

TARGET PRELIMS 2024

BOOKLET-38; S&T-12

CA UPDATES ON S&T

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1. SPACE

1) GSLV-F14/INSAT-3DS MISSION (FEB 2024)

- GSLV-F14 (**GSLV-MK-II**) was the 16th mission of GSLV, and it deployed the INSAT-3DS meteorological satellite in GTO. This mission is fully funded by Ministry of Earth Science.
- **INSAT-3DS**: It is a follow-on mission of Third Generation Meteorological Satellite for Geostationary Orbit. It is designed for enhanced meteorological observations and monitoring of land and ocean surfaces for weather forecasting and disaster warning.
- The satellite will augment the Meteorological services along with the presently operational INSAT-3D and INSAT-3DR satellites.
- **Note**: GSLV MK-II is nicknamed '**Naughty Boy**'. It is because it has had a rather patchy track record.
 - » So far (including GSLV F14), GSLV has had 16 launches so far, and four of them have been failures.
 - » **What is the core issue?**
 - The main problem is the Cryogenic engine that powers the third and final stage. GSLV-MK-II uses a cryogenic engine which is a reverse-engineered version of a Russian technology.
 - **Why?** Russia couldn't supply technology to India due to MTCR restrictions. But it supplied a few of the engines. Initially India used these engines and later tried to reverse engineer the same.
 - **Note**: Now India has its own cryogenic engine as well, a result of decades of R&D. This engine has entirely Indian design, developed within ISRO, and uses a different process to burn fuel. It is closer to the designs of the Arienne rockets that were used by ISRO till a few years ago to launch its heavier rockets. This engine is being used in **LVM-3**.

2) CARTOSAT-2 BROUGHT DOWN (FEB 2024)

- **Background**: The satellite was launched in 2007 in SSPO. Until 2019, the satellite equipped with over 12,000 coupled charged devices used its "panchromatic and multi-spectral cameras" to generate high resolution images that were extensively used for urban planning, monitoring of road networks, and water distribution, creation of land use maps, among others.
- 17 years after its launch, Cartosat-2, the first of India's second generation of high-resolution imaging satellites primarily used in urban planning has been deorbited.
- With a descent into earth's atmosphere, all of its components would be disintegrated. It has led to reduction of collision risk and safe end-of-life disposal of the satellite.

3) GAGANYAAN

- Introduction

- **Gaganyaan project** envisages demonstration of human spaceflight capability by launching crew of 3 members to an orbit of 400 km for a 3-day mission and bring them back safely to earth, by landing in India sea waters.
- Assuming two important test flights (unmanned) in 2024 and 2025 are successful, the first crewed flight of the mission is scheduled for 2025.
- The GSLV MK-III launch vehicle will be used to launch the Gaganyaan mission.
- **Technically, it is a demonstration mission:** It will test various technologies required for human spaceflight, which remains the most complicated form of spaceflight, and demonstrate India's familiarity with their production, qualification and use.

- Significance/ Need of HSP

- **First step towards future space programs** like having India's own space station and sending humans to moon and on other interplanetary mission. PM Modi has set the target of having a space station by 2035 and landing an Indian on Moon by 2040.
- **More R&D in space** – ISRO will be able to conduct micro-gravity experiment.
- **Advances in Science and Technology**
- **Strengthen India's Soft power:** So far, only three countries USA, Russia and China have executed Human Spaceflight at their own.
- **Technological spin-offs will benefit other sectors.**
- **Improvements in Higher Education** in the field of aeronautical engineering, aerospace engineering and physics.
- **Employment Opportunities**
- **Symbolism: Great power status** – Achievements in outer space are a marker of great power status.

- Key components of Human Space Program (HSP)

- **Human Space Flight Centre (HSFC)** – A body set up by ISRO as a coordinating body for Gaganyaan called the Human Space Flight Centre (HSFC).

- Development of **Human rated launch vehicles** for carrying crew safely to space.

- **All systems in LVM3 launch vehicles** are-reconfigured to meet human rating requirements and christened **Human Rated LVM3 (HLVM3)**. It will be capable of launching the orbital module to an intended LEO of 400 km.
- **HLVM3** also consist of **Crew Escape System (CES)** powered by a set of quick acting, high burn rate solid motors which ensure that Crew module along with crew is taken to safe distance in case of emergency either at launch pad or during ascent phase.

