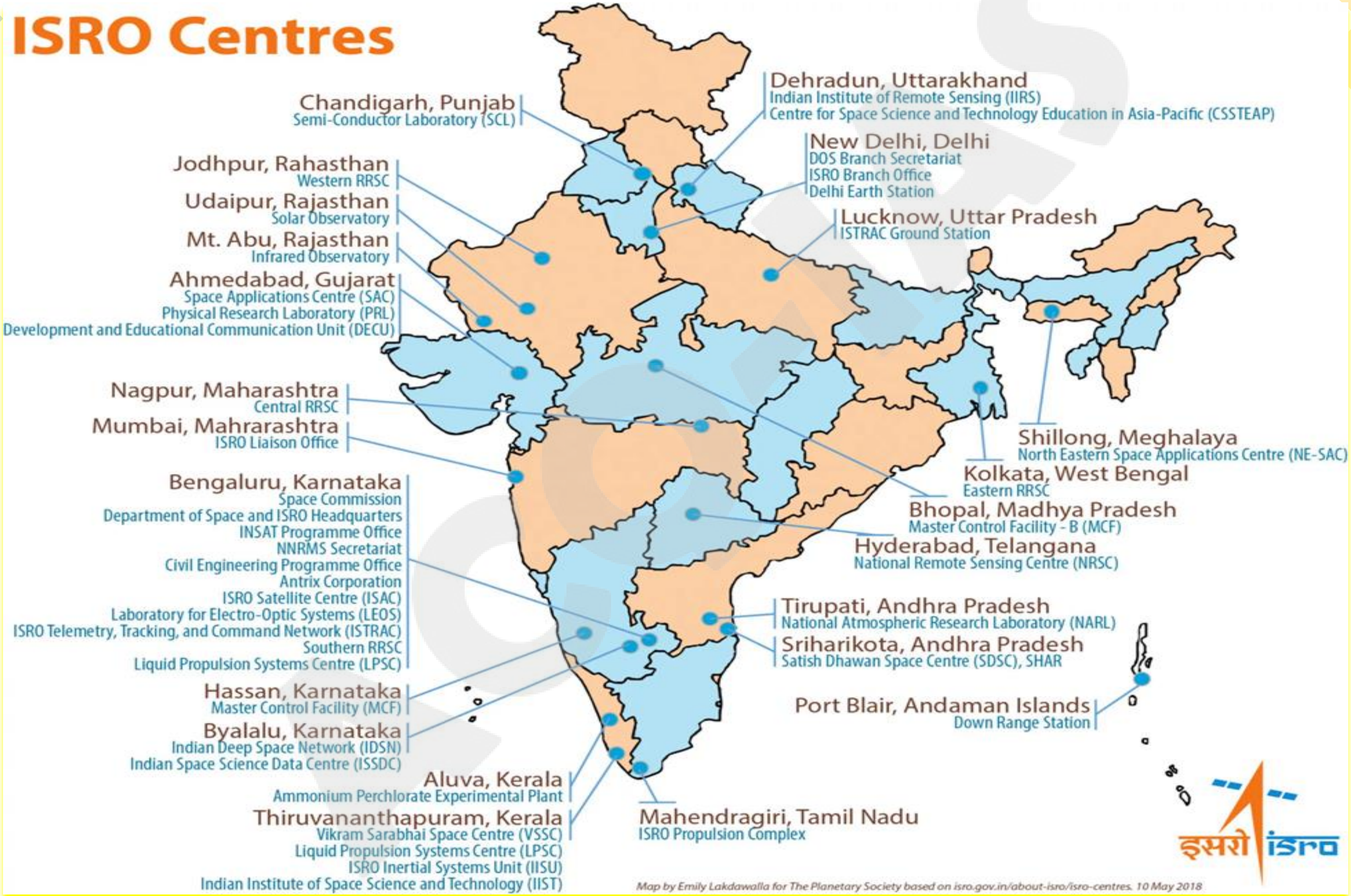

160km
2,000km
35,786km
Low Orbit

ISRO Centres



MASTER CONTROL FACILITY

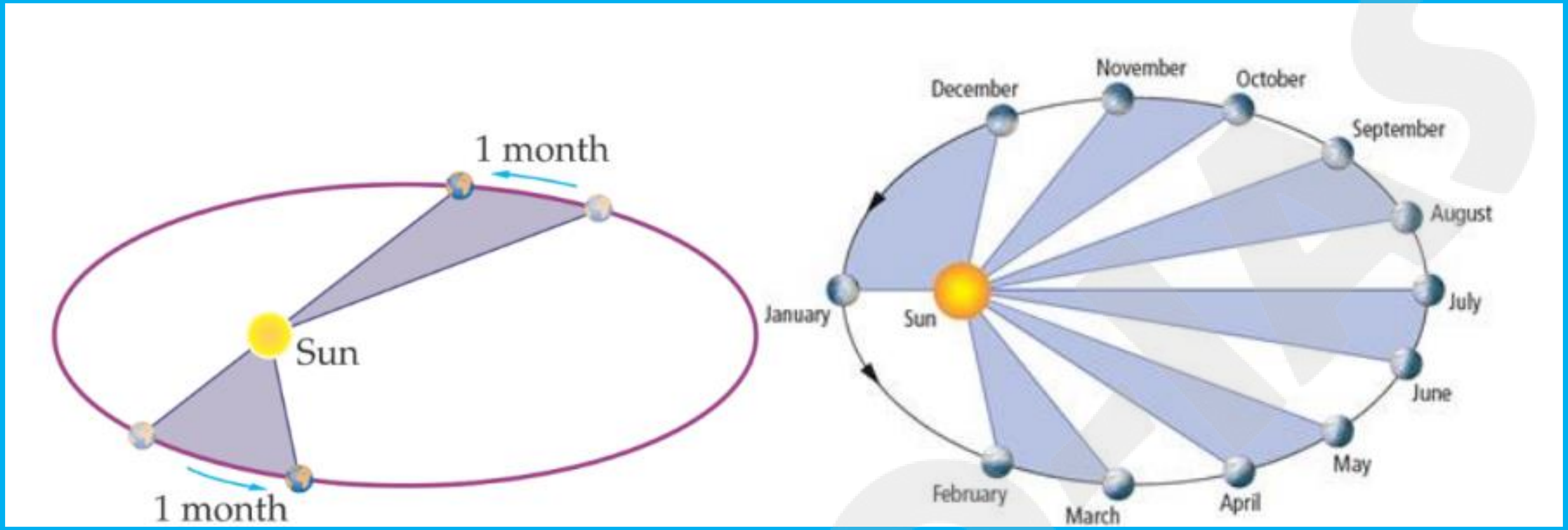
- Master Control Facility (MCF) at Hassan in Karnataka and Bhopal in Madhya Pradesh
- Monitors and controls all the Geostationary / Geosynchronous satellites of ISRO, namely, INSAT, GSAT, Kalpana and IRNSS series of satellites.

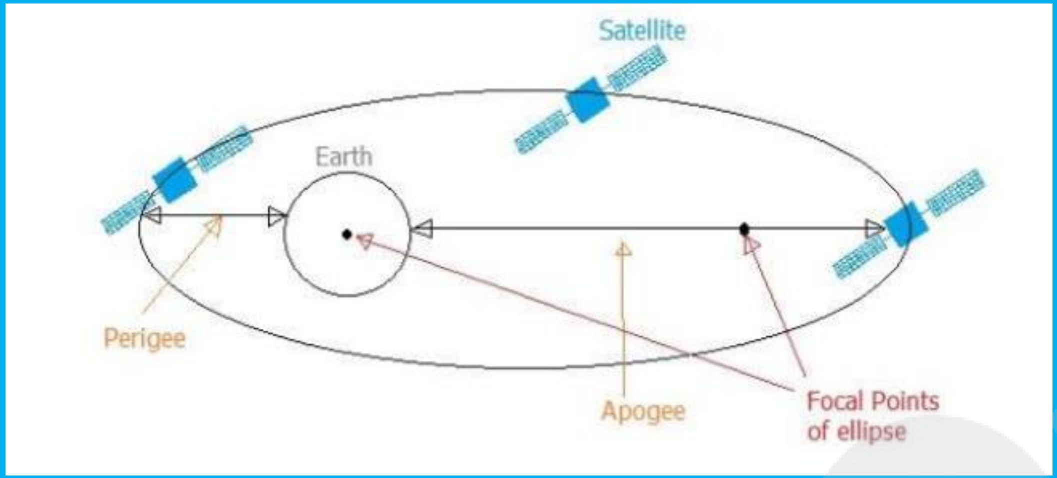
Indian Deep Space Network (IDSN)

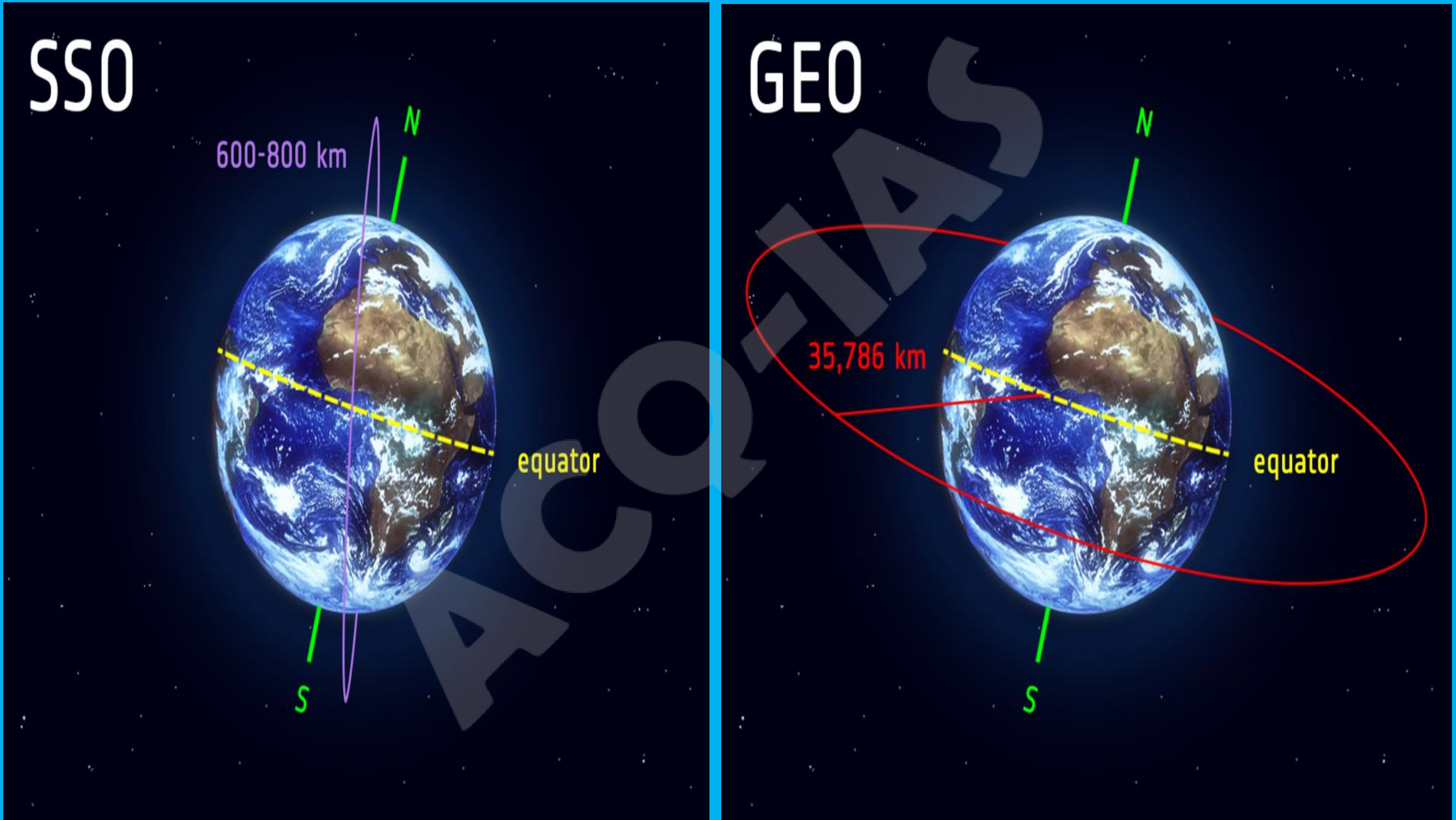
- The Indian Deep Space Network (IDSN), commissioned during the year 2008, at Byalalu village near Bengaluru, forms the Ground segment for providing deep space support for India's Space Science Missions like Lunar mission-Chandrayaan-1, Mars Orbiter Mission (MOM) etc.,

Vikram Sarabhai Space Centre

- VSSC pioneers in rocket research and launch vehicle projects of ISRO
- The ongoing programmes at VSSC include launch vehicle projects like Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV), Rohini Sounding Rockets and Space-capsule Recovery Experiments.


1 month
Sun
1 month
December
November
October
September
August
July
June
May
April
March
February
January
Sun


Satellite
Earth
Perigee
Apogee
Focal Points
of ellipse


SSO
600-800 km
N
S
equator
GEO
35,786 km
N
S
equator

SLV-3

Height	: 22.7m
Lift-off weight	: 17 t
Propulsion	: All Solid
Payload mass	: 40 kg
Orbit	: Low Earth Orbit

ASLV

Height	: 23.5m
Lift-off weight	: 39 t
Propulsion	: All Solid
Payload mass	: 150 kg
Orbit	: Low Earth Orbit

PSLV-XL

Height	: 44m
Lift-off weight	: 320 t
Propulsion	: Solid & Liquid
Payload mass	: 1860 kg
Orbit	: 475 km Sun Synchronous Polar Orbit (1300 kg in Geosynchronous Transfer Orbit)

GSLV Mk II

Height	: 49m
Lift-off weight	: 414 t
Propulsion	: Solid, Liquid & Cryogenic
Payload mass	: 2200 kg
Orbit	: Geosynchronous Transfer Orbit

GSLV Mk III

Height	: 43.43 m
Lift-off weight	: 640 t
Propulsion	: Solid, Liquid & Cryogenic
Payload mass	: 4000 kg
Orbit	: Geosynchronous Transfer Orbit

Polar Satellite Launch Vehicle (PSLV)

Polar Satellite Launch Vehicle (PSLV) is the 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 a reliable and versatile workhorse launch vehicle of India. The vehicle has launched numerous Indian and foreign customer satellites.

Besides, the vehicle successfully launched two spacecraft "Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013"that later travelled to Moon and Mars respectively.

PSLV earned its title 'the workhorse of ISRO' through consistently delivering various satellites into low earth orbits, particularly the IRS Series of satellites

Due to its unmatched reliability, PSLV has also been used to launch various satellites into Geosynchronous and Geostationary orbits, like satellites from the IRNSS Constellation

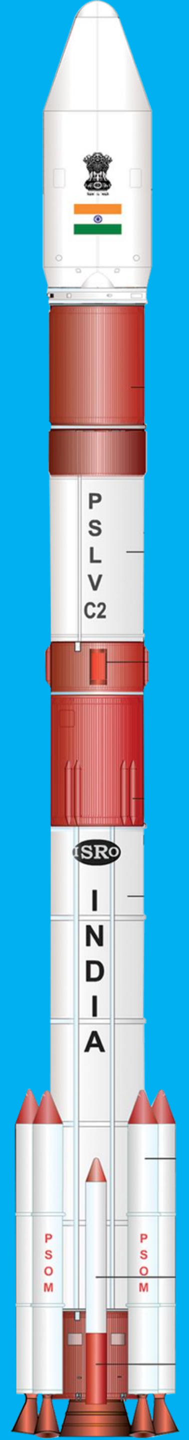
The PSLV is capable of placing multiple payloads into orbit, thus multi-payload adaptors are used in the payload fairing.

Vehicle Specifications

Height	: 44 m
Diameter	: 2.8 m
Number of Stages	: 4
Lift Off Mass	: 320 tonnes (XL)
Variants	: 4 (PSLV,CA,DL,QL,XL)

Strap-on Motors

PSLV uses 6 solid rocket strap-on motors to augment the thrust provided by the first stage. However, strap-ons are not used in the core alone version (PSLV-CA).



Fourth Stage: PS4

The PS4 is the uppermost stage of PSLV, comprising of two Earth storable liquid engines.

Engine	: 2 x PS-4
Fuel	: MMH + MON
Max. Thrust	: 7.3 x 2 kN

Third Stage: PS3

The third stage of PSLV is a solid rocket motor that provides the upper stages high thrust after the atmospheric phase of the launch.

Motor	: S7
Fuel	: HTPB
Max. Thrust	: 240 kN

Second Stage: PS2

PSLV uses an Earth storable liquid rocket engine for its second stage, know as the Vikas engine, developed by Liquid Propulsion Systems Centre.

Engine	: Vikas
Fuel	: UDMH + N_2O_4
Max. Thrust	: 799 kN

First Stage: PS1

PSLV uses the S139 solid rocket motor that is augmented by 6 solid strap-on boosters.

Engine	: S139
Fuel	: HTPB
Max. Thrust	: 4800 kN

Hydroxyl-terminated polybutadiene

Unsymmetrical dimethylhydrazine

Monomethylhydrazine

Strap-on Motors

PSLV uses 6,4,2 solid rocket strap-on motors to augment the thrust provided by the first stage in PSLV-XL, QL & DL variants respectively. However, strap-ons are not used in the core alone version (PSLV-CA).

Motor	: S12
Fuel	: HTPB
Max. Thrust	: 719 kN

- delivering various satellites to Low Earth Orbits,
- It can take up to 1,750 kg of payload to Sun-Synchronous Polar Orbits of 600 km altitude.
- Due to its unmatched reliability, PSLV has also been used to launch various satellites into Geosynchronous and Geostationary orbits

- # GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE

Geosynchronous Satellite Launch Vehicle Mark II (GSLV Mk II) is the launch vehicle developed by India, to launch communication satellites

This operational fourth generation launch vehicle is a three stage vehicle with four liquid strap-ons

The GSLV uses 4 liquid strap-on motors. The strap-ons are
The strap-ons are powered by one Vikas engine each
one Vikas engine each

One Vikas engine is used in the second stage of GSLV. The stage was derived from the PS2 of PSLV where the Vikas engine has proved its reliability

Developed under the Cryogenic Upper Stage Project (CUSP), the CE-7.5 is India's first cryogenic engine, developed by the Liquid Propulsion Systems Centre

Third Stage: CUS

Developed under the Cryogenic Upper Stage Project (CUSP), the CE-7.5 is India's first cryogenic engine, developed by the Liquid Propulsion Systems Centre. CE-7.5 has a staged combustion operating cycle.

Fuel	: LOX + LH2
Nominal Thrust (Max)	: 75 kN
Burn-time	: 814 sec

Second Stage: GS2

One Vikas engine is used in the second stage of GSLV. The stage was derived from the PS2 of PSLV where the Vikas engine has proved its reliability

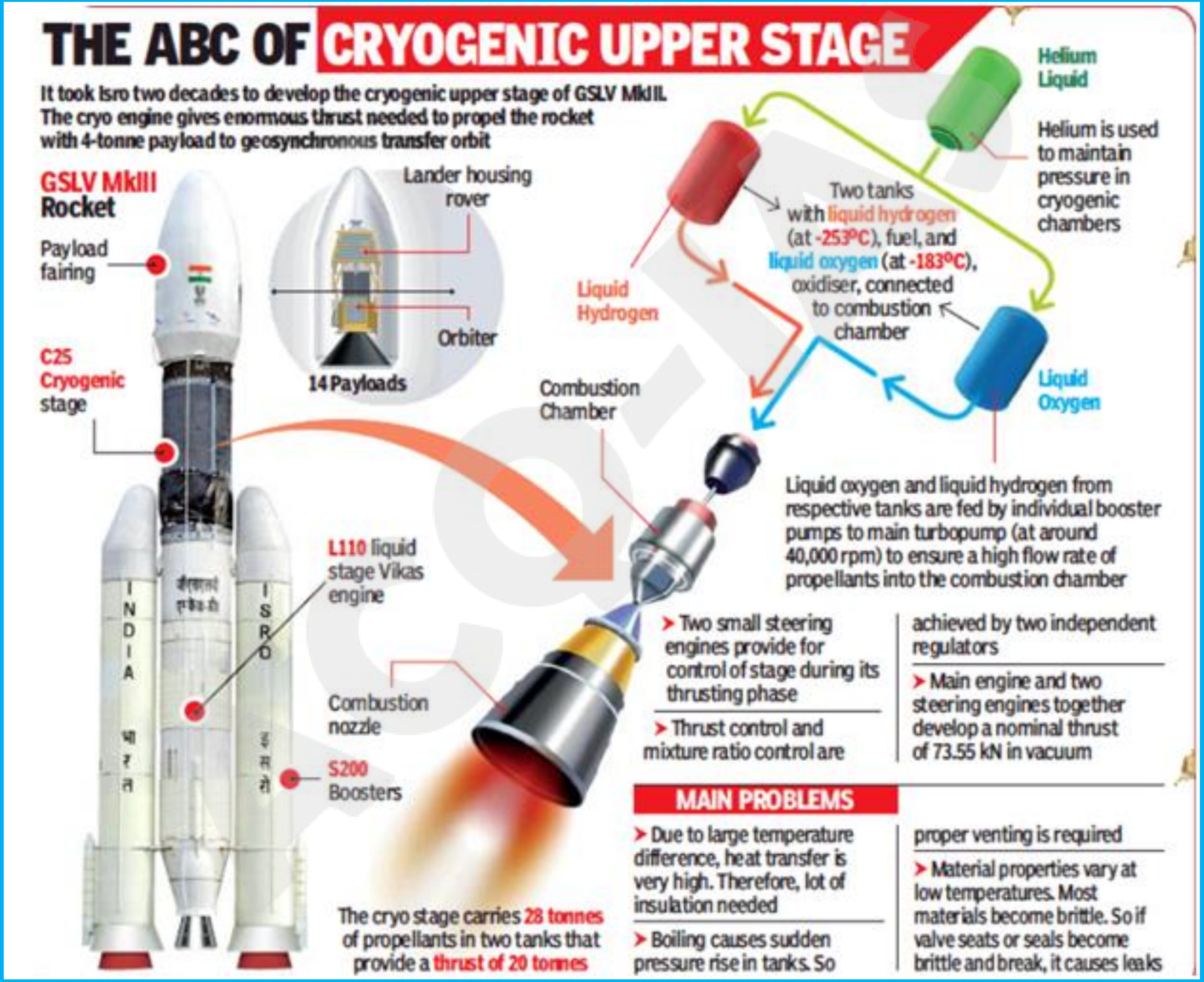
Engine	: Vikas
Fuel	: UH25 + N2O4
Nominal Thrust (Max)	: 846 kN
Burn-time	: 150 sec

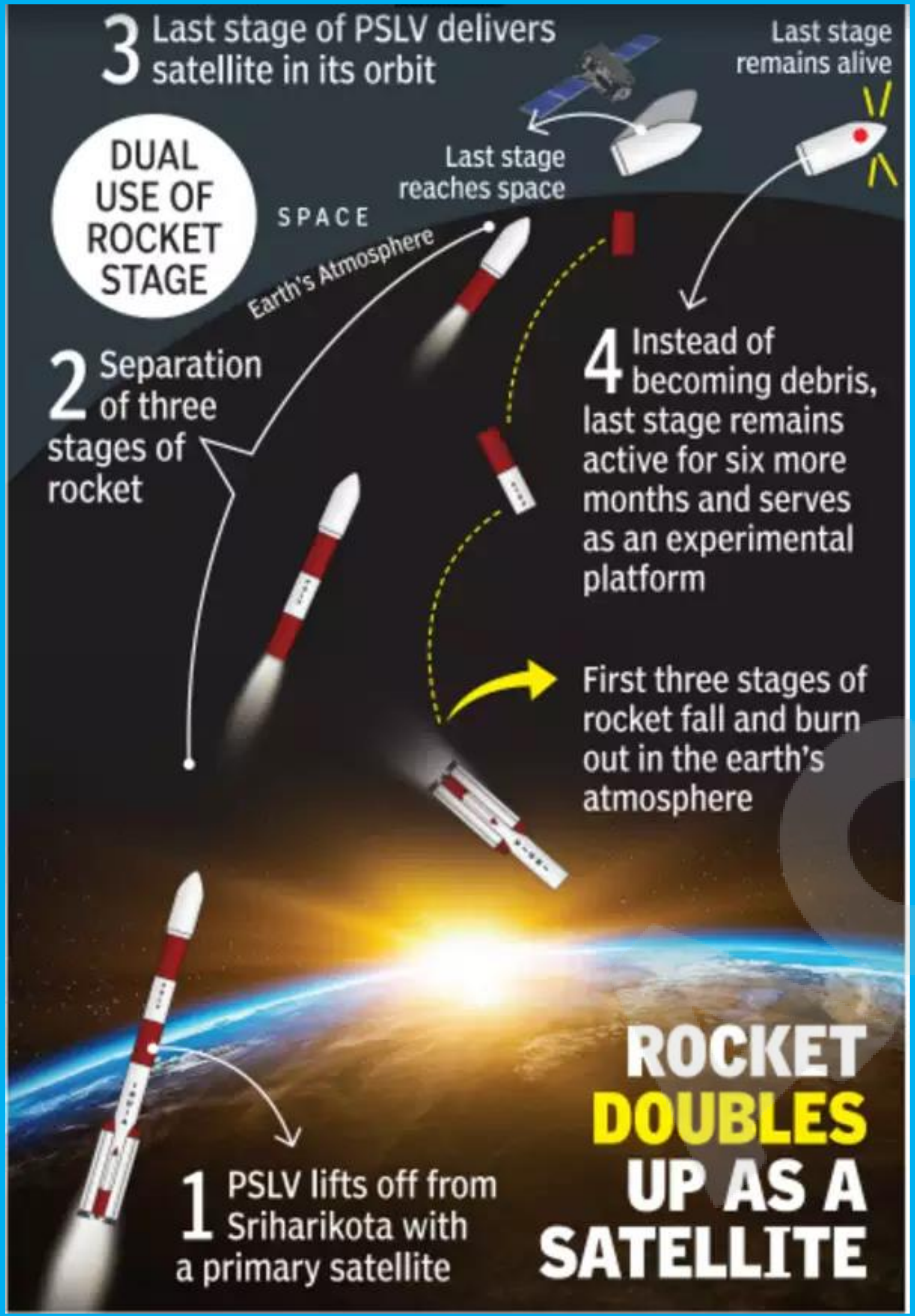
First Stage: GS1

The first stage of GSLV was also derived from the PSLV's PS1. The 138 tonne solid rocket motor is augmented by 4 liquid strap-ons.

