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Daily News Analysis

The Hindu Important News Articles & Editorial For UPSC CSE

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SpaDeX is an upcoming mission by ISRO to demonstrate in-space docking technology.

- It involves two satellites that will dock and undock in orbit, crucial for India's future space station and advanced space operations.

WHAT IS IT?

SpaDeX: meeting in space

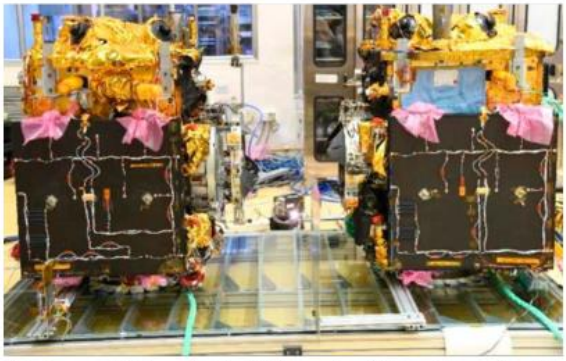
SpaDeX is the name of a new mission to be flown by the Indian Space Research Organisation (ISRO). During the mission, two satellites will be launched into orbit around the earth, where they will demonstrate technologies to dock and undock while in motion.

ISRO needs to master in-space docking so that satellites launched in separate rocket launches can link up to perform more sophisticated tasks. The technology will be essential for the 'Bharatiya Antariksh Station,' a new India-made space station ISRO has begun work on.

If the SpaDeX test is successful, India will become the fourth country in the world to have a space programme capable of docking in space. The satellites for the SpaDeX mission will be launched onboard the PSLV C60 mission. The launch is expected to happen on December 30, 2024.

Each of the spacecraft weighs about 220 kg. The rocket will launch them simultaneously but independently into a 470-km-wide circular orbit at a 55° inclination, with a local time cycle of about 66 days.

The docking manoeuvre will be SpaDeX's primary objective.



The two satellites, dubbed 'Chaser' and 'Target', involved in the ISRO SpaDeX mission. ISRO

Once it has been accomplished, the two satellites will proceed to the secondary objectives: "the transfer of electric power between the docked spacecraft, which is essential for future applications such as in-space robotics, composite spacecraft control, and payload operations after undocking," per an ISRO statement.

With agency inputs

-The Hindu Bureau

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SpaDeX Mission:

- SpaDeX is a mission by the Indian Space Research Organisation (ISRO) focused on mastering in-space docking technology.
- The mission involves launching two satellites into orbit, where they will demonstrate docking and undocking while in motion.
- This technology is crucial for future space operations, enabling satellites launched separately to link up and perform complex tasks.
- The SpaDeX mission is a key step towards the development of the 'Bharatiya Antariksh Station,' India's upcoming space station.
- Upon successful completion, India will join the select group of countries capable of performing space docking, becoming the fourth country globally.
- The two spacecraft, each weighing 220 kg, will be launched together on the PSLV C60 mission, scheduled for December 30, 2024.
- They will be placed in a 470-km-wide circular orbit at a 55° inclination.
- The mission's primary goal is to demonstrate the docking maneuver, with secondary objectives including power transfer between the spacecraft.

PYQ : UPSC Mains : 2023

Ques : "What is the main task of India's third moon mission which could not be achieved in its earlier mission? List the countries that have achieved this task. Introduce the subsystems in the spacecraft launched and explain the role of the 'Virtual Launch Control Centre' at the Vikram Sarabhai Space Centre which contributed to the successful launch from Sriharikota."

Recent studies have revised the minimum mass of dark matter particles, suggesting a higher threshold than previously thought.

In big update, minimum possible mass of dark matter particles revised

In 1922, Jacobus Kapteyn estimated the density of dark matter. Since then, a century of sophisticated measurements has held up the figure. It's equal to the heft of two protons per teaspoon, which means your house could contain dark matter with a mass equivalent of a trillion protons — but herein lies the rub

Nirmal Raj

Dark matter is an enigmatic, invisible substance supplying five-sixths of the matter of the universe. Unlike photons, the particles of light and the particles of dark matter need to have non-zero mass, or else the dense and intricate structure of matter on cosmic scales will not form.

How light can a dark particle then be? For decades, scientists thought this minimum mass was about 10^{-31} times the mass of a proton. But in May this year, theoretical physicists revised the limit and pushed it up by an order of magnitude to 2.3×10^{-30} proton masses. This is a significant update in the world of dark matter.

Uniformly or in lumps?

To understand these numbers and their importance, let us first build a mental picture of dark matter. Dark matter is said to be everywhere in the universe. Does that mean it is in your house? In 1922, Dutch astronomer Jacobus Kapteyn studied the motion of stars neighbouring the Sun and concluded the density of "dark matter" (using that term for one of the first times) must be 0.0003 solar masses per cubic light year.