- Orbital Module: It is the object that LVM-3 rocket will launch and place in LEO. It will be orbiting earth and comprises of Crew Module (CM) and Service Module (SM). It is fit with adequate redundancy considering human safety.

- **CM** is the habitable space with Earth like environment in space for the crew. It can house upto three astronauts for a week.
 - Technical details of crew module:
 - It is of double walled construction consisting of pressurized metallic Inner Structure and unpressurised External Structure with Thermal Protection System (TPS).
 - It houses the crew interfaces, human centric products, life support system, avionics and deceleration systems.
 - It is also **designed for re-entry to ensure safety of the crew during descent till touchdown**. It includes parachutes to slow its descent to the ground once it descends from orbit.
 - It also include a **gynoid** (feminine robot) named '**Vyomamitra**' fit with sensors to track the effects of radiation and weightlessness, monitor capsule conditions, and sound alarms in the event of an impending emergency, aside from being able to perform some task.
 - **SM** will be used for providing necessary support to CM while in orbit. It is an unpressurized structure containing thermal system, propulsion system, power systems, avionics systems and deployment mechanisms.
- Life Support System (Habitable Modules) to provide an earth-like environment to crew in space.
 - **Building a habitable module** in which astronauts will live and work. Such environmental control systems are being developed.
 - **Other life support systems** – Space suits etc.



- **Precursor Missions** for demonstrating the technology preparedness levels before carrying out the actual mission. This includes Integrated Air Drop Test (IADT), Pad Abort Test (PAT), and Test Vehicle (TV) flights.
- **Crew Training Facility established** in Bengaluru caters to Classroom training, Physical Fitness Training, Simulator Training and Flight suit training.
 - **Training Modules** cover academic courses, Gaganyaan Flight Systems, Micro-Gravity familiarization through parabolic Flights, Recovery & Survival training etc. **Aero medical training**, Periodical Flying Practice and Yoga are also included as part of the training.
 - **Note:** A shortlist of candidates was sent to Russia for advanced training.
- **Astronaut Training** – to live in a gravity less environment.
- **Capabilities for recovering astronauts safely.**
- **Other Steps taken so far:**
 - **Space Borne Assistance and Knowledge Hub for Crew Interaction (SAKHI):** A multipurpose app developed by Vikram Sarabhai Space Centre that will help astronauts on Gaganyaan space flight mission carry out a range of tasks such as looking up vital technical information or communicating with one another. It will also monitor the health of astronauts, alert them about their dietary schedule etc. It will also help them stay connected with Earth. It will keep the crew connected with the onboard computer and ground-based stations, guaranteeing a seamless communication link.
 - **Pilots have been selected** and the identities of the four astronaut-designates, all IAF test pilots, were revealed in Feb 2024. The final crew for the mission will be chosen from among the four. **Prashanth Balakrishnan Nair, Ajit Krishnan, Angad Pratap and Shubhanshu Shukla** – are all airforce pilot.
 - In 2018, the Union Cabinet had allocated Rs 10,000 crore for the program.

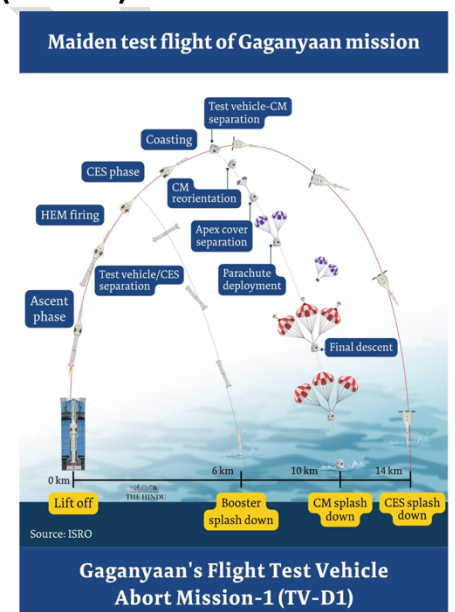
A) CE-20 CRYOGENIC ENGINE IS NOW HUMAN RATED (FEB 2024)

- **Human rating** refers to rating a system that is capable of safely transporting humans.