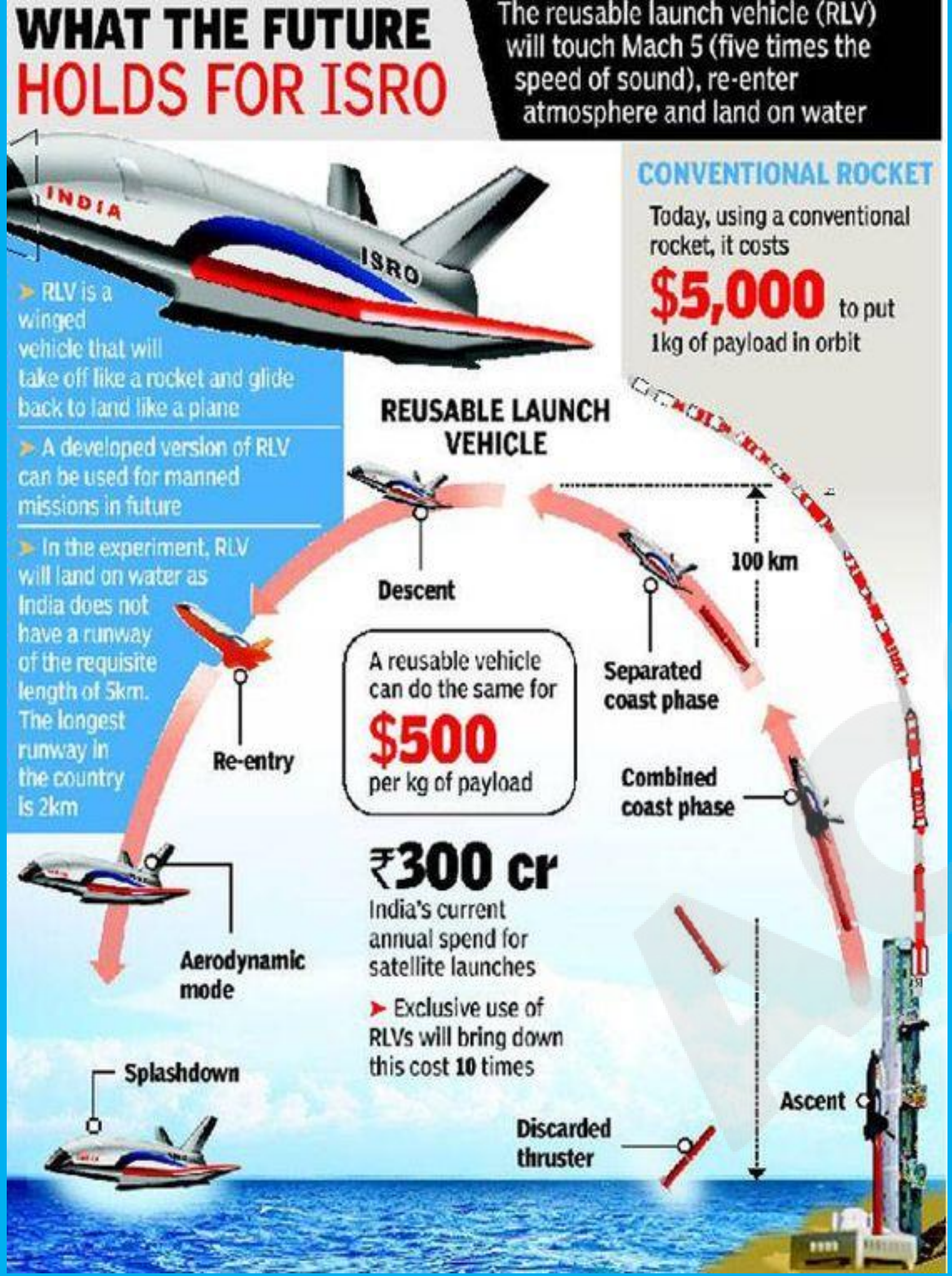
Engine	: S139
Fuel	: HTPB
Max. Thrust	: 4800 kN
Burn-time	: 100 sec

- GSLV MkIII is configured as a three stage vehicle with two solid strap-on motors (S200), one liquid core stage (L110) and a high thrust cryogenic upper stage (C25).


THE ABC OF CRYOGENIC UPPER STAGE
It took Isro two decades to develop the cryogenic upper stage of GSLV MkIII. The cryo engine gives enormous thrust needed to propel the rocket with 4-tonne payload to geosynchronous transfer orbit
GSLV MkIII Rocket
Payload fairing
C25 Cryogenic stage
Lander housing rover
Orbiter
14 Payloads
L110 liquid stage Vikas engine
S200 Boosters
Combustion nozzle
INDIA
ISRO
Helium Liquid
Helium is used to maintain pressure in cryogenic chambers
Two tanks with liquid hydrogen (at -253ºC), fuel, and liquid oxygen (at -183ºC), oxidiser, connected to combustion chamber
Liquid Hydrogen
Liquid Oxygen
Combustion Chamber
Liquid oxygen and liquid hydrogen from respective tanks are fed by individual booster pumps to main turbopump (at around 40,000 rpm) to ensure a high flow rate of propellants into the combustion chamber
➤ Two small steering engines provide for control of stage during its thrusting phase
➤ Thrust control and mixture ratio control are achieved by two independent regulators
➤ Main engine and two steering engines together develop a nominal thrust of 73.55 kN in vacuum
The cryo stage carries 28 tonnes of propellants in two tanks that provide a thrust of 20 tonnes
MAIN PROBLEMS
➤ Due to large temperature difference, heat transfer is very high. Therefore, lot of insulation needed
➤ Boiling causes sudden pressure rise in tanks. So proper venting is required
➤ Material properties vary at low temperatures. Most materials become brittle. So if valve seats or seals become brittle and break, it causes leaks


3 Last stage of PSLV delivers satellite in its orbit
Last stage remains alive
DUAL USE OF ROCKET STAGE
Last stage reaches space
SPACE
Earth's Atmosphere
2 Separation of three stages of rocket
4 Instead of becoming debris, last stage remains active for six more months and serves as an experimental platform
First three stages of rocket fall and burn out in the earth's atmosphere
ROCKET DOUBLES UP AS A SATELLITE
1 PSLV lifts off from Sriharikota with a primary satellite


USA

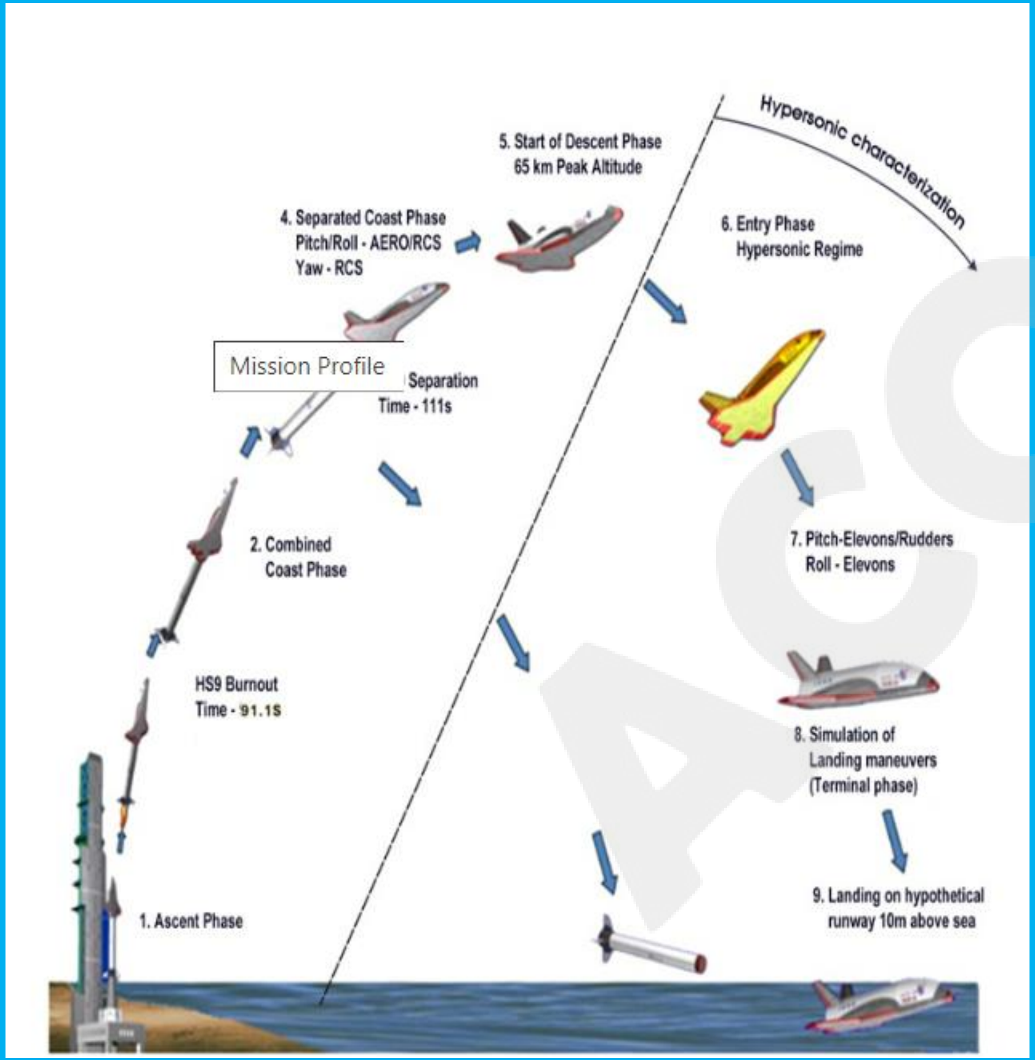


Reusable Launch Vehicle

fully reusable launch vehicle to enable low cost access to space


RLV-TD
INDIA
What are RLV’s?

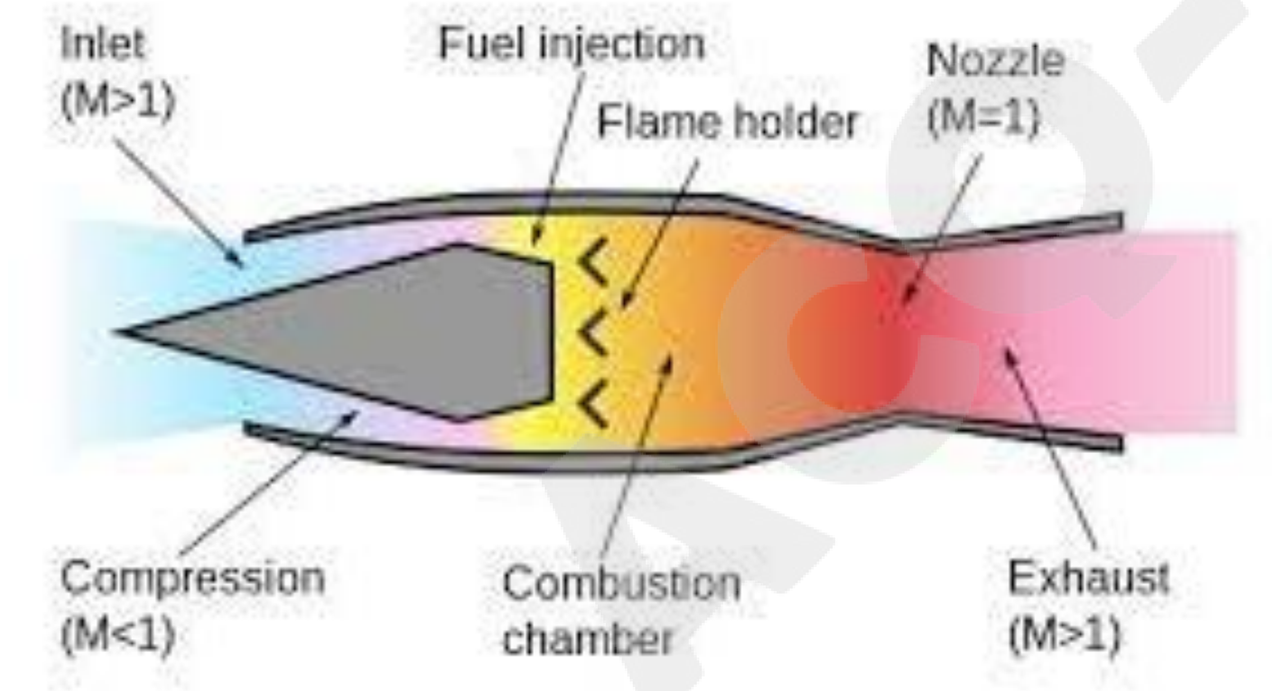
Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)



Space Capsule Recovery Experiment

- Space Capsule Recovery Experiment (SRE) was a remarkable achievement in which ISRO successfully demonstrated the nation’s capability in bringing an orbiting capsule safely back on Earth and recovering it. SRE-1 weighing 555 kg, was launched on January 10, 2007, onboard PSLV-C7

Air Breathing Propulsion



- Launch vehicles use combustion of propellants consisting of oxidiser and fuel for deriving the energy. Air breathing propulsion systems use atmospheric oxygen, which is available up to about 50 km of earth's surface


WHY MOST OF THE WORLD'S SATELLITE LAUNCHING SITES ARE NEAR THE EQATOR AND ON THE EASTERN COAST?
Florida (US)
Kourou (French Guiana)
Sriharikota (India)

Q) Discuss the Contribution of Indian Space Programme for Socio-Economic Development of the country?

Agriculture & Soils	Renewable Energy	Forest & Environment	Geology & Geomorphology	Governance
Land Resources	Ocean Science	Rural Development	Urban Development	Water Resources
Weather & Climate	National Meet Outcomes			

Important initiatives pursued by ISRO towards societal development include :

Tele-education,

Tele-medicine,

Village Resource Centre (VRC)

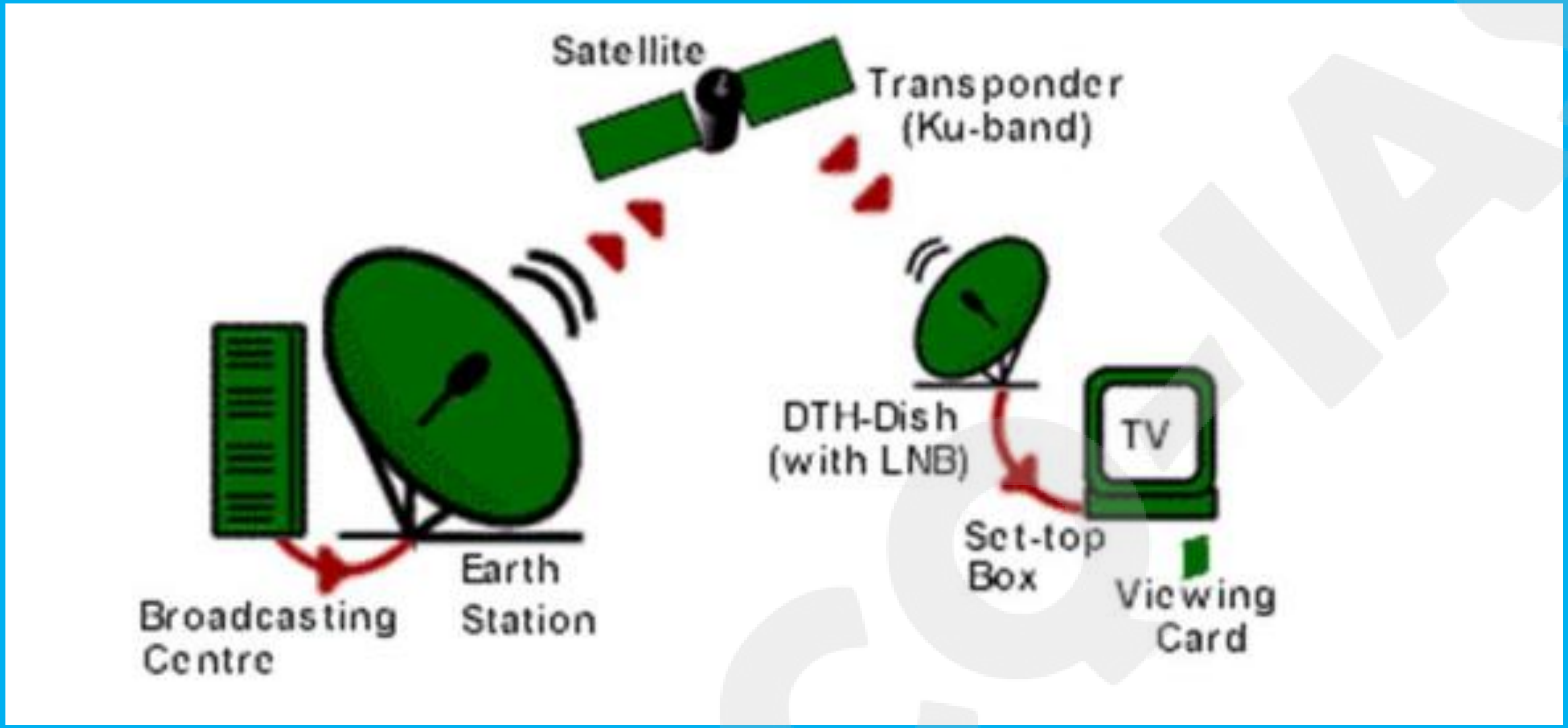
Disaster Management System (DMS) Programmes.

The potential of the space technology for applications of national development is enormous.

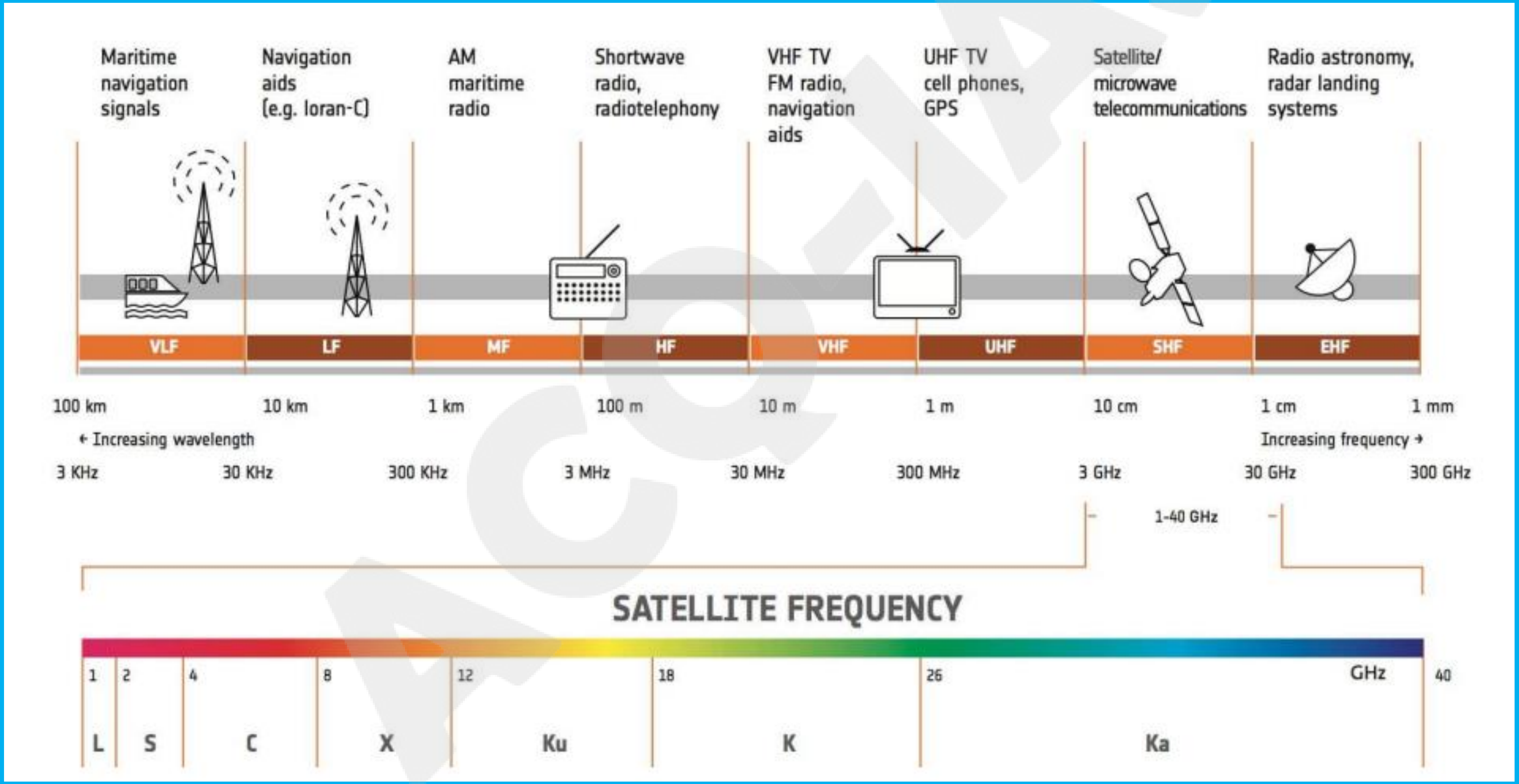
Transponder

- In a communications satellite, a satellite transponder receives signals over a range of uplink frequencies, usually from a satellite ground station.

- The transponder amplifies them and re-transmits them on a different set of downlink frequencies to receivers on Earth, often without changing the content of the received signal or signals.


Satellite
Transponder
(Ku-band)
DTH-Dish
(with LNB)
TV
Set-top
Box
Viewing
Card
Earth
Station
Broadcasting
Centre

Satellite frequency bands



L-band (1–2 GHz)

• Used by Global Positioning System (GPS) carriers and satellite mobile phone communication devices.

S-band (2–4 GHz)

• Used by weather radar, surface ship radar, and some communications satellites.

C band (4–8 GHz)

Used for satellite communications, for full-time satellite TV networks.

Because of the low frequencies, C band waves have longer wavelengths.