- ISRO has achieved a major milestone in the human rating of its CE20 cryogenic engine which powers the cryogenic stage of the human rated LVM3 launch vehicle for Gaganyaan missions, with completion of the final round of ground qualification tests.
- The final test was carried out on Feb 13, 2024. It was the seventh in the series of vacuum ignition test carried out at High Altitude Test Facility at ISRO propulsion Complex, Mahendragiri, to simulate flight conditions.
- According to ISRO, the ground qualification tests for the human rating of the CE20 engine involved life demonstration tests, endurance tests and performance assessment under nominal operating conditions as well as off-nominal conditions w.r.t thrust, mixture ratio, and propellant tank pressure.
- **All the ground qualification test** of the CE20 engine for the Gaganyaan programme have been successfully completed.

B) GAGANYAAN FIRST FLIGHT TEST VEHICLE ABORT MISSION-1 (TV D-1) WAS SUCCESSFULLY ACCOMPLISHED (OCT 2023)

- The purpose of the TV-D1 mission was to **demonstrate the Crew Escape System** for the Gaganyaan program through a test vehicle demonstration in which the vehicle went up to a Mach number, which is slightly above the speed of sound, and initiated an abort condition for the Crew Escape System to function.
- **Outcome:** TV-D1 Mission was fully achieved and that the Crew Escape System (CES) performed as intended.



4) SHIVA SHAKTI

- **What happened?**
 - The IAU working group for Planetary System Nomenclature has approved the name '**Station Shiv Shakti**' for the landing site of Chandrayaan-3's Vikram lander. The approval was given on 19th March 2023.
- **About International Astronomical Union:**

- The International Astronomical Union (IAU) was founded in 1919. It's an **NGO** with mission to promote and safeguard the science of astronomy in all its aspects, including research, communication, education and development, through international cooperation.
 - The IAU consists of **Individual members**, who include both professional astronomers and junior scientists, and **national members**, such as professional associations, national societies, or academic institutions.
 - Its **individual members** – structured into Divisions, Commissions, and Working Groups – are **professional astronomers** from all over the world, at the Ph.D. level and beyond, who are active in professional research, education and outreach in astronomy. It also has junior members.
 - Among other tasks of the IAU are the definition of fundamental astronomical and physical constants, **unambiguous nomenclature** and informal discussions on the possibilities for future international large-scale facilities.
 - Further, the **IAU serves as international authority for assigning designations** to celestial bodies and **surface features** on them. This authority was also recognized by the United Nations in 1982 in **UN Resolution 13 on Extraterrestrial features names**.
 - The IAU also work to promote research, education, and public outreach activities in astronomy for the public.
- **How astronomical sites are named?**
 - **Why naming?**
 - According to the **Gazetteer of Planetary Nomenclature**, planetary nomenclature, like terrestrial nomenclature, is used to uniquely identify a feature on the surface of a planet or satellite so that it can be easily located, described, and discussed.
 - This gazetteer contains detailed information about all names of topographic and albedo features on planets and satellites (and some planetary ring- and ring-shaped systems) that the IAU has named from its founding in 1919 through the present time.
 - **IAU Rule 4** states: **"Solar system nomenclature** should be international in its choice of names. Recommendations submitted to the IAU national committees will be considered, but final selection of the names is the responsibility of the International Astronomical Union. Where appropriate, the [working group] strongly supports an equitable selection of names from ethnic groups, countries, and gender on each map; however, a higher percentage of names from the country planning a landing is allowed on landing site maps.
 - **IAU's Rule 9** states: "No names having political, military or religious significance may be used, except for names of political figures prior to the 19th century.
 - **Note:** The **Astrogeology Science Centre of the U.S. Geological Survey** maintains the Gazetteer of Planetary Nomenclature on behalf of the IAU with funding from NASA.
- **About Station Shiv-Shakti:**
 - In Aug 2023, PM Modi announced that the **point where the moon lander of Chandrayaan-3 touched** will be called 'Shiv Shakti'.
 - IAU has accepted this name.

- The citation for the name in the Gazetteers reads: “Compound word from Indian mythology that depicts the masculine (“Shiva”) and feminine (“Shakti”) duality of nature; Landing site of Chandrayaan-3’s Vikram Lander”.

5) SKYROOT SUCCESSFULLY TEST FIRES STAGE-2 OF VIKRAM-1 SPACE LAUNCH VEHICLE (MARCH 2024)

- About Skyroot Aerospace:

- » It is an Indian, private sector, space enterprise based in Hyderabad, Telangana, India. In 2020, when GoI announced opening up of the space sector, it became the first startup to sign an MoU with ISRO to launch a rocket.

- Rockets being Developed by Skyroot:

- » It is producing a series of Vikram Rockets named after Dr. Vikram Sarabhai. The goal is to launch small satellites using this rocket.
- » **Vikram-S**: In 2022, Skyroot created history by launching India’s first privately developed rocket Vikram-S.
 - It is a single stage sub-orbital rocket. It is India’s first privately developed cryogenic hypergolic liquid and solid fuel-based rocket engine. It was developed using advanced composite and 3-D printing technologies.
 - In its **first flight**, in Nov 2022, it carried three customer payloads in a sub-orbital flight. It was launched from the sounding rocket complex of the ISRO’s Satish Dhawan Space Centre in Sriharikota, Andhra Pradesh. It achieved a peak altitude of 89.5 kms and has met all flight parameters. This mission was called **Prarambh Mission**.
- » **Vikram-1** is being developed to carry 480 kg payload to Low inclination Orbit.
 - **In March 2024**, Skyroot has successfully test fired the Stage-2 of Vikram-1 space launch vehicle, called **Kalam-250**, at the propulsion test bed of the ISRO, at its SDSC, in Sriharikota, Andhra Pradesh.
 - Stage-2 is a critical stage for space launch vehicles as it carries the launch vehicle from atmospheric phase to the deep vacuum of outer-space.
 - **KALAM-250** is a high strength carbon composite rocket motor, which uses solid fuel and a high-performance Ethylene-Propylene-Diene terpolymers (EPDM) Thermal Protection System (TPS). It also houses a carbon ablative flex nozzle along with high-precision mechanical actuators for thrust vector control of the vehicle, which helps the rocket achieve the desired trajectory.
 - **Note**: EPDM is a durable material made to withstand the toughest conditions. It can withstand high temperature and abrasive chemicals.
 - The test also had an important contribution from Vikram Sarabhai Space Center (VSSC), which supplied its proprietary head-mounted safe arm (HMSA) for the test, used for the safe operation of the rocket stage.

- The Solid propellant in Kalam-250 was processed by Solar Industries at their Nagpur facility.
 - The test lasted for 85 seconds and recorded a peak sea-level thrust of 186 KN.
 - **Note:** Skyroot have already tested the stage-3 of Vikram-1 called Kalam-100 in June 2021.
 - **Note:** Vikram-1 is the first private orbital rocket launch.
 - **Testing of Stage-2** is a milestone for Indian Space Industry, marking the successful test of the largest propulsion system ever designed and developed by the Indian private sector so far.
 - **Skyroot** team expects to reach its maiden orbital launch of the Vikram-1 by 2024.
- » **Vikram-2** which will follow Vikram-1, will carry 595 kg to low inclination orbit.
 - » **Vikram-3** will carry 815 kg to Low inclination orbit.
- Skyrocket also says that the rockets will be able to undertake multi-orbit insertion and inter-planetary missions as well as offer “customized, dedicated and ride share options covering a wide spectrum of small satellite customer’s needs”.
 - **Significance of these initiatives**
 - » Step towards privatization in space sector. This will bring innovation and youthful energy in the sector and is also expected to increase investment.
 - » Huge future potential as the demand for launching small satellites is growing.
 - » Scope to increase India’s share in space sector. India’s current share in the space economy is only 2%. PM Modi has been calling it to be increased to 10%.

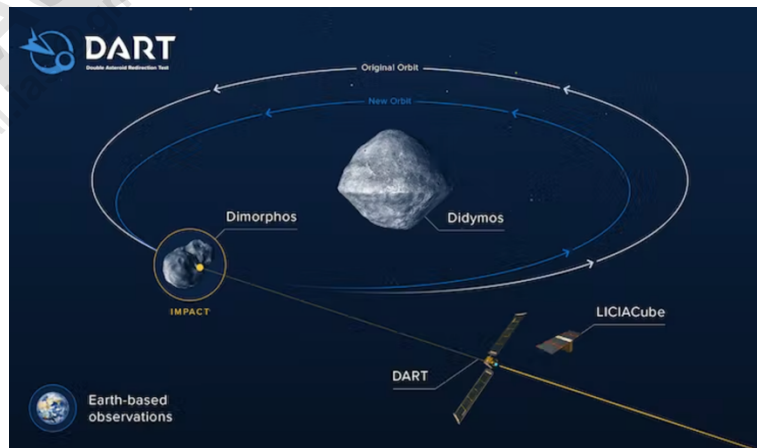
6) INTUITIVE MACHINE – 1 (IM-1) (ODYSSEUS): USA’S PRIVATE SPACECRAFT ODYSSEUS LAND ON MOON (FEB 2024)