Because of bigger wavelengths, a bigger dish is required to receive such frequencieS


C-Band
Vs
Ku-Band


TATA Sky

X-band (8–12 GHz)

• Primarily used by the military. Sub-bands are used in civil, military and government institutions for weather monitoring, air traffic control, maritime vessel traffic control, defence tracking and vehicle speed detection for law enforcement.

Ku-band (12–18 GHz)

Used for satellite communications, most notably the downlink used by DTH television.

Ka-band (26–40 GHz) Used for communications satellites with high-resolution, close-range targeting radars on military aircraft.

Satellite navigation

- **GPS** ➔ owned by the **US government and operated by the US Air Force**.
- **GLONASS** ➔ **Russia**
- **Galileo** ➔ **European Union (EU)**
- **BeiDou** ➔ **China**
- **Quasi-Zenith Satellite System (QZSS)** ➔ **Japan** (regional navigation system still under construction)
- **India's navigation system is called Navigation with Indian Constellation (NavIC)** — previously known as **Indian Regional Navigation Satellite System (IRNSS)**.

IRNSS will provide two types of services, namely

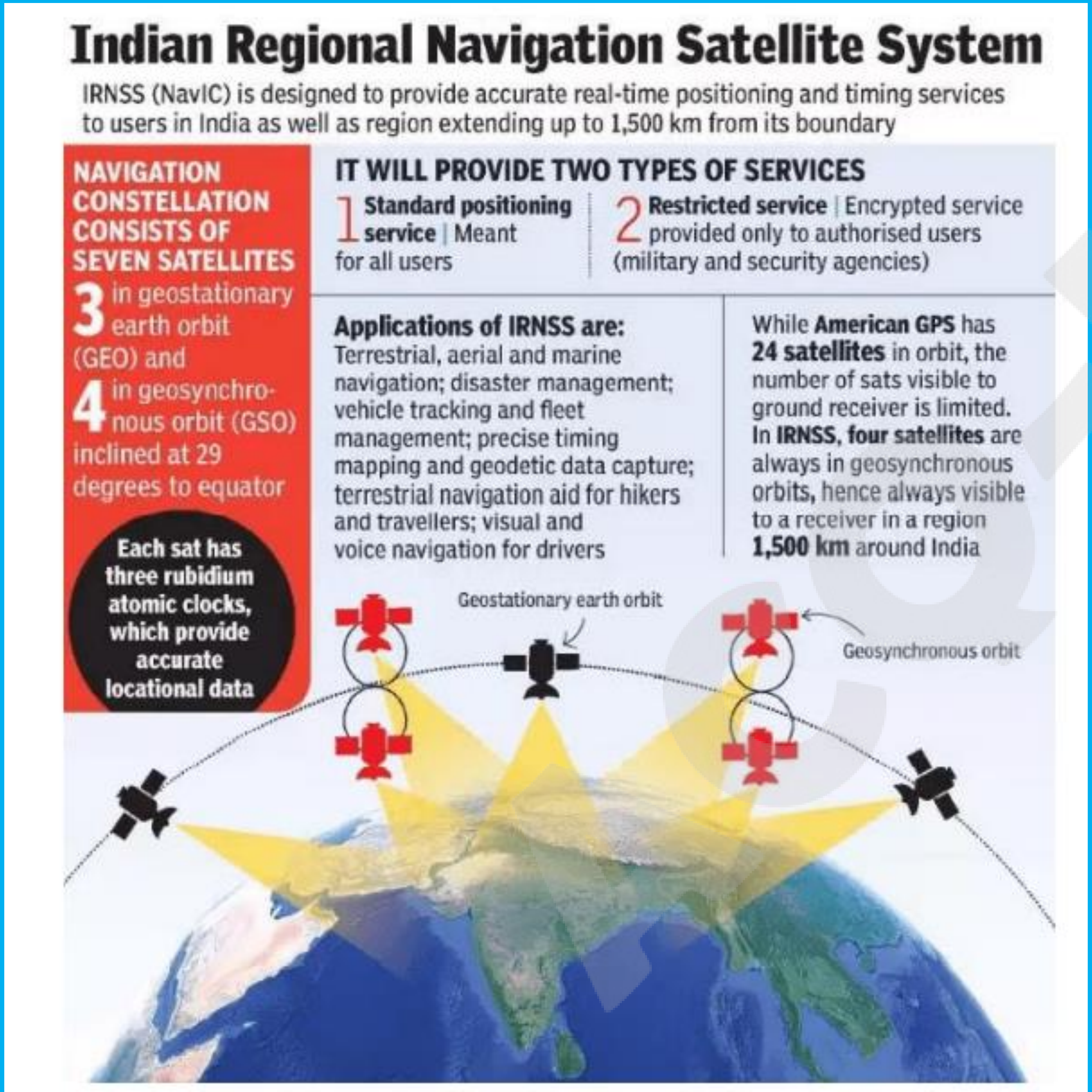
1. Standard Positioning Service (SPS) which is provided to all the users

2. 2. Restricted Service (RS), which is an encrypted service provided only to the authorised users

The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

Some applications of IRNSS are:

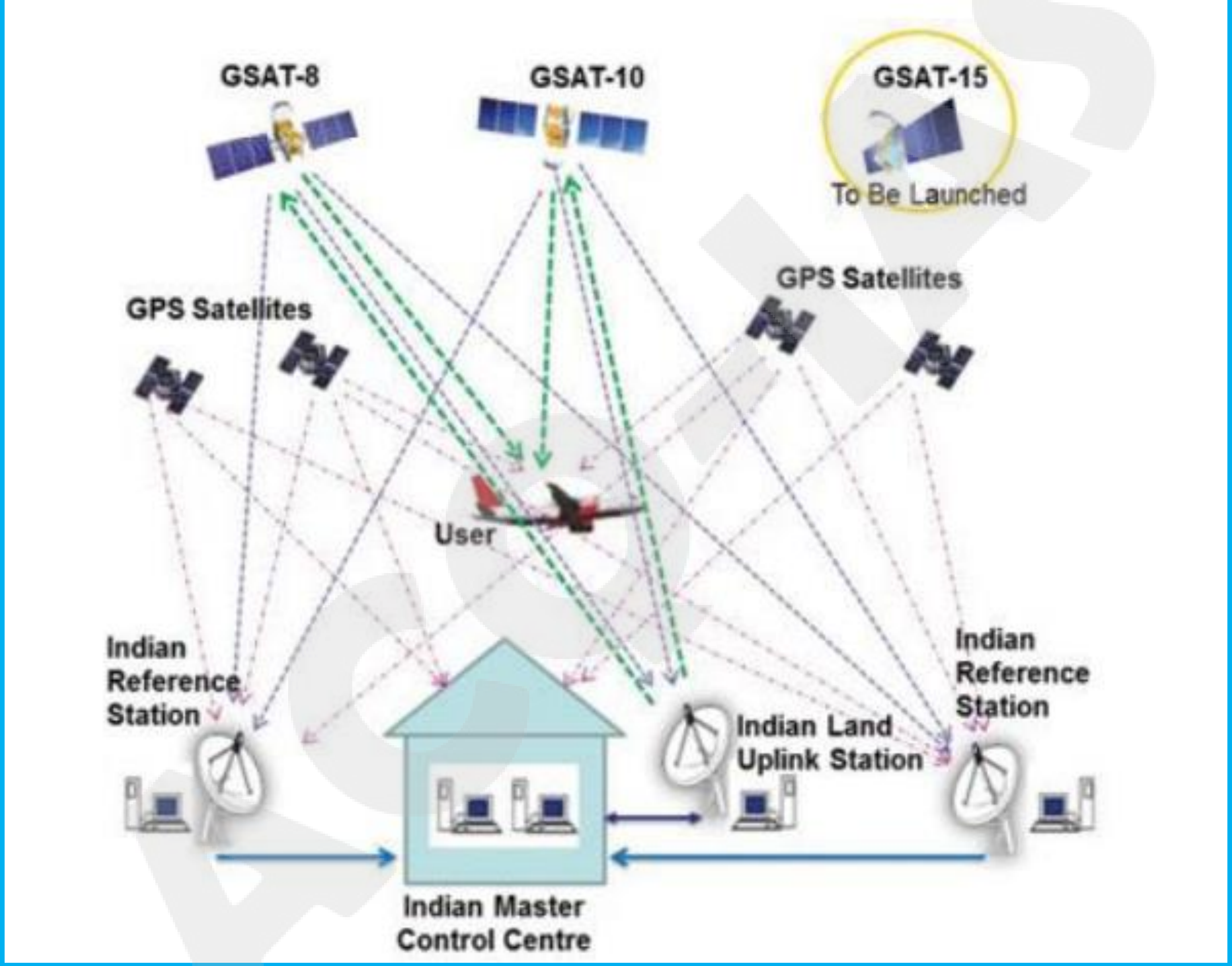
- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers


Indian Regional Navigation Satellite System
IRNSS (NavIC) is designed to provide accurate real-time positioning and timing services to users in India as well as region extending up to 1,500 km from its boundary
NAVIGATION CONSTELLATION CONSISTS OF SEVEN SATELLITES
3 in geostationary earth orbit (GEO) and
4 in geosynchronous orbit (GSO) inclined at 29 degrees to equator
Each sat has three rubidium atomic clocks, which provide accurate locational data
IT WILL PROVIDE TWO TYPES OF SERVICES
1 Standard positioning service | Meant for all users
2 Restricted service | Encrypted service provided only to authorised users (military and security agencies)
Applications of IRNSS are:
Terrestrial, aerial and marine navigation; disaster management; vehicle tracking and fleet management; precise timing mapping and geodetic data capture; terrestrial navigation aid for hikers and travellers; visual and voice navigation for drivers
While American GPS has 24 satellites in orbit, the number of sats visible to ground receiver is limited. In IRNSS, four satellites are always in geosynchronous orbits, hence always visible to a receiver in a region 1,500 km around India
Geostationary earth orbit
Geosynchronous orbit

Q) Discus about the working of GPS. Highlight various applications of this technology.

GPS Aided Geo Augmented Navigation (GAGAN)

- GAGAN is a Satellite Based Augmentation System (SBAS) for the Indian Airspace.
- ISRO and Airports Authority of India (AAI) have implemented the GAGAN project.
- GAGAN is operational through GSAT-8, GSAT-10 satellites & GSAT-15 satellites.



GSAT-8
GSAT-10
GSAT-15
To Be Launched
GPS Satellites
GPS Satellites
User
Indian Reference Station
Indian Reference Station
Indian Land Uplink Station
Indian Master Control Centre

- GAGAN though primarily meant for aviation, will provide benefits beyond aviation to many other segments such as intelligent transportation, maritime, railways, etc.
- GAGAN footprint extends from Africa to Australia.

Sounding Rockets

- Sounding rockets are one or two stage solid propellant rockets used for probing the upper atmospheric regions and for space research

- The launch of the first sounding rocket from Thumba near Thiruvananthapuram, Kerala on 21 November 1963, marked the beginning of the Indian Space Programme .

- In 1975, all sounding rocket activities were consolidated under the Rohini Sounding Rocket (RSR) Programme

- The sounding rocket programme was the bedrock on which the edifice of launch vehicle technology in ISRO could be built.

Vehicle	RH-200	RH-300-Mk-II	RH-560-MK-II
Payload (in kg)	10	60	100
Altitude (in km)	80	160	470
Purpose	Meterology	Aeronomy	Aeronomy
Launch Pad	Thumba Balasore	SDSC-SHAR	SDSC-SHAR

Chandrayaan-1

- Chandrayaan-1, India's first mission to Moon, was launched successfully on October 22, 2008 from SDSC SHAR, Sriharikota, PSLV - C11

- 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.

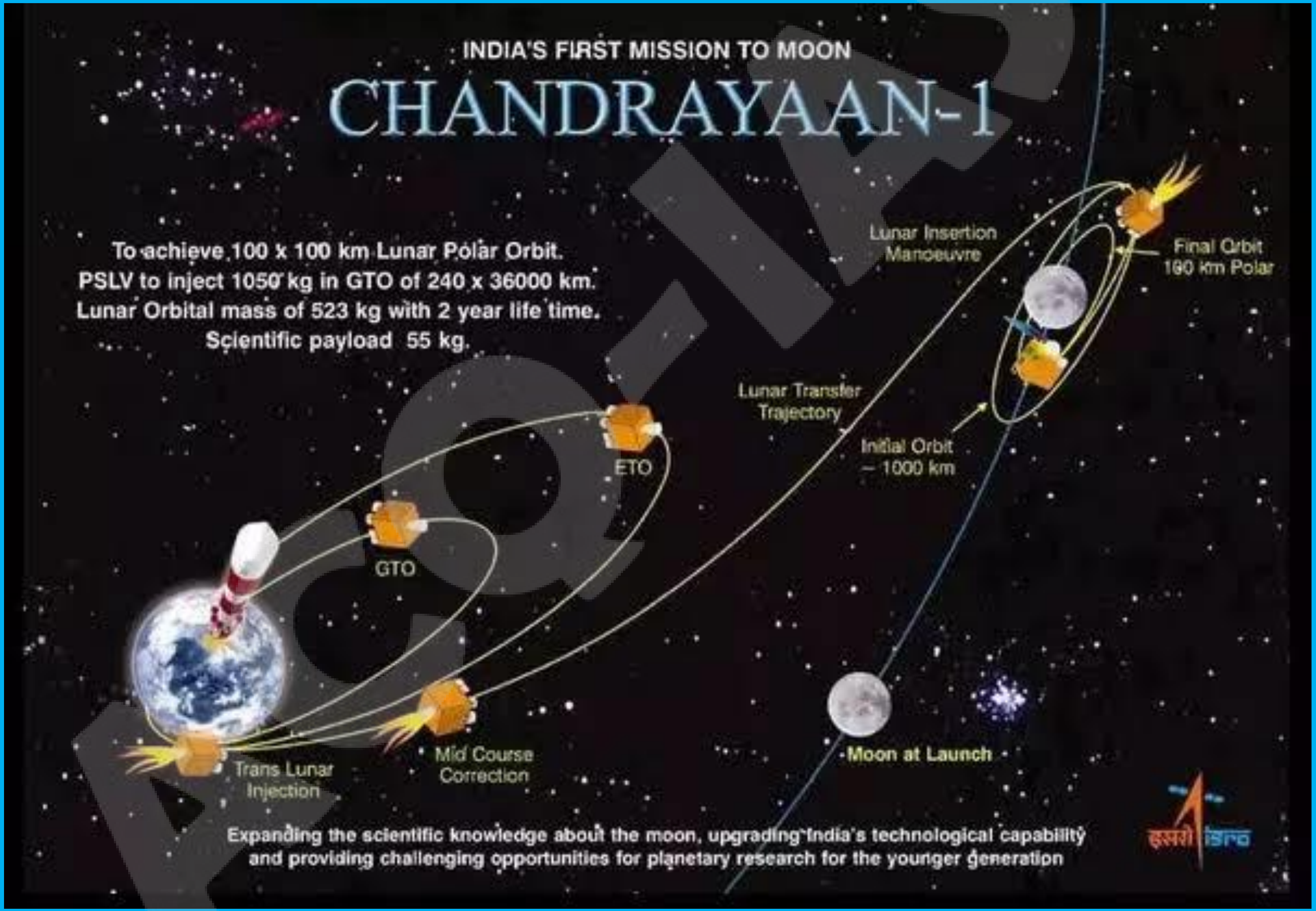
Reasons for renewed interest

Economic

Helium-3 (an isotope of the element helium) is abundant on the Moon, but rare on Earth. It is a potential fuel for nuclear fusion.

Base for future space exploration: It is the best place to test how life reacts to harsh conditions of space.

To study Earth: Moon and Earth share a common past, studying it will reveal how earth's early past.



INDIA'S FIRST MISSION TO MOON
CHANDRAYAAN-1
To achieve 100 x 100 km Lunar Polar Orbit.
PSLV to inject 1050 kg in GTO of 240 x 36000 km.
Lunar Orbital mass of 523 kg with 2 year life time.
Scientific payload 55 kg.
Lunar Insertion Manoeuvre
Final Orbit 100 km Polar
Lunar Transfer Trajectory
Initial Orbit ~ 1000 km
ETO
GTO
Trans Lunar Injection
Mid Course Correction
Moon at Launch
Expanding the scientific knowledge about the moon, upgrading India's technological capability and providing challenging opportunities for planetary research for the younger generation

The spacecraft carried 11 scientific instruments built in India, USA, UK, Germany, Sweden and Bulgaria.

After the successful completion of all the major mission objectives, the orbit has been raised to 200 km during May 2009.

The satellite made more than 3400 orbits around the moon and the mission was concluded when the communication with the spacecraft was lost on August 29, 2009.

Scientific Payloads from India

a) Terrain Mapping Camera (TMC)
b) Hyper Spectral Imager (HySI)
c) Lunar Laser Ranging Instrument (LLRI)
d) High Energy X - ray Spectrometer (HEX)
e) Moon Impact Probe(MIP)

Scientific Payloads from abroad

f) Chandrayaan-I X-ray Spectrometer (CIXS)

g) Near Infrared Spectrometer (SIR - 2)

h) Sub keV Atom Reflecting Analyzer (SARA)

i) Miniature Synthetic Aperature Radar (Mini SAR)

j) Moon Mineralogy Mapper (M3)

k) Radiation Dose Monitor (RADOM)

On 14 November 2008, the Moon Impact Probe separated from the Chandrayaan orbiter and struck the south pole in a controlled manner, making India the fourth country to place its flag insignia on the Moon

The polar regions are of special interest as they might contain water ice

Among its many achievements was the discovery of widespread presence of water molecules in lunar soil

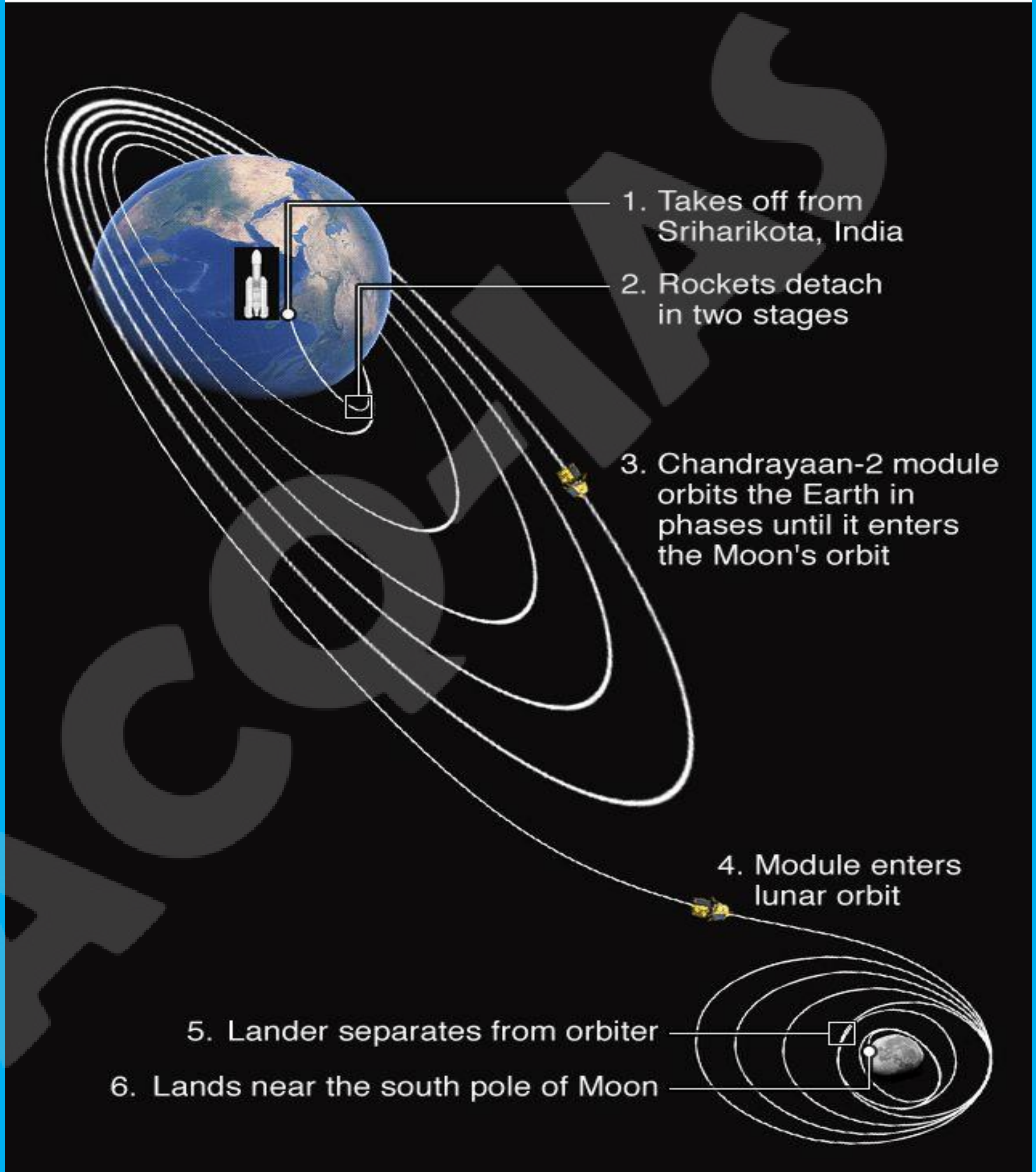
Chandrayaan-1 operated for 312 days as opposed to the intended two years, however the mission achieved most of its scientific objectives including detecting presence of water on the moon

The Chandrayaan-1 payload has enabled scientists to study the interaction between the solar wind and a planetary body like the Moon without a magnetic field

Chandrayaan-1

- Detected water in vapour form in trace amounts,
- Confirmed the Ocean Magma Hypothesis i.e., the moon was once completely in molten state,
- Detected x-ray signals during weak solar flares thus indicating presence of magnesium, aluminum, silicon and calcium on lunar surface,
- Detection of new spinel-rich rock type on lunar far-side.

How India's Chandrayaan-2 will reach the Moon



Graphics not to scale


Mission moon 2.0
A look at the four key components of Chandrayaan 2 – launcher, orbiter, lander and rover
Launcher – GSLV Mk-III | It will carry Chandrayaan 2 to its designated orbit. This three-stage vehicle is India's most powerful launcher to date, and is capable of launching 4-tonne class of satellites to the Geosynchronous Transfer Orbit
ORBITER
Weight: 2,379 kg
Power generation capability: 1,000 W
Capable of communicating with the Indian Deep Space Network at Byalalu and the Vikram lander. It will be placed in a 100X100 km lunar polar orbit
LANDER – VIKRAM
Weight: 1,471 kg
Power generation capability: 650 W
Named after Vikram Sarabhai, the Father of the Indian space programme, it is designed to function for one lunar day, equivalent to about 14 earth days
ROVER – PRAGYAN
Weight: 27 kg
Power generation capability: 50 W
This 6-wheeled robotic vehicle can travel up to 500 m and uses solar energy for its functioning. It can communicate only with the lander
SOURCE: ISRO
INDIA
ISRO

Chandrayaan-2

22 July 2019 --Launched

Detected unambiguous presence of hydroxyl and water molecules on the Moon with the precision of differentiating between the two.

- Detected solar proton events due to high intensity solar flares.
- Imaged Sarabhai crater on the Moon.
- Detection of Argon-40 in the lunar exosphere.

CHANDRAYAAN-3

meant to demonstrate lunar landing and roving capability

Chandrayaan-3 will carry only a modified lander and rover and will use the orbiter of the Chandrayaan 2 mission to communicate with the earth.

Scientific payloads that are being carried on-board are:

- Lander: Langmuir probe, Chandra's Surface Thermo Physical Experiment (ChaSTE) and Instrument for Lunar seismic activity (ILSA).
- Rover payloads are Alpha Particle X-Ray Spectrometer (APXS) and Laser Induced Breakdown spectroscope (LIBS).

• Chandrayaan-3 lander is planned to perform an in-situ experiment of surface and sub-surface measurements of temperature.

o It is meant to help understand the thermal exchange and physical properties of the uppermost Lunar soil.

Mars Orbiter Mission

- Mars Orbiter Mission (MOM), India's first interplanetary mission to planet Mars was launched onboard PSLV-C25 on November 05, 2013.
- ISRO has become the fourth space agency to successfully send a spacecraft to Mars orbit

Objectives

The objectives of this mission are primarily technological and include design, realization and launch of a Mars Orbiter spacecraft capable of operating with sufficient autonomy during the journey phase;

Mars orbit insertion / capture and in-orbit phase around Mars. MOM carries five scientific payloads to study the Martian surface features, morphology, mineralogy and Martian atmosphere.