- **Why in news?**
 - » US achieves first moon landing in 50 years with private spacecraft Odysseus (Feb 2024)
- **The Intuitive Machines 1 (IM-1, TO2-IM) mission objective** was to place a NOVA-C lander, called **Odysseus**, at Crater Malapert A near the south pole of the Moon.
 - » **Rocket:** The uncrewed mission was sent on its way to the moon atop **Falcon 9 rocket** launched by Elon Musk’s company SpaceX from NASA’s Kennedy Space Center in Cape Canaveral, Florida.
- **Success:**
 - » **Spacecraft Odysseus** built and flown by Texas-based company Intuitive Machines landed near the south pole of the moon. This is the first US touchdown on lunar surface in more than 50 years. Before this a US Spacecraft to land on Moon was **Apollo 17 in 1972**, when NASA’s last crewed moon mission landed there with astronauts Gene Cernan, and Harrison Schmitt.

- » This is the first ever achieved entirely by private sector.
- » This is also the first landing under NASA's Artemis lunar program. A host of small landers like **Odysseus** are expected to pave the way under NASA's Commercial Lunar Payload Services (CLPS) program, designed to deliver instruments and hardware to the moon at lower costs than the US Space Agency's traditional method of building and launching those vehicles itself.
- » The robotic lander is dubbed **Odysseus** and consist of six legs. It landed at a crater named Malapert A near the moon's south pole.
- **Payloads:** The vehicle is carrying a suite of scientific instruments and technology demonstration for NASA and several commercial customers **designed to operate for seven days on solar energy before the sun sets over the polar landing sites.**
- **Note:** So far, spacecrafts from only five countries have **landed on Moon** – USA, USSR, China, India and Japan.

7) DART MISSION CHANGED THE SHAPE OF DIMORPHOUS (MARCH 2024)

- **Why in news?**
 - Collision with NASA spacecraft altered shape of asteroid Dimorphos (March 2024: Source: TH)
- **Introduction**
 - DART is a **planetary defense-driven test of technologies** for preventing an impact of Earth by a hazardous asteroid.
 - Under this NASA launched a mission in Nov 2021, aboard Space X Falcon 9 rocket. It sent a space capsule of the size of a fridge towards an asteroid to shoot it off course. The target asteroids were 11 million kms away from Earth and DART mission reached here after 11 months of journey.
 - **Target Asteroid:**
 - DART's test target was an **asteroid (Diomorphos/Didymos B)** that passed the earth in 2022 and will come back two years later.
 - It's primary body (Didymos A) is approx. 780 meters across, its secondary body (or "moonlet") – Dimorphos/ Didymos B is about 160 meter in size, which is more typical of the size of asteroids that could pose the most likely significant threat to Earth.
 - NOTE: DART's target asteroid was **NOT** a threat to earth, and it is only a test mission.
 - In Sep 2022, this space capsule was crashed into Dimorphous/Didymos-B.
 - It used **autonomous targeting**, using images of the asteroids it acquires as it approaches. DART needed to recognize the asteroid itself, automatically lock onto Dimorphous, and adjust its trajectory to hit it. This is while it was moving at a speed of 24,000 km per hour.



- **Aim of the project:** Prepare to save earth from future threat of asteroids.
- **Technology**
 - » DART is the first mission to demonstrate the Kinetic Impactor Technique - striking the asteroid to shift its orbit - to defend against potential future asteroid impact.
- **Aim of this test:** Evaluate whether Kinetic Impactor technique can be used to deflect an object (Dimorphous/Didymos B) from its orbit.
- **Why Didymos system was chosen?**
 - Because it is a binary pair, it will be possible for astronomers on Earth to assess the results of the impact.
 - These asteroids pose no risk to Earth and have been chosen as the target for partly due to that fact.
- **How observations were made:**
 - Measurements from telescopes on Earth.
 - **LICIACube:** It is an Italian Space Agency CubeSat (a small type of satellite) that was deployed from a spring-loaded box aboard the craft on 11th Sep. LICIACube followed along and photographed the collision and its aftermath.
- **Outcome:**
 - For the first time, humans have demonstrated that it was possible to change celestial object's trajectory, if needed, to protect earth. The impact shortened Dimorphos' orbit time by 32 minutes.
 - » **Proof:** The test was a proof of concept for many technologies, that NASA has invested over the last few years.
 - **Collision** has also changed asteroid's shape.
 - » Before the DART encounter, the Asteroid was a bit plump in the waist, now appears to be shaped more like a watermelon – or, technically, a triaxial ellipsoid.
 - » Scientists say that the shape change was so dramatic because of its rubble-pile composition.
 - **DART** has also given some fascinating data about both asteroid properties and the effectiveness of a kinetic impactor as a planetary defence technology.