Indian Mars Orbiter Mission carried the following five scientific payloads:

1. Mars Color Camera (MCC)
2. Thermal Infrared Imaging Spectrometer (TIS)
3. Methane Sensor for Mars (MSM)
4. Mars Exospheric Neutral Composition Analyser (MENCA)
5. Lyman Alpha Photometer (LAP)

Achievements

- The Mars Colour Camera, one of the scientific payloads onboard MOM, has produced 1100+ images so far and published a Mars Atlas.
- Published more than 35 research papers in peer-reviewed journals.

- India’s ability to successfully realize the complex mission to Mars in its first attempt, in a cost-effective (Rupees 450 Cr) has captured the world attention

Q)India has achieved remarkable successes in unmanned space missions including the Chandrayaan and Mars Orbiter Mission, but has not ventured into manned space mission, both in terms of technology and logistics. Explain critically.

Gaganyaan

The objective of Gaganyaan programme is to demonstrate indigenous capability to undertake human space flight mission to LEO.

Benifits

1. Progress towards a sustained and affordable human and robotic programme to explore the solar system and beyond.
2. Advanced technology capability for undertaking human space exploration, sample return missions and scientific exploration.
3. Future capability to actively collaborate in global space station development & to carry out scientific experiments of interest to the nation.

Create a broad frame work for wider Academia – Industry partnership in taking up development activities for national development.

Ample scope for employment generation and human resource development in advanced science and R&D activities.

.

Unique opportunity to inspire and excite Indian youth and steer many students toward careers in science and technology towards challenging jobs that encourage knowledge, innovation and creativity.

The programme will strengthen international partnerships and global security through the sharing of challenging and peaceful goals. Having a vibrant human spaceflight programme can be leveraged as a potent foreign policy tool

The major new technologies required for Gaganyaan programme are as follows:

Human rated launch vehicle

Crew escape systems

Habitable orbital module

Life support system

Crew selection and training and associated crew management activities

Major collaborating partners for Gaganyaan include

Indian Armed Forces

Defence Research Development organisation

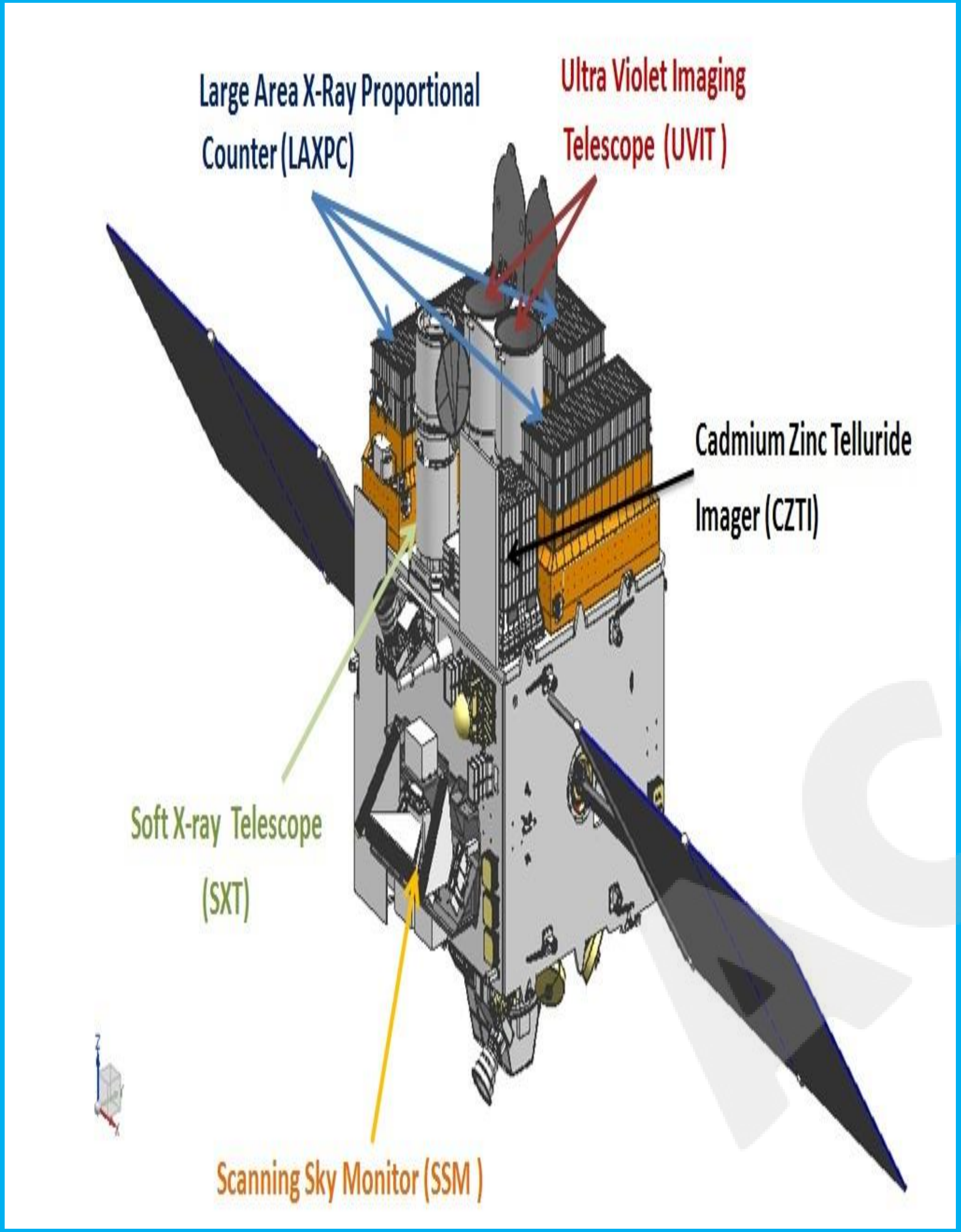
Indian maritime agencies - Indian Navy, Indian Coast Guard, Shipping corporation of India, National institute of Oceanography, National Institute of Ocean Technology.

Indian Meteorological Department

CSIR Labs

Academic institutes

Industry partners



AstroSat

AstroSat is the first dedicated Indian astronomy mission aimed at studying celestial sources in X-ray, optical and UV spectral bands simultaneously. The payloads cover the energy bands of Ultraviolet (Near and Far), limited optical and X-ray regime (0.3 keV to 100keV).

One of the unique features of AstroSat mission is that it enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.

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.

Reforms in the Space sector

- Aimed at boosting private sector participation in the entire range of space activities
- Will enable Indian Industry to be an important player in global space economy
- The proposed reforms will enhance the socio-economic use of space assets and activities, including through improved access to space assets, data and facilities.

- These reforms will allow ISRO to focus more on research and development activities, new technologies, exploration missions and human spaceflight programme.
- Some of the planetary exploration missions will also be opened up to private sector through an ‘announcement of opportunity’ mechanism

IN-SPACe

- The newly created Indian National Space Promotion and Authorization Centre (IN-SPACe) will provide:
- A level playing field for private companies to use Indian space infrastructure.
- It will also hand-hold, promote and guide the private industries in space activities through encouraging policies and a friendly regulatory environment.
- IN-SPACe which is under creation will have Safety and Security Directorate to ensure security of ISRO installations when allowing access to private entities.

NSIL

The Public Sector Enterprise ‘New Space India Limited (NSIL)’ ensures optimum utilization of our space assets.

The major business areas of NSIL include:

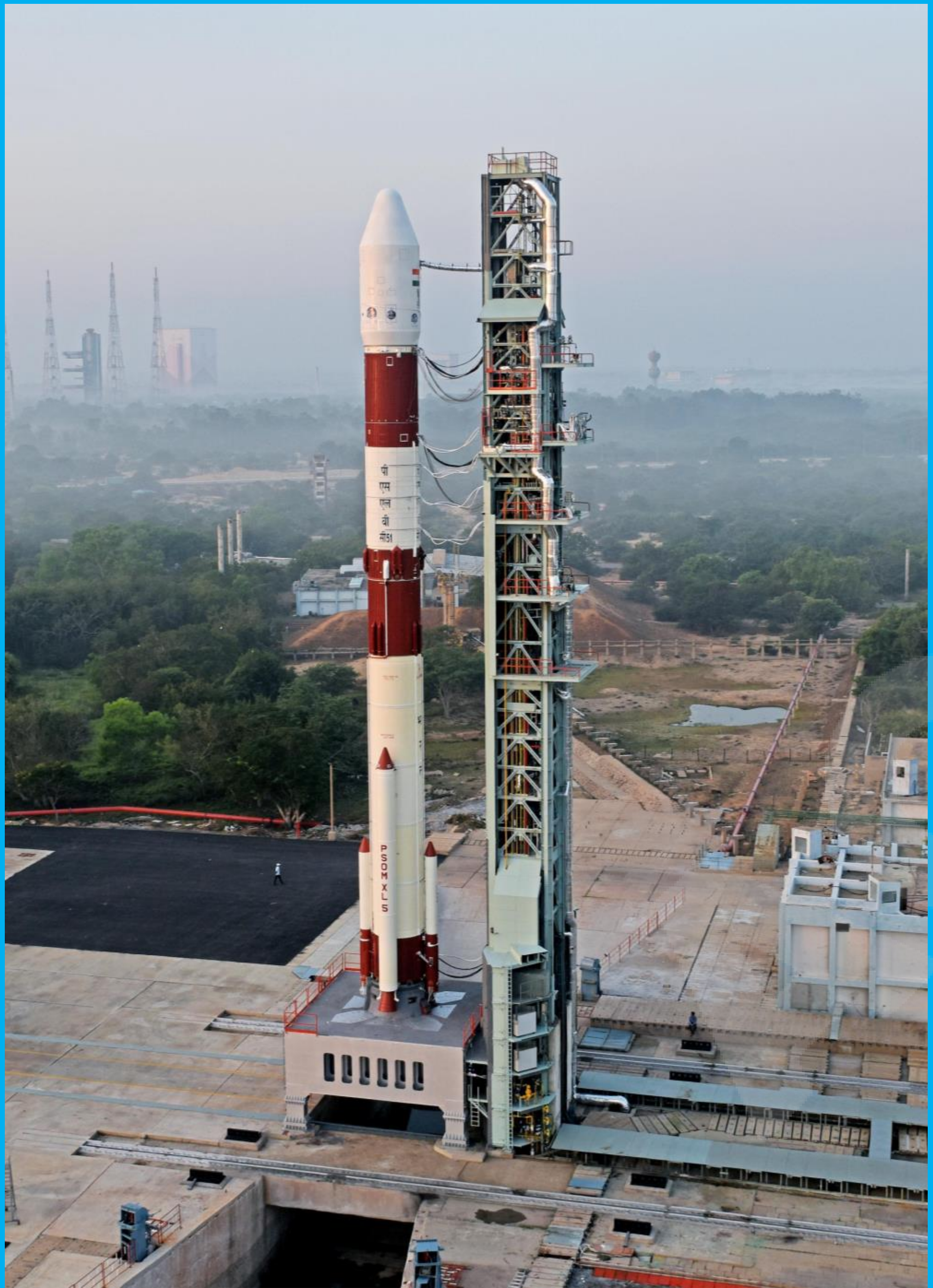
1. Production of Polar Satellite Launch Vehicle (PSLV) and Small Satellite Launch Vehicle (SSLV) through industry;
2. Production and marketing of space-based services, including launch services and space-based applications like transponder leasing, remote sensing and mission support services;

- Building of Satellites (both Communication and Earth Observation) as per user requirements.
- Transfer of technology developed by ISRO centres/ units and constituent institutions of Dept. of Space;
- Marketing spin off technologies and products/ services emanating out of ISRO activities
- Consultancy services

NewSpace India Limited (NSIL), incorporated on 6 March 2019 (under the Companies Act, 2013) is a wholly owned Government of India company, under the administrative control of Department of Space (DOS).

Antrix

- Antrix Corporation Limited is an Indian government-owned company under the administrative control of the Department of Space.
- It was incorporated in September 1992 commercially exploiting space products of ISRO, providing technical consultancy services and transferring technologies to industry.
- ts objective is to promote the ISRO's products, services and technologies.
- It was awarded 'Miniratna' status by the government in 2008



PSLV-C51/Amazonia-1

India’s Polar Satellite Launch Vehicle PSLV-C51 successfully launched Amazonia-1 along with 18 co-passenger satellites

PSLV-C51/Amazonia-1 is the first dedicated commercial mission of NewSpace India Limited (NSIL), a Government of India company under Department of Space

Amazonia-1 is the optical earth observation satellite of National Institute for Space Research (INPE). This satellite would further strengthen the existing structure by providing remote sensing data to users for monitoring deforestation in the Amazon region and analysis of diversified agriculture across the Brazilian territory.

Small Satellite Launch Vehicle Planned by ISRO

- The maiden flight of Small Satellite Launch Vehicle (SSLV) - ISRO's compact launcher - will be made soon.
- SSLV will meet the "launch on demand" requirements in a cost-effective manner for small satellites in a dedicated and ride-share mode.
- It is a 3-stage all solid vehicle that can launch up to 500 kg satellite into 500 km Low Earth Orbit and 300 kg into Sun Synchronous Orbit.
- With lower per kg launch cost, the mini launcher will have multiple satellite mounting options for nano, micro and small satellites.
- SSLV can be assembled in 3 days (PSLV needs 60 days).

China’s Space Missions

- Recently, China launched an unmanned module of its permanent space station that it plans to complete by the end of 2022.
- The module, named "Tianhe", or "Harmony of the Heavens", was launched on the Long March 5B, China's largest carrier rocket.
- India has also set its eye on building its own space station in low earth orbit to conduct microgravity experiments in space in 5 to 7 years.
- The only space station currently in orbit is the International Space Station (ISS), from which China is excluded.
- The ISS is backed by the United States, Russia, Europe, Japan and Canada.

Strides in space | China successfully landed a spacecraft on Mars for the first time on Saturday. Here is a timeline of key moments to this feat

October 2003: Shenzhou-5 carries first Chinese astronaut, Yang Liwei, into space, third country after Soviet Union and U.S. to do so

October 2007: Launch of first lunar mission Chang'e-1, fifth country to launch moon probe

September 2011: Launch of Tiangong-1, first space lab and precursor to plan for space station

November 2011: First Mars orbiter, Yinghuo-1, launched with Russia but fails to enter Mars orbit

June 2012: Shenzhou-9 docks with Tiangong-1, first manned docking for China's space programme

December 2013: Chang'e-3, third moon probe with rover, makes first soft landing on moon, third country to do so after U.S. and Soviet Union

September 2016: Launch of second space lab, Tiangong-2, accelerating space station plans

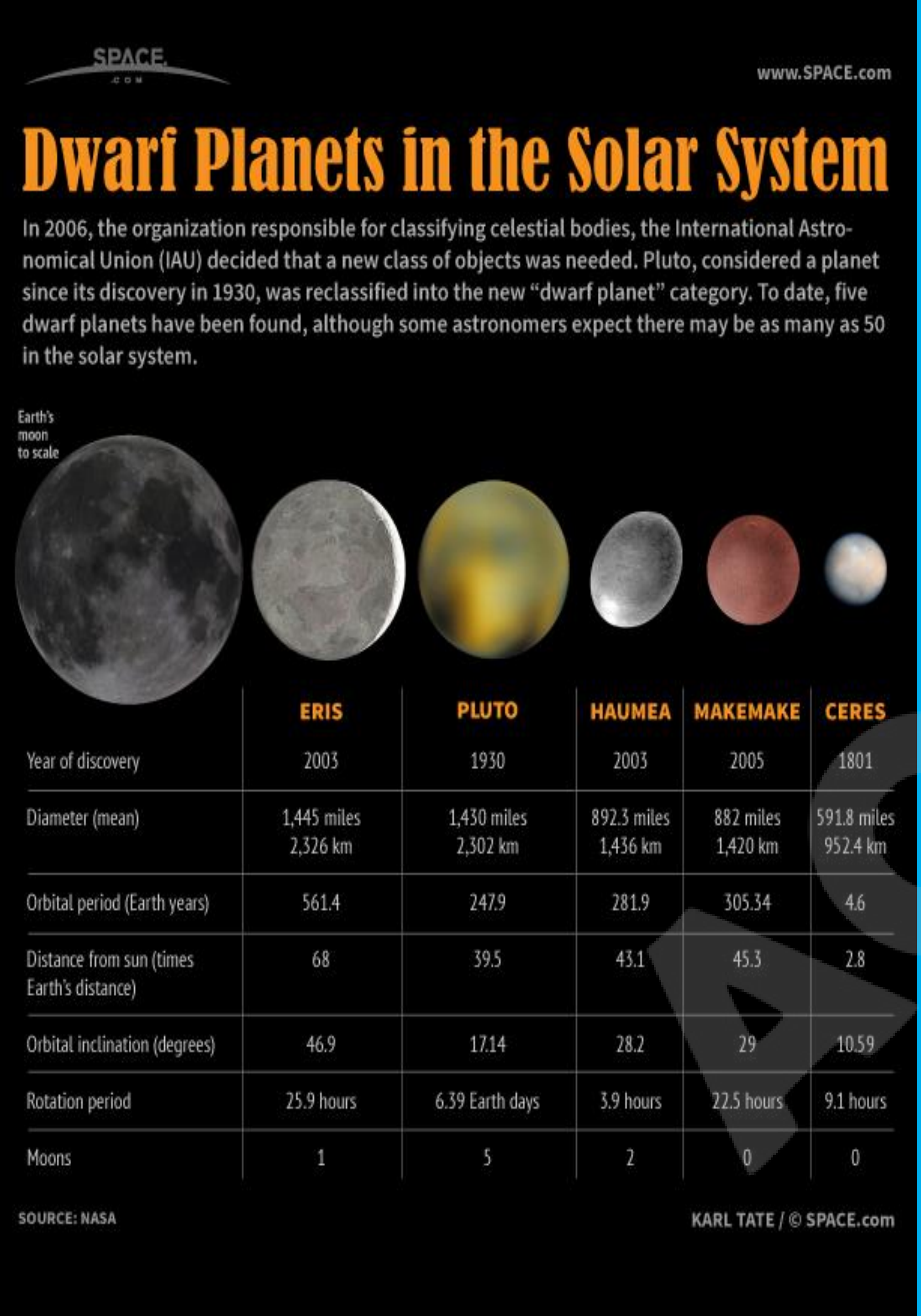
January 2019: Chang'e-4 lunar probe makes world's first landing on "far side" of the moon

Great leap: An artistic depiction of the Chinese Mars rover and lander. • XINHUA/AP

July 2020: Launch of first Mars mission, Tianwen-1, carrying orbiter, lander and rover

April 29, 2021: Long March-5B rocket carries Tianhe module into space, first of three parts of space station set to be completed in 2022; debris falls in Indian Ocean

May 15, 2021: Zhurong lander touches down on Mars, third country to achieve Mars landing after Soviet Union and the U.S.



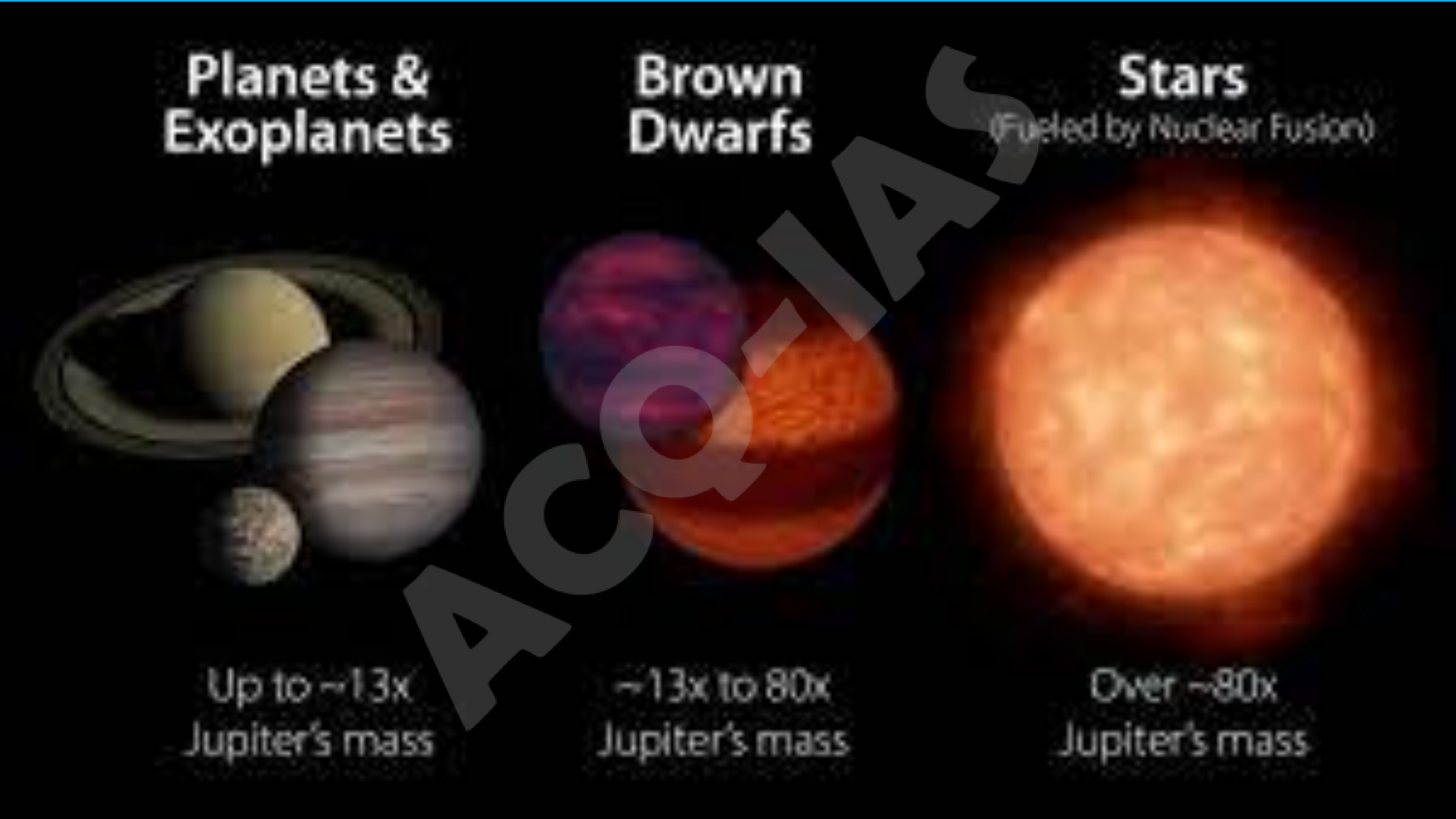
Dwarf planet

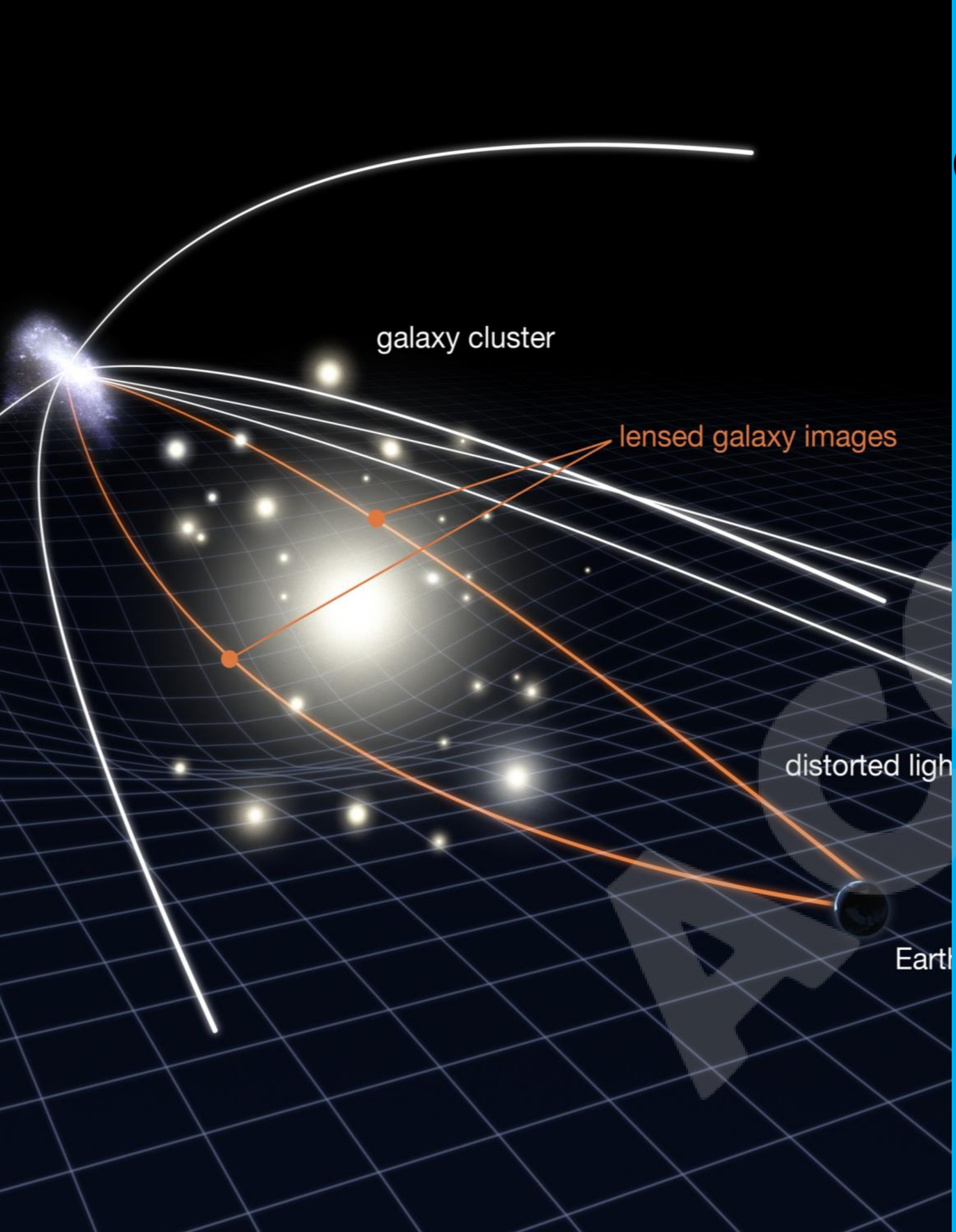
Dwarf planet, body, other than a natural satellite (moon), that orbits the Sun and that is, for practical purposes, smaller than the planet Mercury yet large enough for its own gravity to have rounded its shape substantially.