8) JAPAN'S SLIM (SMART LANDER FOR INVESTIGATING MOON)

- **Japan** has become the fifth country to land on Moon when its spacecraft SLIM landed on the Lunar surface in Jan 2024. Before this, USA, USSR, China and India had reached moon.
- **SLIM** (nicknamed **Moon Sniper**) is a lightweight spacecraft about the size of a passenger vehicle.
- It **aimed for a pinpoint target**. While most previous probes have used landing zones about 10 kms wide, **SLIM was aiming at a target of just 100 meters** (330 feet). It was a product of 2 decades of work on precision technology by Japan Aerospace Exploration Agency, JAXA.

- **Successful: Japan** has confirmed that its moon lander successfully achieved its pin-point landing on the moon on 19th Jan 2024

9) COSMIC MICROWAVE BACKGROUND RADIATION (CMBR)

- Cosmic Microwave Background (CMB) is a cooled remnant of the **first light** that could ever travel freely throughout the universe. This fossil radiation is the 'furthest that any telescope can see' and was released soon after the '**Big Bang**'.
- CMBR is electromagnetic radiation as a remnant from an early stage of the Universe in Big Bang Cosmology. It is an all-pervasive, but weak, electromagnetic radiation from early universe, when matter was still to be formed.
- **This radiation doesn't come from any of the object that we see in the universe around us** (like stars and galaxies). It is coming from the time when these things were still to be formed. Thus, they are relic from an early universe when matter and radiation were in Thermodynamic Equilibrium.
- It was first discovered in 1964 and since then has emerged as an **important source of information on the early universe**.
- **Spectrum of CMBR**
 - Spectrum produced by CMB **is very smooth**. It does, however, contains some wiggles, or deformities, in its shape.
 - These wiggles encode information about specific events that can be expected to be found from in the CMB spectrum in different scenarios.
 - It is believed that the neutral hydrogen pervading the cosmos during dark ages absorbed some of the CMB radiation to produce an **extremely small dip in the frequency of spreading radio waves**.
 - **Thus far** theory and actual observations of CMB spectrum have matched perfectly.
- **Key things that scientists have learned from CMBR.**
 - From CMBR, scientists have inferred that the **early Universe was filled with hot, dense and extremely uniform gas, mostly hydrogen** and that the first stars were formed when these blobs of gases came together. That is when visible light also made its first appearance. Scientists refer this phase as **cosmic dawn**.
 - It also gives evidence that **Universe expanded from an initial violent explosion**. Cosmic Microwave radiation have become less energetic due to the redshift which also gives evidence of expanding universe.

10) SOME TELESCOPES PLANNED ON THE FAR SIDE OF THE MOON TO STUDY COSMIC MICROWAVE BACKGROUND (CMB) RADIATION (APRIL 2024)