The International Astronomical Union (IAU) adopted this category of solar system bodies in August 2006, designating Pluto, the even more-remote object Eris, and the asteroid Ceres as the first members of the category.

- Unlike major planets, these bodies are not massive enough to have swept up most smaller nearby bodies by gravitational attraction; they thus failed to grow larger.

- In June 2008 the IAU created a new category, plutoids, within the dwarf planet category. Plutoids are dwarf planets that are farther from the Sun than Neptune.
- All the dwarf planets except Ceres are plutoids. because of its location in the asteroid belt, Ceres is not

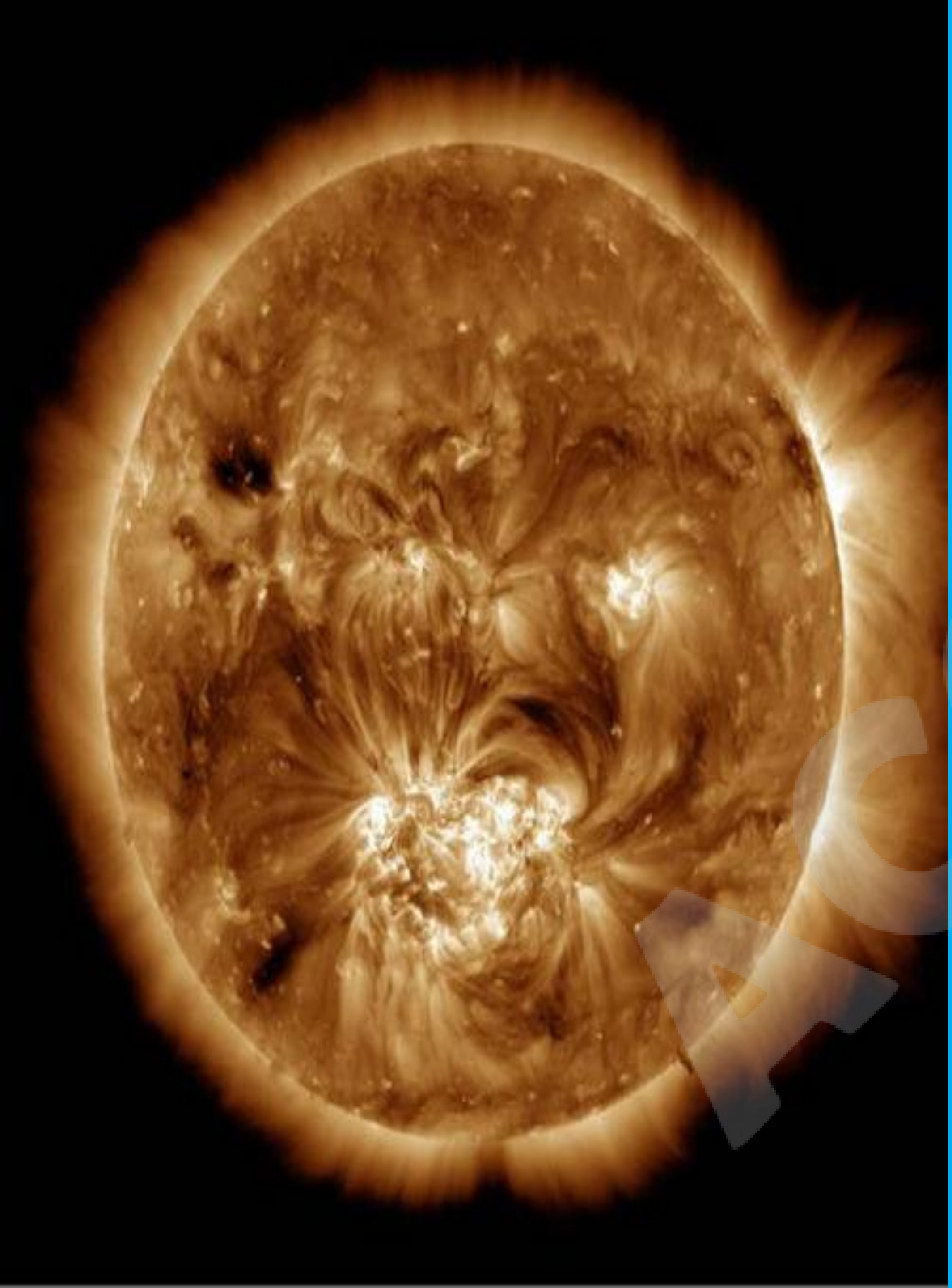

Planets & Exoplanets
Brown Dwarfs
Stars
(Fueled by Nuclear Fusion)
Up to ~13x Jupiter's mass
~13x to 80x Jupiter's mass
Over ~80x Jupiter's mass
ACQ-IAS



Gravitational lensing

As the light emitted by distant galaxies passes by massive objects in the universe, the gravitational pull from these objects can distort or bend the light. This is called gravitational lensing.

- Strong gravitational lensing can actually result in such strongly bent light that multiple images of the light-emitting galaxy are formed.
- Weak gravitational lensing results in galaxies appearing distorted, stretched or magnified. Although difficult to measure for an individual galaxy, galaxies clustered close together will exhibit similar lensing patterns.
- Analysing the nature of gravitational lensing patterns tells astronomers about the way dark matter is distributed within galaxies and their distance from Earth. This method provides a probe for investigating both the development of structure in the universe and the expansion of the universe.



Sun's Corona

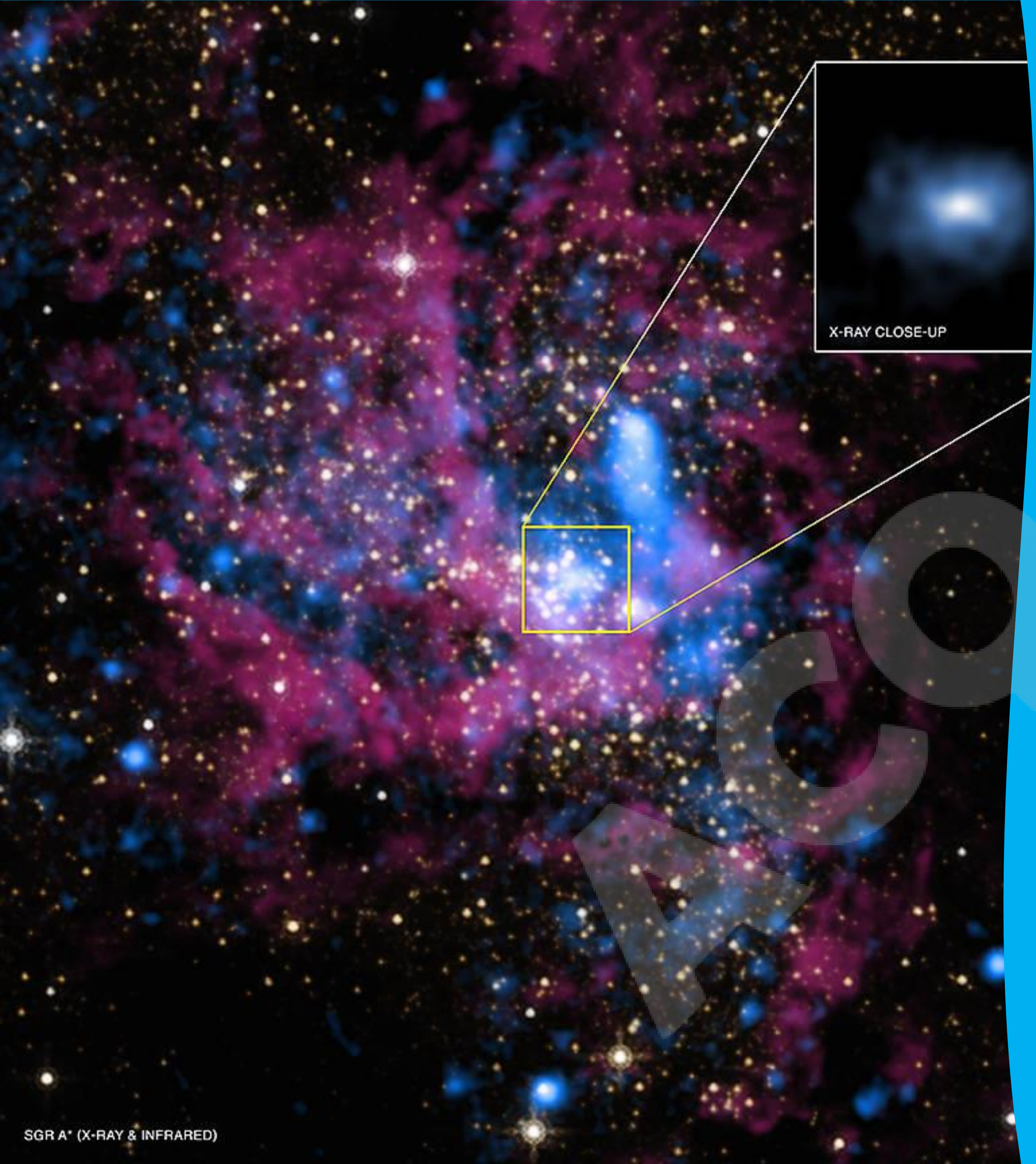
The Sun’s corona is the outermost part of the Sun’s atmosphere. The corona is usually hidden by the bright light of the Sun's surface. That makes it difficult to see without using special instruments. However, the corona can be viewed during a total solar eclipse.

The corona is about 10 million times less dense than the Sun’s surface. This low density makes the corona much less bright than the surface of the Sun.

The corona’s high temperatures are a bit of a mystery. Imagine that you’re sitting next to a campfire. It’s nice and warm. But when you walk away from the fire, you feel cooler. This is the opposite of what seems to happen on the Sun.

Astronomers have been trying to solve this mystery for a long time. The corona is in the outer layer of the Sun's atmosphere—far from its surface. Yet the corona is hundreds of times hotter than the Sun's surface.

The corona extends far out into space. From it comes the solar wind that travels through our solar system. The corona's temperature causes its particles to move at very high speeds. These speeds are so high that the particles can escape the Sun's gravity.



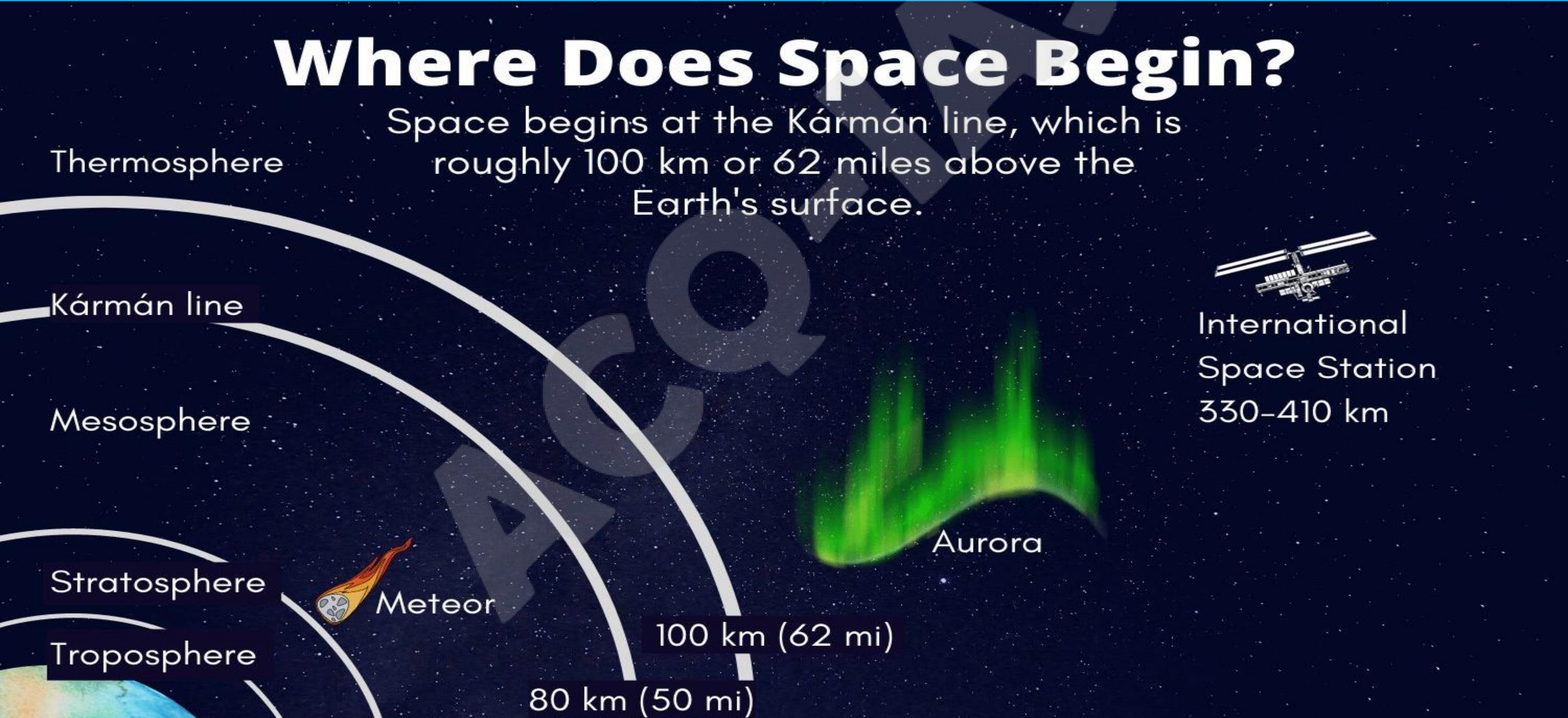
Sagittarius A*

- Sagittarius A*, supermassive black hole at the centre of the Milky Way Galaxy, located in the constellation Sagittarius. It is a strong source of radio waves and is embedded in the larger Sagittarius A complex. Most of the radio radiation is from a synchrotron mechanism, indicating the presence of free electrons and magnetic fields. Sagittarius A* is a compact, extremely bright point source

. X-ray, infrared, spectroscopic, and radio interferometric investigations have indicated the very small dimensions of this region. Infrared observations of stars orbiting the position of Sagittarius A* demonstrate the presence of a black hole with a mass equivalent to 4,310,000 Suns.

(For these infrared observations, American astronomer Andrea Ghez and German astronomer Reinhard Genzel were awarded the 2020 Nobel Prize for Physics.)

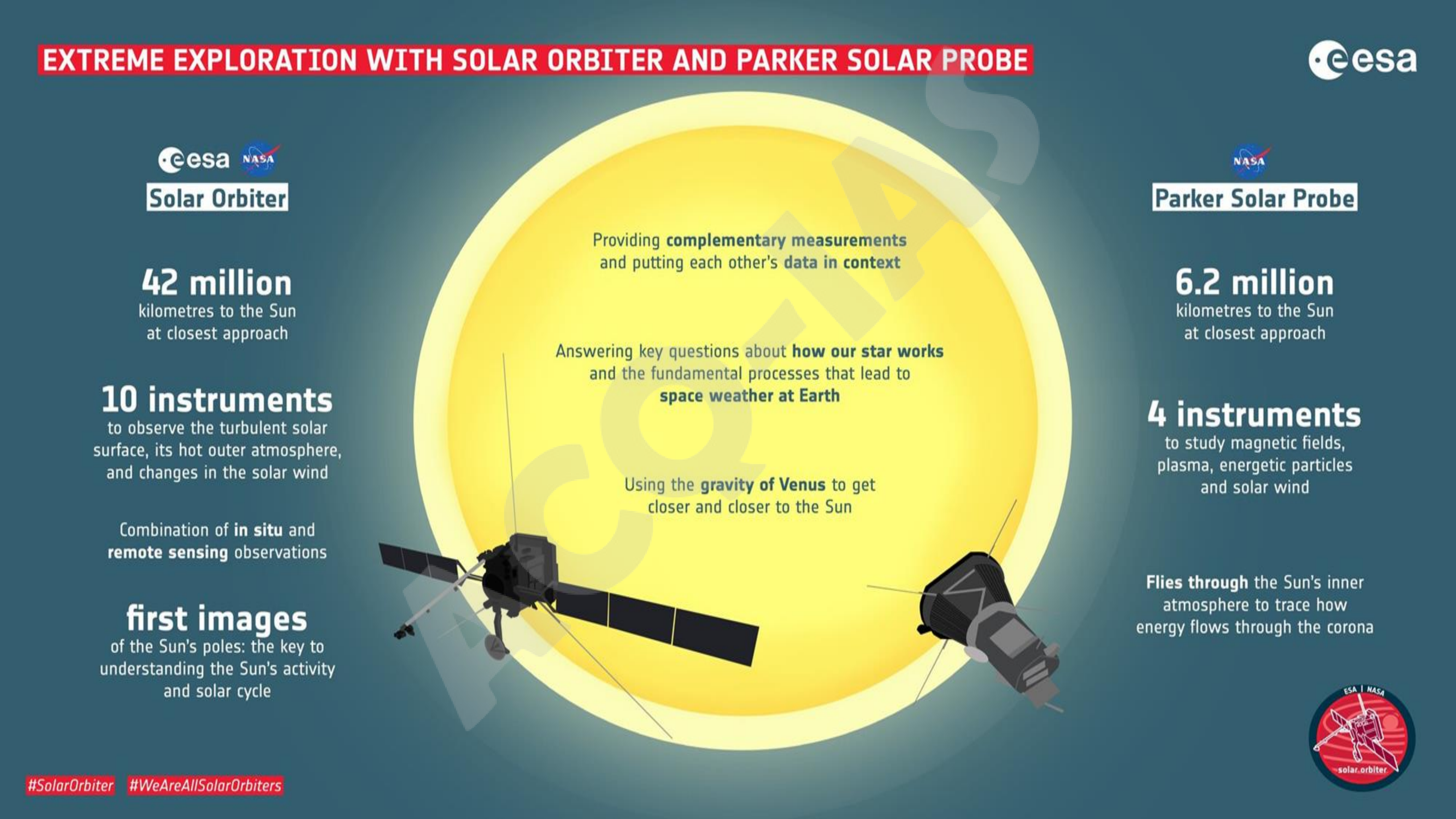
The Kármán line is an attempt to define a boundary between Earth's atmosphere and outer space, which is important for legal and regulatory purposes: aircraft and spacecraft fall under different jurisdictions and are subject to different treaties




Exoplanet
Missions
WFIRST
Webb
TESS
Kepler
Spitzer
Hubble
Future Exoplanet
Missions
Ground-based
Observatories

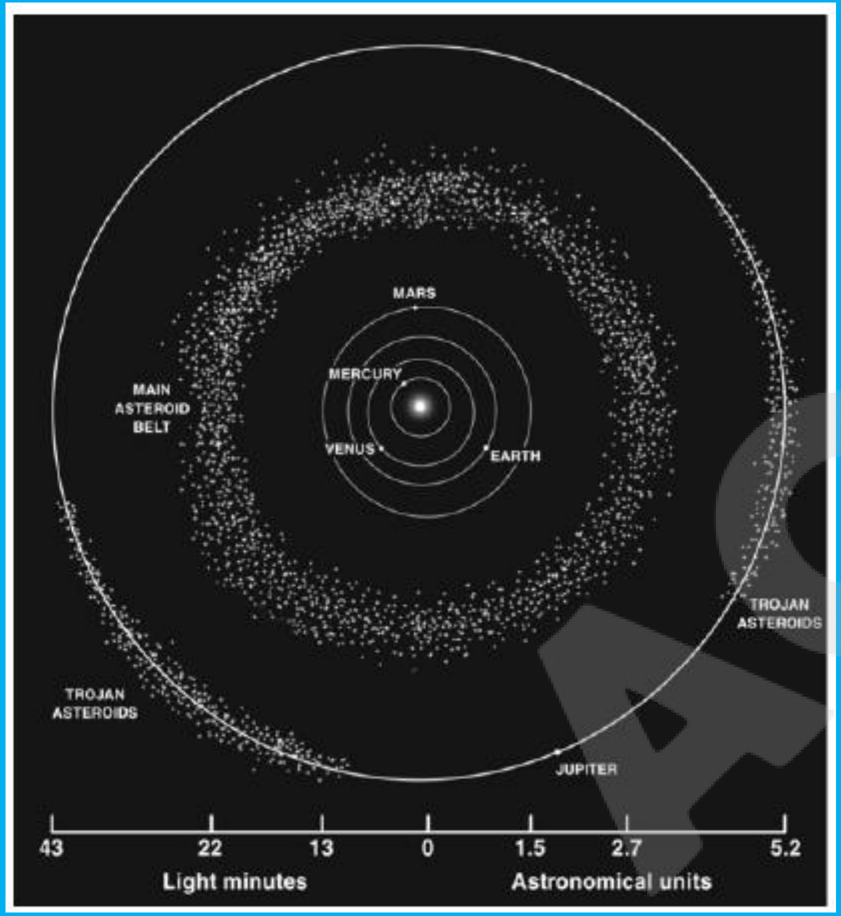
Chandra X-ray Observatory

- The Chandra X-ray Observatory is part of NASA's fleet of "Great Observatories" along with the Hubble Space Telescope, the Spitizer Space Telescope and the now deorbited Compton Gamma Ray Observatory. Chandra allows scientists from around the world to obtain X-ray images of exotic environments to help understand the structure and evolution of the universe.