- **Need:** Terrestrial telescopes can't properly detect the frequency drop in the CMB radiation.
- **Advantages of placing telescopes on the far side of the moon (rather than on earth)**
 - » **No atmosphere:** On earth, the telescope has to peer through layers of atmosphere.
 - » **No pollution or artificial lighting:** On earth, it is becoming difficult for telescope to see through pollution or artificial lighting.
 - » **Long night of Moon:** On moon, one night lasts 14 days thus ensuring dark skies for observation for longer period.
 - » **Earth's ionosphere** also blocks radio waves from reaching earth. And an orbiting telescope also receive radio noise from the whole planet along with signals from outer space.
- **Therefore, scientists are seriously considering an idea they have toyed with since the 1950s:** Placing optical and radio-telescopes on the far side of the moon, which always faces away from earth.
- **Different agencies working towards sending satellite on far side of the moon:**
 - » **NASA-Berklee Joint Project – LuSEE Night** (Lunar surface electromagnetic Experiment): It is scheduled for launch in Dec 2025 and will launch on the far side of the moon and almost exactly opposite from the earth. This location is useful because it best shields radio frequency noise coming from the earth.
 - » **NASA's Long Baseline Optical Imaging Interferometer** is scheduled to be launched in parts before this decade is out.
 - » **China** also plans to send a moon orbiting radio telescope scheduled for launch by 2026.
 - » India's **PRATUSH** (Probing ReionizATIOn of the Universe Using Signal from Hydrogen) plans to orbit the moon and study the background radiation when it is on the far side of the moon. The telescope is being built by Raman Research Institute (RRI) in Bengaluru with active collaboration from ISRO.
 - Initially, ISRO will be put around earth. After some fine-tuning, the space agency will launch it moonward. It will carry a wideband frequency-independent antenna, a self-calibrating analog receiver and a digital correlator to catch radio noise in the all-important signal from the Dark ages.

11) MOONS IN SOLAR SYSTEM

- **How Many Moons are there in our Solar System**
 - » According to the latest data by NASA, planets together have 293 confirmed moons now.
 - **Saturn (146) and Jupiter (95)**, with total 241 account for more than 80% of these.
 - **Uranus (28) and Neptune (16)** are other planets with a greater number of Moons.
 - **Mars (2) and Earth (1)** are other planets with Moon in the solar system.
 - **Pluto** (It is a dwarf planet and not planet) also have five moons.
 - » **Why this kind of distribution?**

- **Mercury** is too close to sun and its gravity will not be able to hold on its own moon. The moon there would crash into Mercury or start orbiting around Sun.
 - Scientists are **not yet sure about why Venus doesn't have a moon.**
- » **Moons are classified into two separate categories.**
 - **Regular Moons:** Moons which have prograde orbits (they orbit in the direction of the planet rotation) and lie close to plain of their equators.
 - **Irregular Moons** can have pro or retrograde orbits and often lie at extreme angles to the planet's equators. Irregular moons are probably minor planets that have been captured from surrounding space. Most irregular moons are less than 10 kms in diameter.
- **Important Moons**
 - » Largest: **Ganymede** (Jupiter), Titan (Saturn), Callisto (Jupiter) etc.
 - » **Note:** Ganymede (though a moon) is bigger than Mercury and Pluto.

- **Number of Moons by dwarf planets:**

Dwarf Planet	Number of Moons
Ceres	0
Pluto	5
Haumea	2
Make make	0
Eris	1

A) GANYMEDE

- **About Ganymede:**
 - » It is the largest moon of our solar system, larger than planet Mercury and dwarf Planet Pluto. It is the **only natural moon in the solar system with a known magnetic field.** The magnetic field causes auroras.
 - » It's an ice-covered world that may hold more water than all the earth's water combined. But unlike Earth, Ganymede's oceans are below its 100-mile-thick icy crust.
- **Details of Water Vapor at Ganymede:**
 - » Astronomers using archival data from NASA's Hubble Space Telescope found evidence of water vapor in the thin atmosphere of Jupiter's Moon Ganymede. This water vapor may have come from sublimation of ice occurring on the surface of the moon.

B) CALLISTO

- **Why in news?**

» An international team of scientists, including from India, has discovered strong evidence indicating the presence of ozone on Jupiter's Moon Callisto. (March 2024)

- **About CALLISTO:** Callisto is the 2nd largest moon of Jupiter (3rd largest of the solar system). More than its size, it is distinguished by its composition. Despite being as big as planet mercury, it is half as much mass. It is primarily composed of water ice, rocky materials, sulphur dioxide, and some organic compounds. These substances make moon a potential candidate for supporting life in the Solar System beyond the earth.
- **A study was published in March 2024** issue of the journal Icarus. It outlines the researchers' investigation into the chemical evolution of "SO₂ astrochemical ice", which is ice primarily composed of SO₂ in the presence of ultraviolet irradiation. This shed light on the chemical process and composition on the surface of Callisto. By analyzing the data of the UV absorption spectra of the irradiation ice samples, the team was able to identify a distinct signature indicating the formation of ozone.
- **Significance of Ozone:** the presence of ozone is crucial for life to exist. In the absence of ozone layers, UV-B and UB-C radiation reaching the surface will make the possibility of life less probable.
 - » The discovery of ozone also suggests presence of oxygen, which in turn is a fundamental ingredient required for the formation of complex molecules, required for life (as we know it), such as amino acids, raising question about moon's habitability. This extends to other icy moons in our Solar System, potentially informing our understanding of habitable conditions beyond Earth.