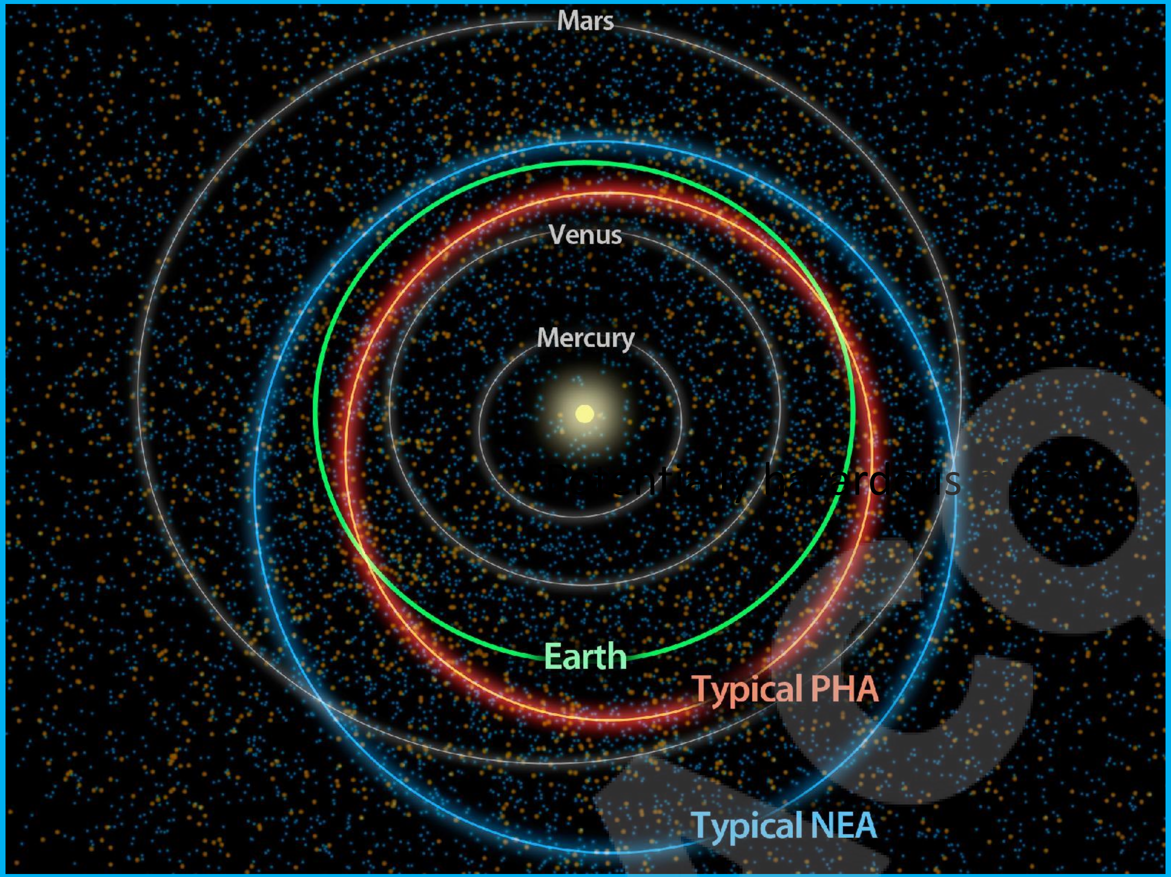


EXTREME EXPLORATION WITH SOLAR ORBITER AND PARKER SOLAR PROBE
esa
esa NASA
Solar Orbiter
42 million
kilometres to the Sun at closest approach
10 instruments
to observe the turbulent solar surface, its hot outer atmosphere, and changes in the solar wind
Combination of in situ and remote sensing observations
first images
of the Sun's poles: the key to understanding the Sun's activity and solar cycle
Providing complementary measurements and putting each other's data in context
Answering key questions about how our star works and the fundamental processes that lead to space weather at Earth
Using the gravity of Venus to get closer and closer to the Sun
NASA
Parker Solar Probe
6.2 million
kilometres to the Sun at closest approach
4 instruments
to study magnetic fields, plasma, energetic particles and solar wind
Flies through the Sun's inner atmosphere to trace how energy flows through the corona
ESA | NASA
solar orbiter
#SolarOrbiter
#WeAreAllSolarOrbiters

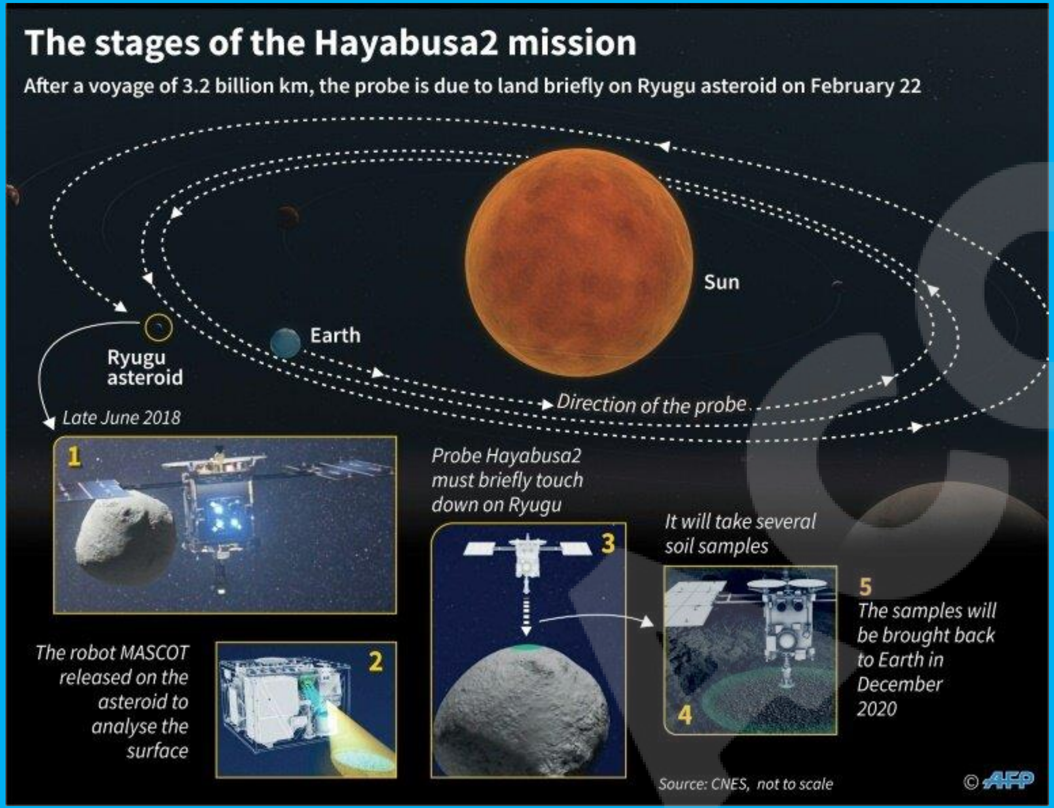
Asteroids


MARS
MERCURY
MAIN ASTEROID BELT
VENUS
EARTH
TROJAN ASTEROIDS
TROJAN ASTEROIDS
JUPITER
43
22
13
0
1.5
2.7
5.2
Light minutes
Astronomical units

Potentially hazardous object



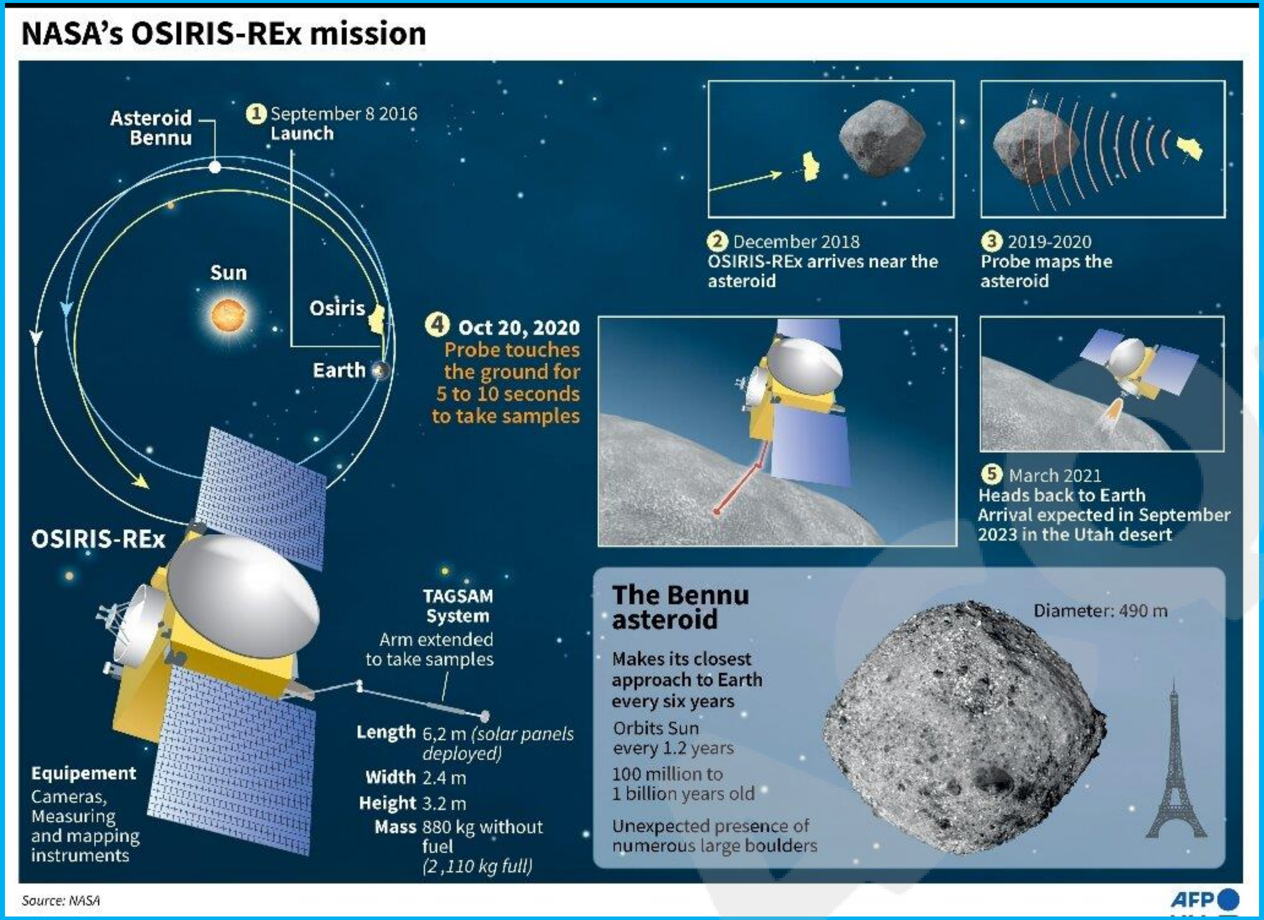
Hayabusa 2

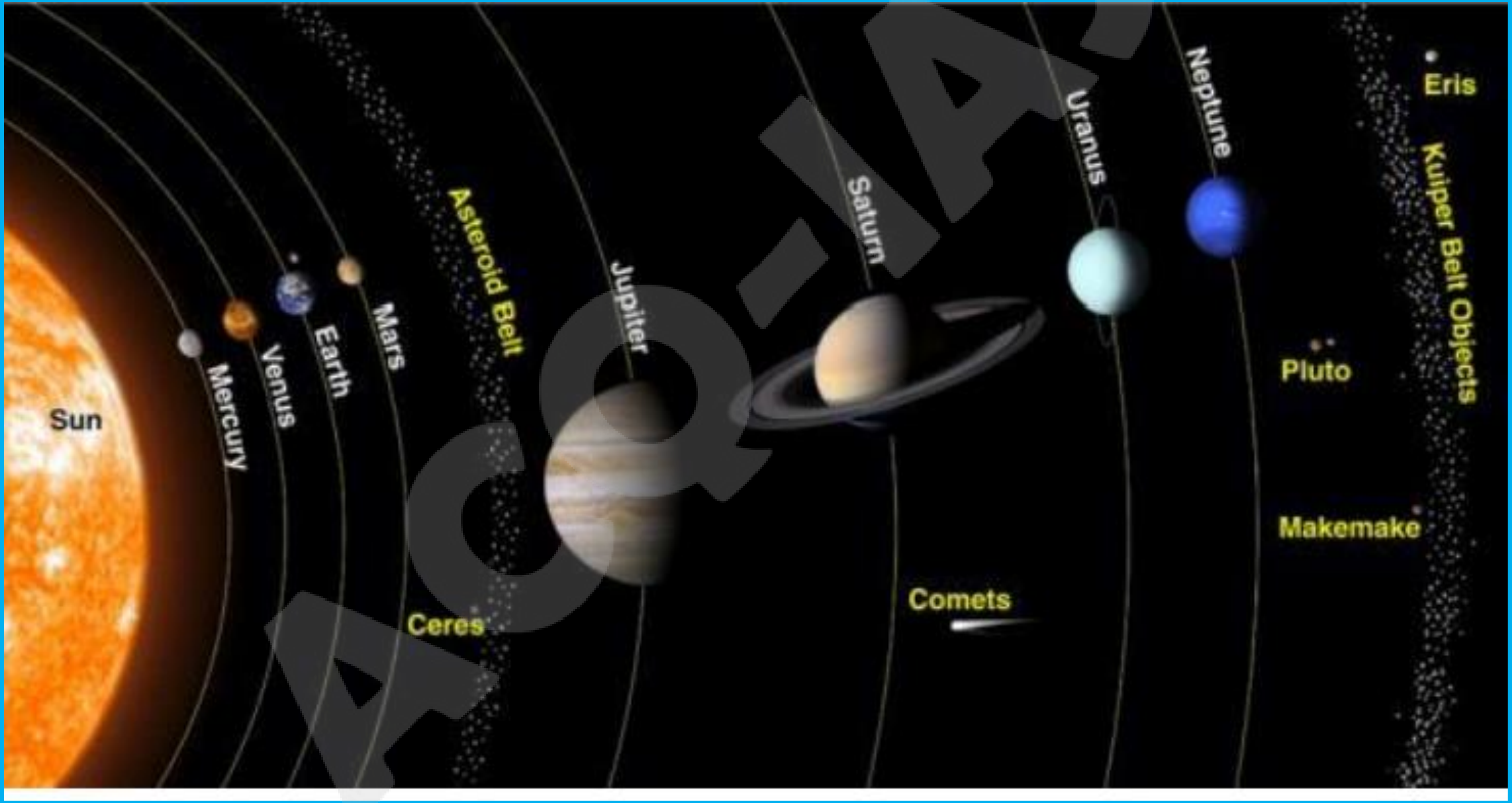

The stages of the Hayabusa2 mission
After a voyage of 3.2 billion km, the probe is due to land briefly on Ryugu asteroid on February 22
Sun
Earth
Ryugu asteroid
Late June 2018
Direction of the probe
1
Probe Hayabusa2 must briefly touch down on Ryugu
3
It will take several soil samples
The robot MASCOT released on the asteroid to analyse the surface
2
4
5
The samples will be brought back to Earth in December 2020
Source: CNES, not to scale
© AFP

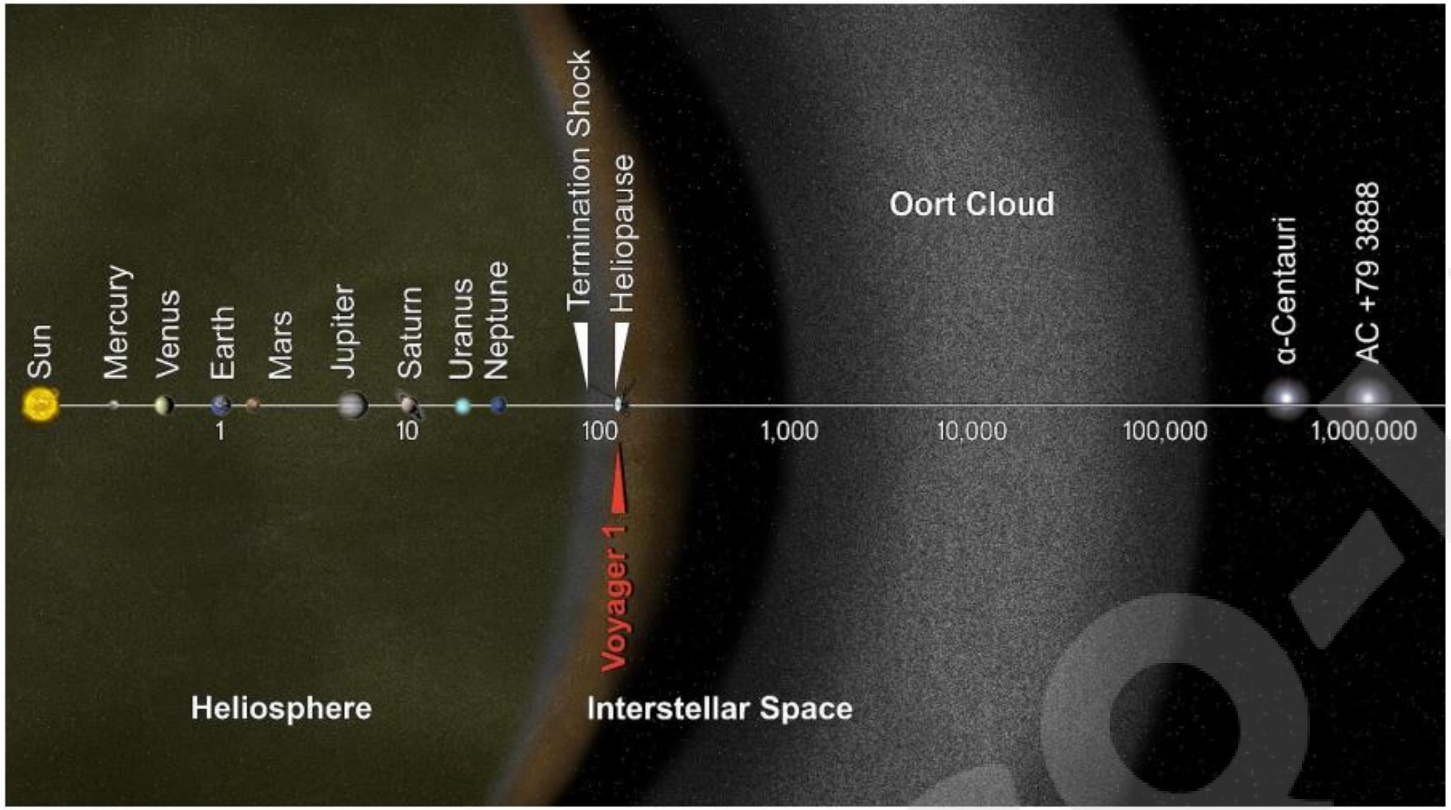
OSIRIS-REx

OSIRIS-REx traveled to near-Earth asteroid Bennu and is bringing a small sample back to Earth for study.

The mission launched Sept. 8, 2016, from Cape Canaveral Air Force Station. The spacecraft reached Bennu in 2018 and will return a sample to Earth in 2023.


NASA's OSIRIS-REx mission
Asteroid Bennu
1 September 8 2016 Launch
Sun
Osiris
Earth
OSIRIS-REx
2 December 2018
OSIRIS-REx arrives near the asteroid
3 2019-2020
Probe maps the asteroid
4 Oct 20, 2020
Probe touches the ground for 5 to 10 seconds to take samples
5 March 2021
Heads back to Earth
Arrival expected in September 2023 in the Utah desert
TAGSAM System
Arm extended to take samples
Length 6,2 m (solar panels deployed)
Width 2.4 m
Height 3.2 m
Mass 880 kg without fuel (2,110 kg full)
Equipement
Cameras, Measuring and mapping instruments
The Bennu asteroid
Diameter: 490 m
Makes its closest approach to Earth every six years
Orbits Sun every 1.2 years
100 million to 1 billion years old
Unexpected presence of numerous large boulders
Source: NASA
AFP


Sun
Mercury
Venus
Earth
Mars
Asteroid Belt
Ceres
Jupiter
Saturn
Comets
Uranus
Neptune
Pluto
Makemake
Eris
Kuiper Belt Objects


Sun
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Termination Shock
Heliopause
Oort Cloud
α-Centauri
AC +79 3888
1
10
100
1,000
10,000
100,000
1,000,000
Voyager 1
Heliosphere
Interstellar Space

Outer Space Treaty

- The Outer Space Treaty was considered by the Legal Subcommittee in 1966 and agreement was reached in the General Assembly in the same year
- The Outer Space Treaty provides the basic framework on international space law, including the following principles:
- the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
- outer space shall be free for exploration and use by all States;
- outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;

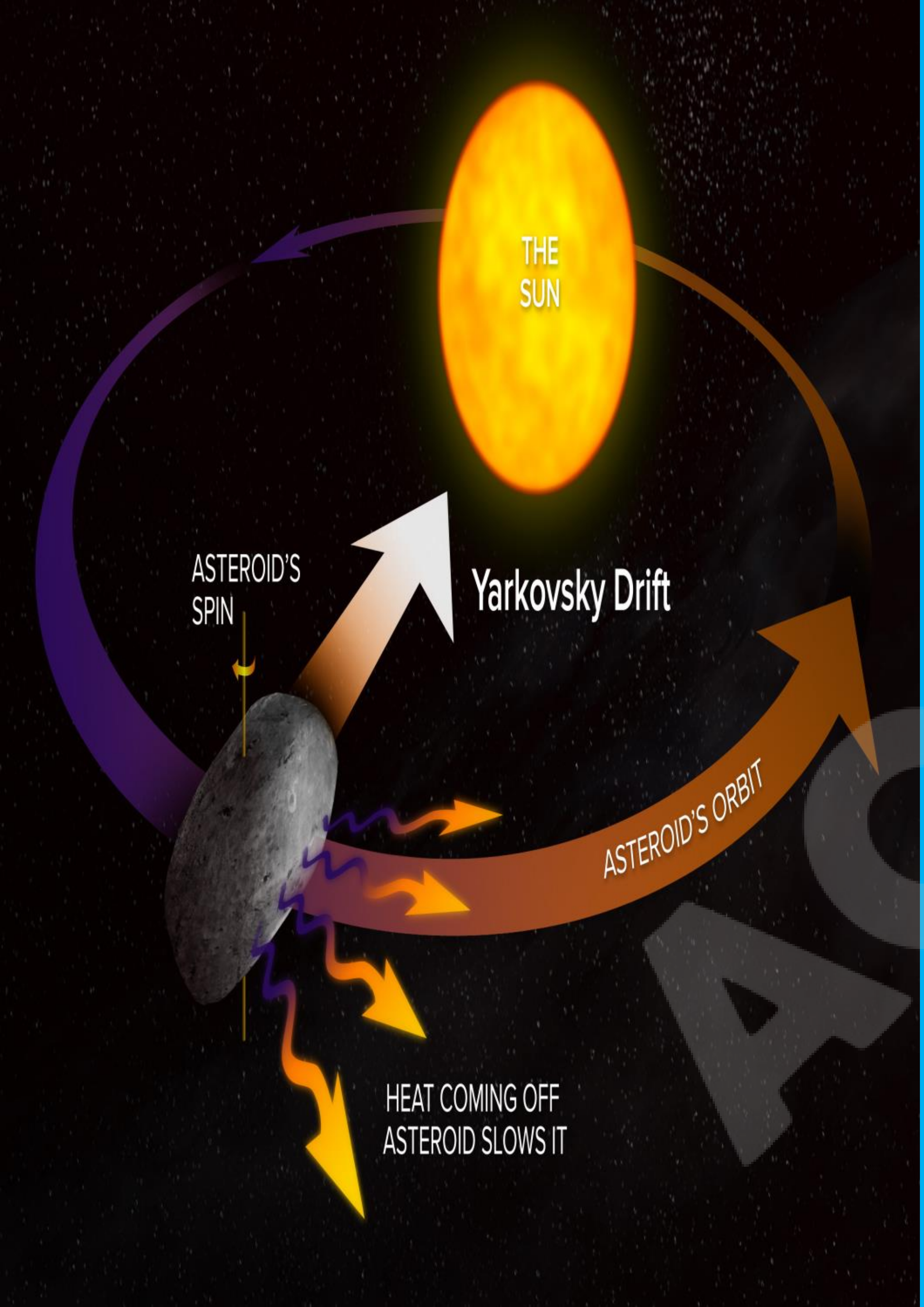
- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- the Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- astronauts shall be regarded as the envoys of mankind;
- States shall be responsible for national space activities whether carried out by governmental or non-governmental entities;
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.

Open Skies Treaty

- Signed March 24, 1992, the Open Skies Treaty permits each state-party to conduct short-notice, unarmed, reconnaissance flights over the others' entire territories to collect data on military forces and activities.

- Observation aircraft used to fly the missions must be equipped with sensors that enable the observing party to identify significant military equipment, such as artillery, fighter aircraft, and armored combat vehicles.