12) BINARY STARS EATING THEIR OWN PLANTS

- **Why in news?**
 - » A study of 91 pairs of stars finds that about 8%, or 1/12, swallowed up a planet at some point in their lives (March 2024)
- **Understanding Twin Stars (Or Binary Stars):**
 - » A binary star or binary star system is a system of two stars that are gravitationally bound to and in orbit around each other. Binary stars in the night sky that are seen as a single object to the naked eye are often resolved using a telescope as separate stars, in which case they are called visual binaries.
 - » Stars in binary system don't necessarily have the same mass, size or brightness. The larger star of a binary couple is called the primary star, while the smaller one is known as the secondary star or the companion star.
 - » **Note: Binary stars are not rare.**
 - » It is estimated that around 85% of stars exist in binary star systems or systems with three or more stars. Single stars account for just 15% of all stars.

- **Twin Stars** born at the same time should have a virtually identical composition, as they are both born from the same parent cloud of gas and dust.
 - » Any major chemical differences between these so-called “co-natal” stars may thus be a sign that one devoured a world.
- **A new study** by researchers used the European Space Agency’s Gaia satellite to identify 91 pairs of stars.
- **How is composition of a star understood?**
 - » Within each travelling pair, the stars sit relatively close to one another – less than a million astronomical unit apart – and are likely co-natal. Scientists analyzed lights coming from distant stars. When molecules are heated, they give off unique spectrum of light wavelengths corresponding to the element’s they are made up of. Scientists analyzing light coming from distant stars can therefore deduce the stars’ elemental composition as stellar molecules are exposed to very high temperatures.
 - » The scientists utilized the European Southern Observatory’s Very Large Telescope in Chile, the Magellan Telescope, also found in Chile, and the Keck Telescope in Hawaii to analyze the light from these co-natal stars. They found that about 8% of these pairs – about one in 12 – had one star that displayed signs it had engulfed a planet. In other words, its chemical makeup differed from its twin.
 - » **Note:** The study was analyzing stars in their prime phase engulfing the planets (not the Red-Giant phase) engulfing the planet.
- **Significant Understanding:** Stable Planetary Systems like our own solar system might not be a norm.

13) HIGH ALTITUDE PSEUDO SATELLITES (HAPS)

- **Why in news?**

Why India wants to develop high-altitude pseudo-satellite vehicles, powered by the Sun (Feb 2024)
- **In Feb 2024**, the Bengaluru based **National Aerospace Laboratories (NAL)** successfully flew a prototype of new generation unmanned aerial vehicle (UAV). It is being seen as a huge breakthrough as it can fly at Great Heights, about 20 km above ground and runs entirely on Solar Energy. It can also remain in the air for months on end. Such UAV belong to the class of flying objects called HAPS, or High-Altitude Pseudo Satellite Vehicles, or **HALE** High Altitude Long-endurance vehicles.
- **Uses of HAPS/HALS:**
 - Surveillance and Monitoring
 - Disaster Management
- **Advantages of HAPS over UAVs and Satellites.**

- **UAVs are battery powered** and thus can't stay in air for long duration.
- **Drones** fly at **relatively low height**, and thus their vision is restricted to small areas.
- **Satellites** in LEO move very fast and thus can't continuously watch the same point and Satellites in Geo stationary orbit are too expensive for these purposes and are very far to give a clear picture of ground.
- **HAPS** will overcome these challenges.
- **HAPS technology** is still under development. Several countries, and companies, have developed and flown such vehicles with encouraging success, but none has mastered the technology yet. The world record for a vehicle of this class is held by the **Airbus-manufactured Zephyr**, which flew for continuously 64 days in 2022 before crashing.
- **What about prototype tested by NAL?**
 - It flew for 8.5 hours. Next time, NAL wants to go for 24 hours. The full-scale machine that NAL is planning to build by 2027, would be aiming to remain in the air for 90 days at a stretch.
- **HAPS** is another technology where India is entering the race at a relatively early stage.

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