- Though satellites can provide the same, and even more detailed, information, not all of the treaty states-parties have such capabilities. The treaty is also aimed at building confidence and familiarity among states-parties through their participation in the overflights.



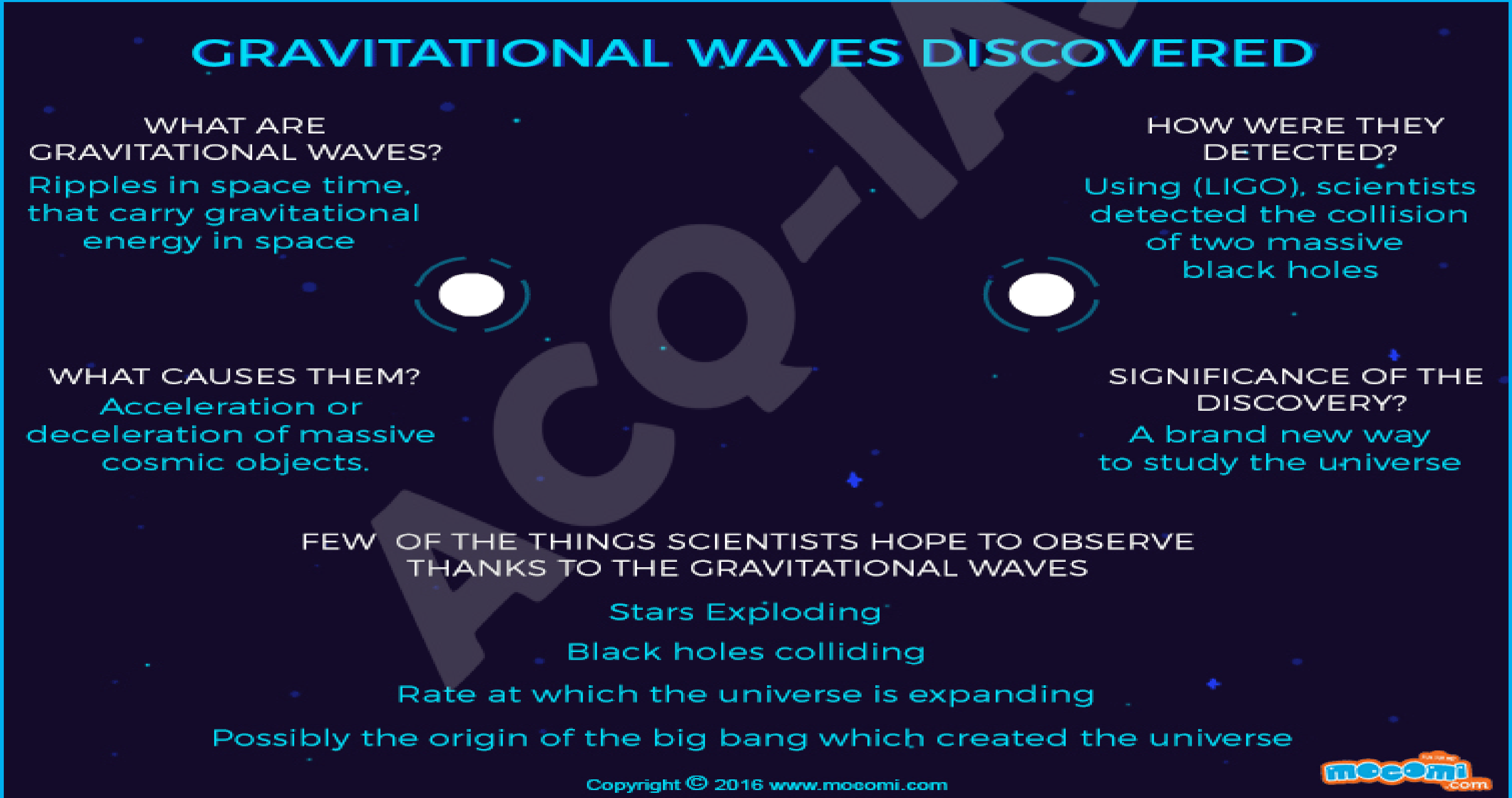
Yarkovsky effect

Rotating asteroids have a tough time sticking to their orbits. Their surfaces heat up during the day and cool down at night, giving off radiation that can act as a sort of mini-thruster. This force, called the Yarkovsky effect, can cause rotating asteroids to drift widely over time, making it hard for scientists to predict their long-term risk to Earth.

. In order to learn more about this process on asteroid Bennu, NASA is sending a spacecraft called OSIRIS-REx to make detailed observations of Bennu's shape, brightness, and surface features.

These factors are thought to influence the Yarkovsky effect, and understanding how will enable scientists to better predict the orbit of Bennu and other near-Earth asteroid

Gravitational Waves

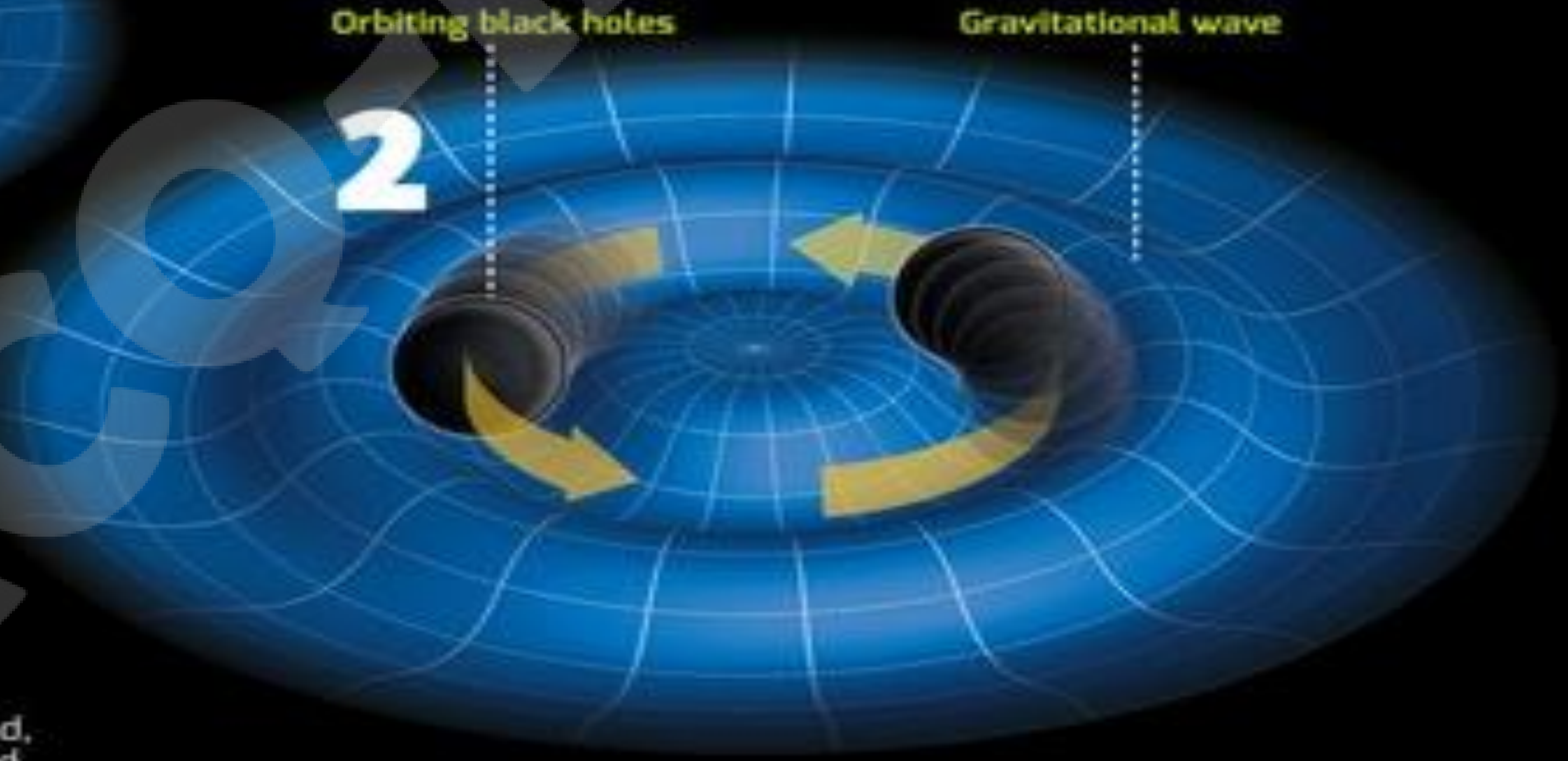


What are gravitational waves?

Just as waves in a pond are created by disturbances in the water, gravitational waves are created by disturbances in the fabric of spacetime.

Lots of things can create gravitational waves, but most are too weak to us to measure. Luckily, because black holes distort spacetime so much, they can create waves that we can detect here on Earth.

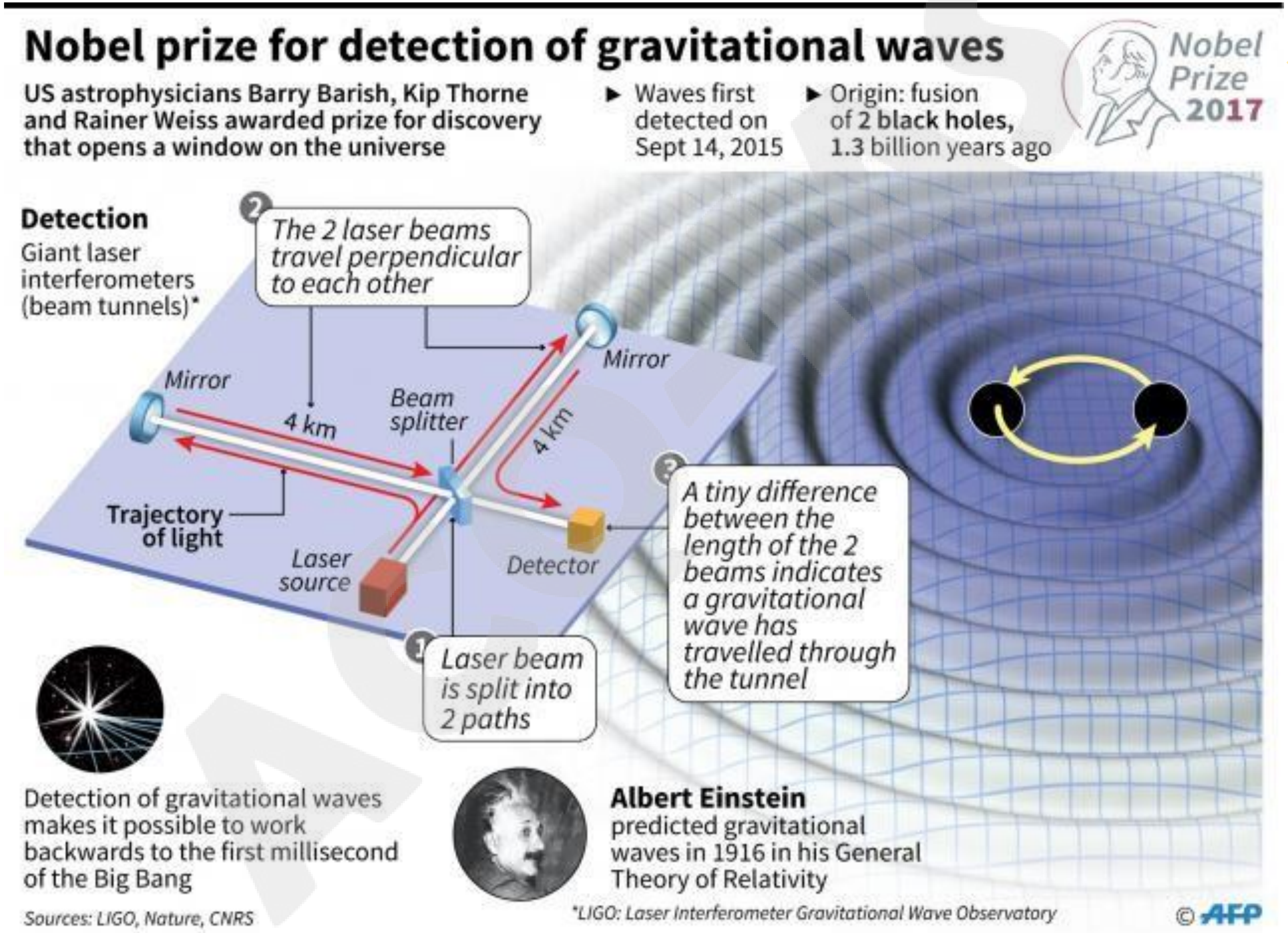
Black holes are the collapsed remains of a star many times more massive than our Sun. When the star dies, its core collapses under the gravitational force of its own mass.



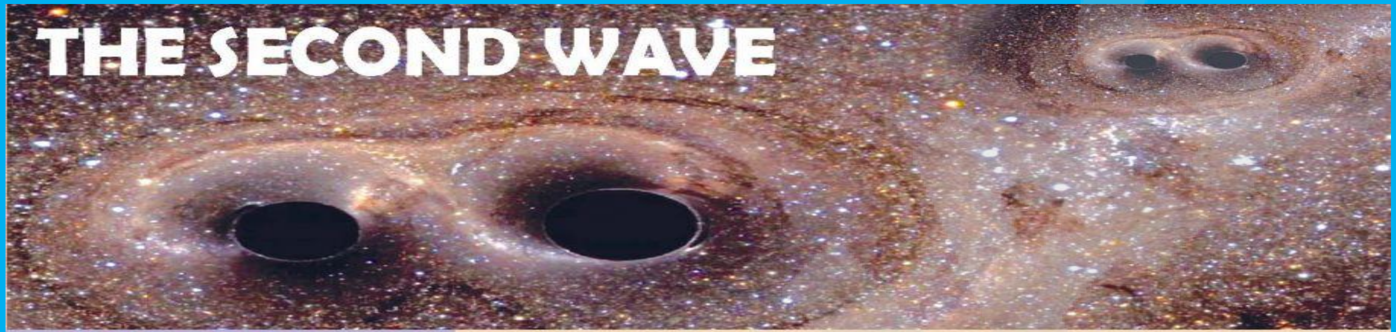
1. A black hole by itself makes a deep dent in the fabric of spacetime, but it doesn't throw out any gravitational waves.

2. Here are two black holes orbiting each other (binary system). As they orbit, they whiz around each other so quickly that, instead of just making a dent in spacetime, they plough up waves (like when you stir water with your finger) – these are gravitational waves.

But it takes energy to create gravitational waves and, with each orbit, the pair lose energy, which is carried away by the gravitational waves. As they lose energy, their orbits will begin to shrink. Eventually, it will shrink so much that the black holes will crash together.

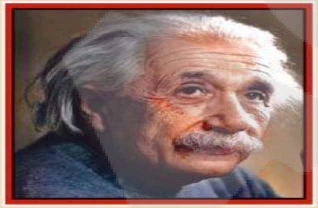

Nobel prize for detection of gravitational waves
US astrophysicians Barry Barish, Kip Thorne and Rainer Weiss awarded prize for discovery that opens a window on the universe
Waves first detected on Sept 14, 2015
Origin: fusion of 2 black holes, 1.3 billion years ago
Nobel Prize 2017
Detection
Giant laser interferometers (beam tunnels)*
The 2 laser beams travel perpendicular to each other
Mirror
Mirror
4 km
Beam splitter
4 km
Trajectory of light
Laser source
Detector
A tiny difference between the length of the 2 beams indicates a gravitational wave has travelled through the tunnel
Laser beam is split into 2 paths
Detection of gravitational waves makes it possible to work backwards to the first millisecond of the Big Bang
Albert Einstein
predicted gravitational waves in 1916 in his General Theory of Relativity
Sources: LIGO, Nature, CNRS
*LIGO: Laser Interferometer Gravitational Wave Observatory
© AFP

- When 2 black holes merge, it will radiate GW. GW are ‘ripples’ in the fabric of space-time caused by some of the most violent and energetic processes in the Universe.
- They are extremely weak so are very difficult to detect.
- Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity.
- These ripples travel at the speed of light without being scattered significantly.



EINSTEIN'S THEORY

Einstein predicted the existence of the waves in his theory of relativity a century ago, and scientists have been able to detect them with an instrument known as the Laser Interferometer Gravitational-Wave Observatory, or LIGO



GRAVITATIONAL WAVES

Black holes form in the final stage of most massive stars' evolution. The space bodies are so dense that neither light nor matter can escape them.

Sometimes the holes couple, orbiting in a 'dance' around each other as they lose energy in the form of gravitational waves, ultimately merging into a single black hole

Those gravitational waves allow scientists to detect when the black holes merge

THE FIRST DETECTION

The first detection of waves– in September 2015 –was announced in February 2016, in a landmark discovery for physics and astronomy after decades of efforts

THE NEW WAVE

Researchers announced they had found the waves a second time in December 2015, produced by the collision of two black holes some 1.4 billion years ago.

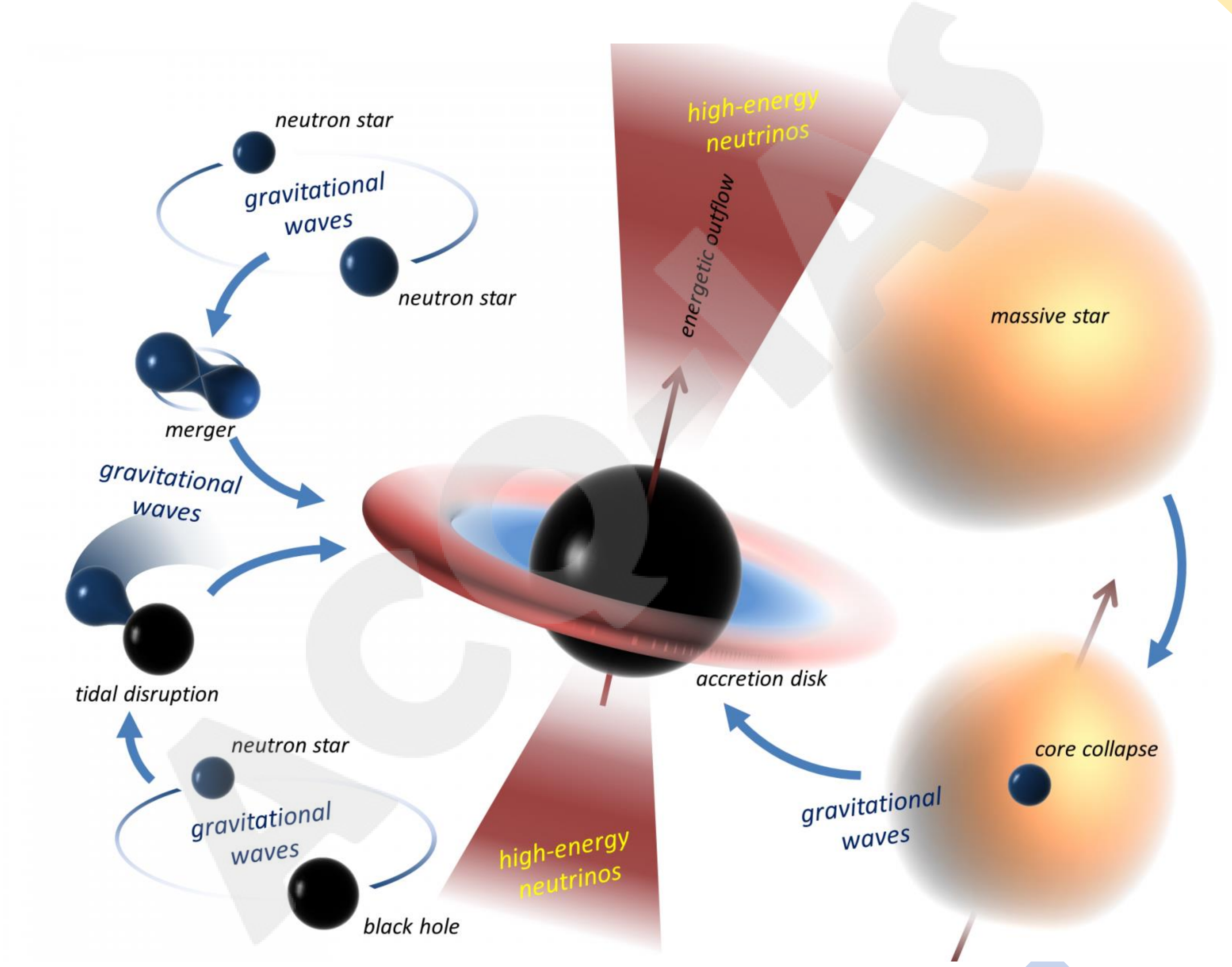
SIZE OF BLACKHOLE

It is very significant that these black holes were much less massive than those in the first detection. It is a promising start to mapping the populations of black holes in our universe.

WHAT IS LIGO? The Laser Interferometer Gravitational-Wave Observatory (LIGO) consists of two identical detectors 3,000 km apart – one in Livingston, Louisiana and the other in Hanford, Washington

Sources of Gravitational waves

- Mergers of black holes or neutron stars, rapidly rotating neutron stars, supernova explosions and the remnants of the disturbance caused by the formation of the universe, the Big Bang itself, are the strongest sources.
- There can be many other sources, but these are likely to be too weak to detect.
- Scientists have for the first time detected gravitational waves produced by the collision of a neutron star and a black hole.
- This finding confirms that there are neutron star-black hole systems and will help answer many questions about the cosmos, from star formation to the expansion rate of our universe.


neutron star
gravitational waves
neutron star
merger
gravitational waves
tidal disruption
neutron star
gravitational waves
black hole
high-energy neutrinos
energetic outflow
high-energy neutrinos
accretion disk
massive star
core collapse
gravitational waves

- **Interferometer**
- It is an instrument that uses interference patterns formed by waves (usually light, radio, or sound waves) to measure certain characteristics of the waves themselves or of materials that reflect, refract, or transmit the waves.
- Interferometers can also be used to make precise measurements of distance.
- Interference patterns are produced when two identical series of waves are brought together.

Laser Interferometer Gravitational Wave Observatory (LIGO)

- It is the world's largest gravitational wave observatory and a wonder of precision engineering.
- It comprises of two enormous laser interferometers located thousands of kilometres apart, each having two arms which are 4 km long. The detectors are in (Livingston) Louisiana and (Hanford) Washington.
- It exploits the physical properties of light and of space itself to detect and understand the origins of Gravitational Waves (GW). Upgraded version is called Advanced LIGO.
- The Japanese detector, KAGRA, or Kamioka Gravitational-wave Detector, is expected to join the international network soon.
- LIGO detectors: Unlike optical or radio telescopes, it does not see electromagnetic radiation

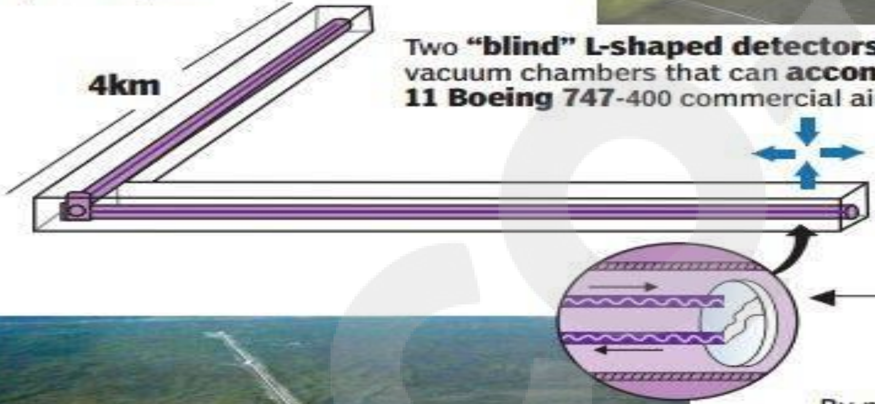
Source: TNN, phdcomics.com, LIGO, Scientific American, phys.org, aps.org, symmetrymagazine.org

WHAT IS LIGO?

The advanced Laser Interferometer Gravitational Wave Observatory (or LIGO) is at the centre of the path-breaking find:

The LIGO experiment is an example of extreme engineering chasing an impossible dream

The twin LIGO installations — one in Livingston, Louisiana, and the other in Hanford, Washington — are located 3,000km apart



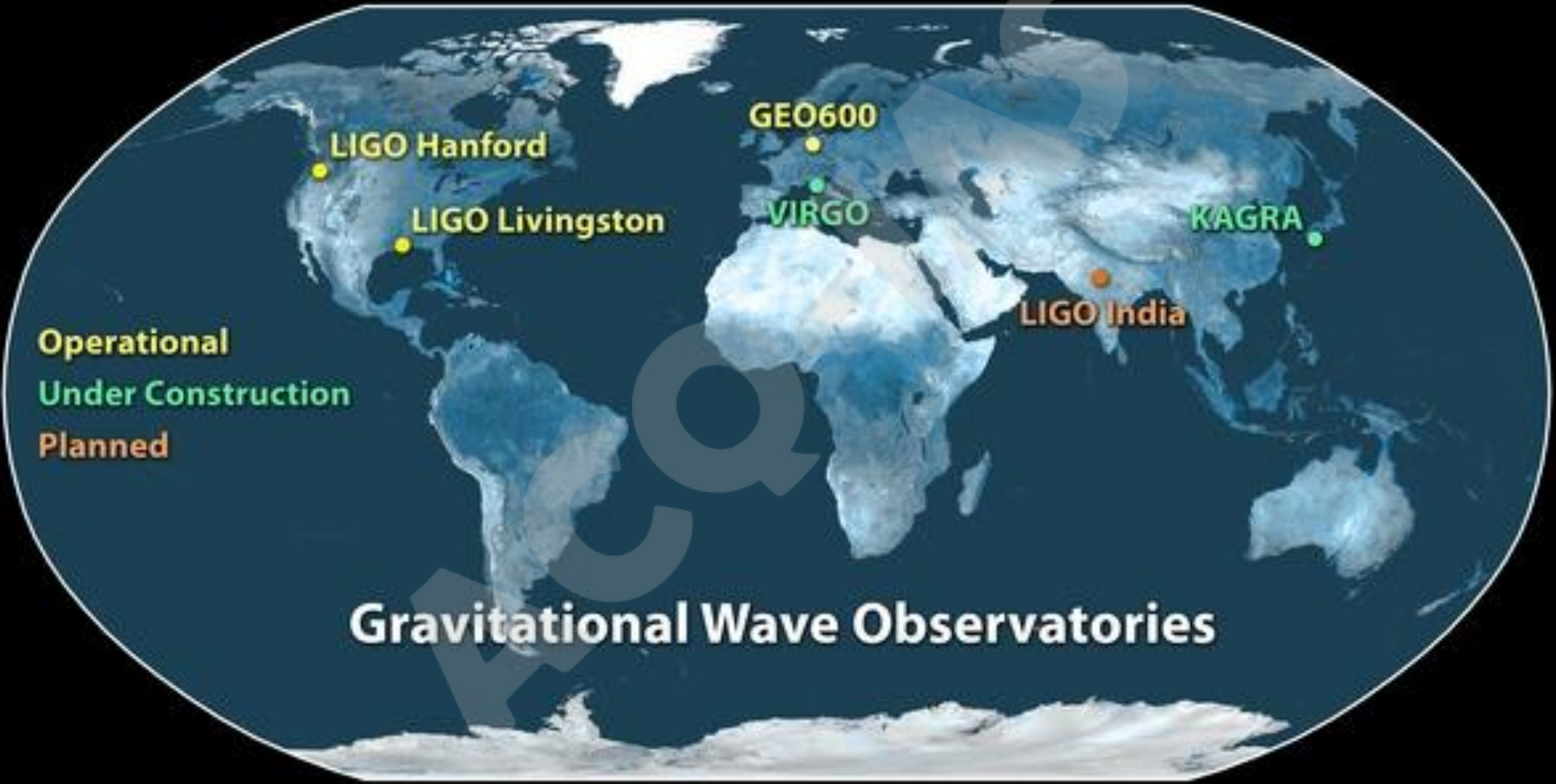
Two **"blind" L-shaped detectors** with 4km long vacuum chambers that can **accommodate 11 Boeing 747**-400 commercial airliners

When a gravitational wave comes through, it stretches space in one direction, and squeezes space in the other direction

By measuring the interference of the laser as they bounce between the different point, phsicists can measure very precisely whether the space in between has streched ore compressed

- Built **3,000km** apart, operating in unison
- To make the smallest measurement ever attempted by science — **a motion 10,000 times smaller than an atomic nucleus**
- Caused by the most violent and cataclysmic events in the Universe occurring millions of light years away
- Can detect gravitational waves in a volume of 1 billion cubic light years – **covering about 1 million Milky Way type galaxies**

- To detect a gravitational wave we should be able to tell when something changes in length by a few parts in 10 to the power 23
- LIGO makes the smallest measurement ever attempted — a motion 10,000 times smaller than an atomic nucleus
- It's like trying to hear a song being hummed in a very, very noisy party


GEO600
LIGO Hanford
LIGO Livingston
VIRGO
KAGRA
LIGO India
Operational
Under Construction
Planned
Gravitational Wave Observatories

- **IndIGO (India Initiative of GW Observations) in Hingoli district, Maharashtra.**
- The proposed LIGO-India project aims to move one Advanced LIGO detector from Hanford to India.
- LIGO-India project is envisaged as an international collaboration between the LIGO Laboratory and 3 lead institutions in the IndIGO consortium: Institute of Plasma Research (IPR) Gandhinagar, Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune and Raja Ramanna Centre for Advanced Technology (RRCAT), Indore.

- **Significance of IndiGo Project**
- To locate the source of gravitational waves more accurately.
- Identification of new sources.
- The project will help Indian scientific community to be a major player in the emerging research frontier of GW astronomy.
- The high-end engineering requirements of the project (such as the world's largest ultra-high vacuum facility) will provide unprecedented opportunities for Indian industries in collaboration with academic research institutions.
- A cutting edge project in India can serve as a local focus to interest and inspire students and young scientists.

VERITAS Mission and DAVINCI+ Mission: NASA Missions on Venus

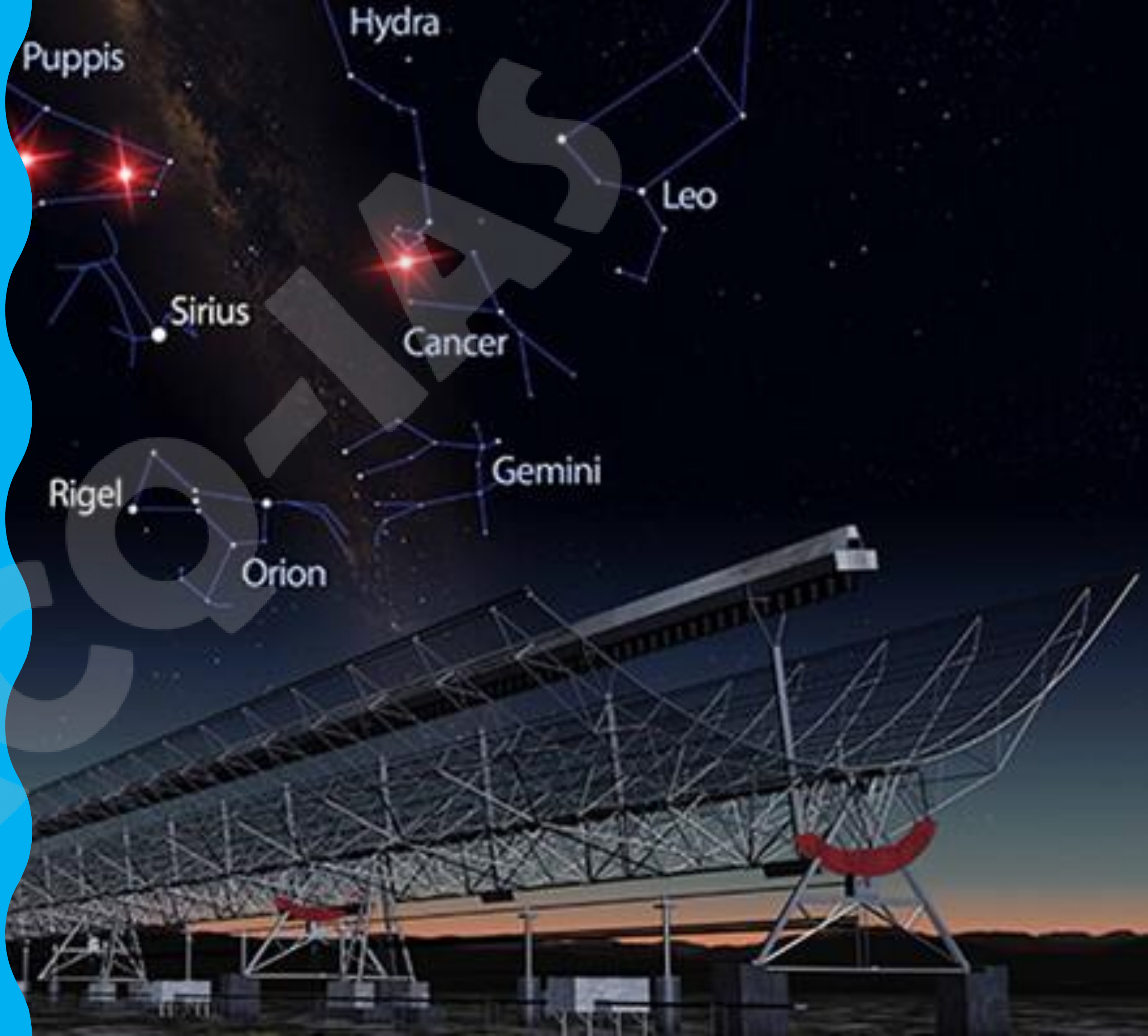
- NASA announced two missions to Venus, Earth's closest planetary neighbour, as part of its 'Discovery Program' that aims to explore and study the solar system.
- **Missions are**
- The VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy) mission will map the surface of the planet, study its geology, and hunt for volcanic activity.
- The DAVINCI+ (Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging) with its atmospheric probe, called Plus, will study the dense atmosphere of Venus to understand the trigger and evolution of the runaway greenhouse effect active on the planet.
- The missions are funded for $500 million each and are expected to launch somewhere around 2028-2030.

- Earth’s twin: Venus is often called Earth’s twin because of similar mass, size, gravity, surface composition and complex atmospheric processes.
- However, we know much less about it compared to the other planetary neighbour, Mars. This is largely due to it being obscured by an extremely dense layer of atmosphere and clouds.

- **VERITAS Mission**
- The VERITAS mission will study the planet's geology with radar, map its entire surface topography in 3D and will try to understand why it developed differently from Earth.
- It will also study infrared emissions from the surface to map various kinds of rocks.
- The mission will also seek to understand if any volcanic or tectonic activity is present on the planet currently.
- It will also try to find out if any active volcanoes are releasing water vapour into the atmosphere, sustaining its greenhouse effect.
- **DAVINCI+ Mission**
- The DAVINCI+ will measure the atmospheric composition of Venus and its formation and evolution.
- The mission will also try to determine if the planet held an ocean of liquid water in the past.
- The mission will return the first high-resolution images of unique surface features known as "tesserae" on Venus, which are akin to the continents on Earth, and suggest the existence of plate tectonics.
- The mission's accompanying Plus probe will drop into the atmosphere, making measurements of noble gas composition in the layers.

Fast Radio Bursts

- FRBs are oddly bright flashes of light, registering in the radio band of the electromagnetic spectrum, which blaze for a few milliseconds before vanishing without a trace.
- These brief and mysterious beacons have been spotted in various and distant parts of the universe, as well as in our own galaxy.
- Their origins are unknown and their appearance is highly unpredictable.
- But the advent of the CHIME project — a large stationary radio telescope in British Columbia, Canada — has been a game changer and has nearly quadrupled the number of fast radio bursts discovered to date.



NASA's Mars Exploration Program

- NASA's Mars Helicopter Ingenuity has successfully flown on Mars. It is the first powered flight on another planet.
- The helicopter's main task is to carry out a technology demonstration to test the first powered flight on Mars. It also aims to collect samples from the locations on Mars where the rover cannot reach.
- Moreover, it is also solar-powered and is able to charge on its own
- Perseverance is a car-sized Mars rover designed to explore the crater Jezero on Mars as part of NASA's Mars 2020 mission.
- The rover was launched in July,2020. It landed at the Jezero Crater of Mars in February.2021.

- NASA’s Psyche mission: The primary target of the Psyche mission to be launched in 2022 by NASA is to study this asteroid completely and confirm the assumptions being made by the scientists.
- It was found that Psyche could be a unique asteroid composed of iron and nickel almost completely which is similar to earth's core.
- Psyche mission will be the first mission to investigate this metallic asteroid. Psyche spacecraft will land on the asteroid in early 2026. As the composition of Psyche is very similar to earth’s own core, its study will also give an insight to earth’s violent history of collisions and accretion that created it.
- Asteroid 2001 FO32 is the largest asteroid passed by Earth in 2021.

Why Study Asteroids?

- Asteroids, like comets, are primitive bodies that can be considered to be the building blocks of the early solar system. They hold a record of the birth and initial evolution of the solar system.
- Larger planets like Earth went through a more complex evolution over which the pristine materials were melted and altered significantly. Due to this change, the materials found on large planets do not hold information into their early stages of formation.
- Comets and asteroids, formed early in the evolution of the Solar System, retain a record of when, where and in what conditions they were formed. Exploration of these primitive bodies is essential in gaining insight into the formation of the Solar System.

Asteroid Impact and Deflection Assessment (AIDA)

- It is the first international space mission to demonstrate asteroid impact hazard mitigation ny using a kinetic impactor to deflect an asteroid and measure the deflection.
- This mission that targets a double asteroid called Didymos is cooperation between NASA's Double Asteroid Redirection Test (DART) mission and European Space Agency's (ESA's) Hera.
- DART (to be launched in 2021) would slam into the smaller asteroids of the Didymos system in 2022.
- Hera (to be launched in 2024) would measure the impact crater produced by DART collision and study the change in the asteroid's orbital trajectory. It will arrive at the Didymos system in 2027.
- AIDA will help in studying asteroid strength, surface physical properties and internal structure.

Solar Missions

Aditya-L1

- Aditya-L1 Mission is India's first solar mission planned by the Indian Space Research Organisation (ISRO). Earlier the name was Aditya -1, which has been renamed as Aditya-L1 Mission.
- The main objective of the Aditya L1 Mission is that it will help in tracking Earth-directed storms and predict its impact through solar observations
- The L1 point is home to the Solar and Heliospheric Observatory Satellite (SOHO), an international collaboration project of National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA).

Coronal Mass Ejections

- Coronal Mass Ejections (CMEs) that comes from the Sun are huge bubbles of gas threaded with magnetic field lines.
- They cause various disturbances to the space environment, and cause geomagnetic storms, satellite failures, and power outages.

Indo French Space Collaboration

- Indian Space Research Organisation (ISRO) and French space agency Centre National dEtudes Spatiales (CNES) are working on their 3rd joint satellite mission.
- ISRO and CNES have completed the feasibility study to realise the earth observation satellite mission with TRISHNA, thermal infrared imager.
- TRISHNA will monitor the water cycle to help in properly utilizing it.
- ARGOS of CNES will be integrated into ISRO's OCEANSAT-3 satellite.
- ARGOS is the data collection and location system of its kind dedicated to studying and preserving the environment.
- There are discussions on establishing 'NavIC' reference station in France and CNES 'Scintillation' receivers in India.

Previous Joint Satellite Missions

- MEGHA-TROPIQUES (2011) - This Indo-French joint satellite mission that was launched to study the tropical atmosphere and climate related to aspects such as monsoons, cyclones, etc.
- SARAL (2013) - This mission was launched to study the ocean from space using altimetry.

Bacteria found on International Space Station named after Indian scientist

- 4 species of bacteria have been discovered onboard the International Space Station (ISS).
- One of the bacteria has been named after Indian biodiversity scientist Seyed Ajmal Khan (Methylobacterium ajmalii).
- These bacteria aid in plant growth.
- International Space Station (ISS) is a modular space station or a habitable artificial satellite.It has been installed in low Earth orbit.
- It is a multinational collaborative project that involves the participation of five space agencies namely, NASA from United States, Roscosmos from Russia, JAXA from Japan, ESA from Europe, and CSA from Canada.

NISAR

- ISRO and NASA signed a partnership in 2014, to collaborate on and launch NISAR (NASA-ISRO SAR) by 2022.
- NASA is providing L-band SAR, a high-rate communication subsystem for science data, etc.,
- ISRO is providing the S-band radar, and launch services.
- NISAR is a Synthetic Aperture Radar that can produce extremely high-resolution images for a joint earth observation satellite mission.
- It will be the first satellite mission to use 2 radar frequencies (L-band and S-band) to measure changes in Earth's surface less than a centimetre across.

- The Giant Metrewave Radio Telescope (GMRT), located near Pune, Junnar, near Narayangaon at khodad in India, is an array of thirty fully steerable parabolic radio telescopes of 45 metre diameter, observing at metre wavelengths. It is operated by the National Centre for Radio Astrophysics (NCRA), a part of the Tata Institute of Fundamental Research, Mumbai.

- One of the aims for the telescope during its development was to search for the highly redshifted 21-cm line radiation from primordial neutral hydrogen clouds in order to determine the epoch of galaxy formation in the universe.
- Astronomers from all over the world regularly use this telescope to observe many different astronomical objects such as galaxies, pulsars, supernovae, and Sun and solar winds
- In February 2020, it helped in the observation of the biggest explosion in the history of the universe, the Ophiuchus Supercluster explosion. The eruption occurred due to a supermassive black hole.

THIRTY METER TELESCOPE PROJECT.

- It is an astronomical observatory with an extremely large telescope (ELT).
- It is an international project being funded by scientific organisations of Canada, China, India, Japan and USA.
- Planned location is Mauna Kea on the island of Hawaii in the US state of Hawaii
- The TMT is designed for near-ultraviolet to mid-infrared observations, featuring adaptive optics to assist in correcting image blur.
- TMT will enable scientists to study fainter objects far away from us in the Universe, which gives information about early stages of evolution of the Universe

- SpaceX, an aerospace company, has beaten the record of the Indian Space Research Organisation- ISRO where it deployed 104 satellites in February 2017 in a single launch.
- The reusable rocket launched 143 satellites to space which are part of the SmallSat Rideshare program of SpaceX from Florida's Cape Canaveral Space Force Station.

Science, Technology and Innovation (STI) Policy, 2013

- The policy seeks to focus on both STI for people and people for STI.
- It aims to bring all the benefits of STI to the national development and sustainable and more inclusive growth.
- It seeks the right sizing of gross expenditure on R&D by encouraging private sector participation in R&D, Technology and Innovation.
- It also wants to bring gender parity in STI activities and gaining global competitiveness in select technological areas through International collaboration and alliances.
- A Strong and viable Science, Research and Innovation system for High Technology led path for India (SRISHTI) is the goal for the STI policy.

Key Features of the STI policy 2013

- Promoting the spread of scientific temper amongst all sections of society.
- Enhancing skills for applications of science among the young from all social sectors.
- Making careers in science, research and innovation attractive enough for talented and bright minds.
- Establishing the world-class infrastructure for R&D for gaining global leadership in some select frontier areas of science.

- Positioning India among the top five global scientific powers by 2020 (by increasing the share of global scientific publications from 3.5% to over 7% and quadrupling the number of papers in top 1% journals from the current levels).
- Creating an environment for enhanced private sector participation in R &D.
- Enabling conversion of R & D output with societal and commercial applications by replicating hitherto successful models, as well as establishing of new PPP structures.
- Creating a robust national innovation system.
- Sharing of IPRs between inventors and investors.
- Modifying IPR policy to provide for marching rights for social good when supported by public funds and for co-sharing IPRs generated under PPP.

PM's Science, Technology and Innovation Advisory Council (PM-STIAC)

- Govt scraps Scientific Advisory Committee (SAC) and replace it with PM's Science, Technology and Innovation Advisory Council (PM-STIAC)
- It has 2 functions
- Act as a high level advisory body to several ministries.
- Execute Mission oriented programmes.
- It has 9 members. Unlike the earlier SACs, Secretaries of various scientific ministries like Education, Environment and Health would be special invitees to PM STIAC meetings.
- PM-STIAC identified 9 National S&T Missions

- **National Language Translation**

- By MEITy, MHRD and DST.
- It combines machine and human translation, that will eventually enable access to teaching and reseach material bilingually i.e. in English and one's native language.
- It removes the English barrier.

- **National Mission on Quantum Frontier**

- By DST, Dept of Space, DAE, DRDO, MEITy.
- To initiate work in the control of quantum mechanical systems.
- It will also be helpful for national security and in development of quantum computers, quantum chemistry, quantum sensors, quantum communication and quantum cryptography.

- **National Mission on Artificial Intelligence**

- By NITI Aayog, DST, MEITy, DBT.
- It will address societal needs like healthcare, education, agriculture, smart cities and infrastructure, including smart mobility and transportation.

- **National Biodiversity Mission**
- By MoEFCC, DBT.
- It includes documentation of India's biodiversity (cataloguing) and mapping all lifeforms in India including associated cultural and traditional practices.
- Assessment of the distribution and conservation status of India's biodiversity.
- Development of a cadre of professionals.
- Establishment of a vibrant biodiversity based economy.
- Engagement with the public
- Enhanced options for agricultural production and livelihood security.

- **National Mission on Waste to Health**

- DST, DBT, MoEFCC, SBA and Ministry of Urban Development.
- It aims to identify, develop and deploy technologies to treat waste to generate energy, recycle materials and extract worth.
- It will identify and support new technologies in creating a clean and green environment.
- The mission will assist and augment the Swachh Bharat and Smart Cities project.

- **Deep Ocean Exploration**
- By Ministry of Earth Sciences, DBT, Dept of Space, MNRE, ONGC, DRDO, Geological Survey of India, National Hydrographic Office, National Biodiversity Authority.
- It aims to scientifically explore the deep oceans towards improving India’s understanding of the blue frontier.
- It will address issues arising from long term changes in the ocean due to climate change.
- It includes exploration of resources and life; development of underwater vehicles and robotics; desalination techniques etc.

- **National Mission on Electric Vehicles**

- By DST, Dept of Heavy Industries, MNRE, Ministry of Power, NITI.
- Academia - Industry collaboration to develop vehicle subsystems and components including including rare earth based 4 electric motors, Li-ion batteries, power electronics etc.
- To reduce fossil fuel consumption and mitigate emissions.
- Make EVs economically viable and scalable and build indigenous capability.

- **National Mission on Bioscience for Human Health**

- By DST, DBT, Dept of Health Research, DAE and Dept of Health.
- Construct comprehensive reference maps of genomes and their study to identify the prevalence of rare and inherited diseases.
- The outcome will stimulate better diagnosis and treatment.

- **AGNI (Accelerating Growth of New India's Innovations)**

- By Invest India.
- It supports the innovation ecosystem in India by connecting innovators across industry, individuals and the grassroots by commercially innovative solutions.
- It will provide a platform for innovators to bring their technology ready products.
- It includes techno commercialization, working with Govt R&D labs, training and capacity building.

I-STEM

- I-STEM (www.istem.gov.in) is an initiative of Office of the Principal Scientific Adviser to the Govt. of India (PSA, GOI) under the aegis of Prime Minister Science, Technology and Innovation Advisory Council (PM-STIAC) mission.
- I-STEM project has been accorded extension for five years, until 2026 and enters its second phase with added features.
- Providing necessary supplies and supports to researchers by enabling them an access to existing publicly funded R&D facilities in the country through the I-STEM web portal.
- I-STEM portal facilitates researchers to access slots for the use of equipment, as well as to share the details of the outcomes, such as, patents, publications and technologies.

- In the first phase, the portal is listed with more than 20,000 pieces of equipment from 1050 institutions across the country and has more than 20,000 Indian researchers.
- Under Phase II, the portal will host indigenous technology products listed through a digital catalogue.
- The portal will also provide a platform for the various City Knowledge and Innovation Clusters supported by the Office of PSA to enhance effective use of R&D infrastructure through leveraging collaboration and partnership built on a shared STI ecosystem.
- It will also host and provide access to selected R&D software required to undertake research projects by students and scientists.
- The I-STEM portal in its new phase will be designed as a dynamic digital platform that will provide boost to research and innovation especially for 2 tier and 3 tier cities and also for the emerging start-up ecosystem.