Since then, through a century of increasingly sophisticated measurements, the accuracy of Kapteyn's conclusion has held up remarkably well. This density of dark matter can be re-expressed as the heft of two protons per teaspoon, which means your house could contain dark matter with a mass equivalent of a trillion protons.

But this would also be naïve: Kapteyn's and subsequent measurements are only valid when regarding the million-cubic-lightyear volume and don't apply when we zoom in for a closer look. This is because stars, whose motion is used for the measurement, are themselves separated by a few light years. Whether or not dark matter is present on smaller length scales would depend on how it is distributed: either uniformly or in lumps.

An occasional visitor?

Let's assume it is spread around like fine flour, which the standard theories of cosmology also predict. If it comes in lumps, the spacing between them may be as large as many light years, and there will perhaps be no dark matter under your roof.

Now, since we know the local density of dark matter, the value of the unknown mass of the dark particle will determine the separation between two neighbouring particles. If it is 100 proton masses, the inter-particle separation will be 7 cm. Then dark particles at any given moment will not only be in your house but also in your head.

If dark matter is made of an elementary particle, the heaviest it can be is about 10^{19} times a proton's mass. In that case the interparticle separation would be 30 km. So dark matter won't be a resident of your house but will visit occasionally (since the particles travel randomly at around 300 km/s).

Then again, a 10^{20} gram agglomerate of dark particles would be apart by more than the size of the solar system, reducing our chance of discovering them.

Fluid rather than a flock

What about small masses? At 10^{-11} proton masses, every red blood cell in your body will contain a dark matter particle. But now quantum physics becomes important. Every object is also a wave, with its wavelength given by the inverse of its momentum. Thus the lighter a dark matter particle is, the larger its wavelength will be. For 10^{-11} proton masses, the wavelength will be about 2 cm, much larger than its micrometre interparticle separation.

So for small masses, we must picture a collection of dark particles as a fluid rather than as a flock of grains.

It's not every day that particle physics gets to redraw a fundamental goal post by an order of magnitude. And it is a sign of our times that this could only have been done with computers as opposed to a blackboard

If we now dial the mass of a dark particle all the way down to 10^{-31} proton masses, the wavelength is 200 light years, about the size of a dwarf galaxy. The substance of a dwarf galaxy is chiefly in the form of dark matter, with only about 1% contribution from stars. This simple fact translates to a restriction on the dark matter particle's mass: it must be greater than 10^{-31} proton masses. If it were lower, its spatial extent would exceed the dwarf galaxy, and we can't form a macroscopic object smaller than its microscopic constituents.

The time of computers

This is where the paper from May matters. Its authors have shown that this lore is too simplistic and that researchers can do something sharper. First, using data on how stars move in Leo II, a dwarf galaxy orbiting the Milky Way, they inferred the dark matter density in it as a function of the distance from its centre. This density profile isn't unique due to measurement uncertainties, so they generate a set consistent with the stellar data. Next, they numerically solved the Schrödinger equation after modifying it to account for gravity and obtained an ensemble of density profiles. Finally, they carried out a statistical procedure to match the two sets of density profiles – the empirical one from observing Leo II and the theoretical one from solving the equation.

Their key finding here was that the inner regions of Leo II contained more invisible mass which dark particles of 10^{-31} proton mass couldn't account for. Thus they surmised heavier particles are needed to accommodate the inner crowding.

It's not every day that particle physics gets to redraw a fundamental goal post by an order of magnitude. And it is a sign of our times that this could only have been done with computers as opposed to a blackboard.

(Nirmal Raj is an assistant professor of theoretical physics at the Centre for High Energy Physics in the Indian Institute of Science, Bengaluru. nraj@iisc.ac.in)

A Hubble Space Telescope view of the galaxy NGC2985. The evidence for dark matter emerged in the 1970s when astronomers found an unusual pattern in the rate at which stars in a galaxy rotated the farther they were from the centre. JUDY SCHMIDT/NASA

THE GIST

Scientists thought the minimum mass of dark matter was about 10^{-31} times the mass of a proton. But in May, theoretical physicists revised the limit and pushed it up by an order of magnitude to 2.3×10^{-30} proton masses

If the mass of a dark particle is 10^{-31}, the wavelength is 200 light years, about the size of a dwarf galaxy, which is chiefly dark matter. This restricts the dark matter particle's mass. It must be greater than 10^{-31}. If it were lower, its spatial extent would exceed the galaxy

Researchers inferred the dark matter density in Leo II.They matched the two sets of density profiles — empirical and theoretical. They found that Leo II contained more invisible mass, which dark particles of 10^{-31} proton mass couldn't account for

- This finding, based on the analysis of the Leo II dwarf galaxy, challenges earlier assumptions about dark matter's distribution.
- The study emphasizes the need for heavier particles in certain regions.

Dark Matter Distribution

- Dark matter is distributed throughout the universe, but it is not evenly spread.
- In 1922, astronomer Jacobus Kapteyn suggested a dark matter density of 0.0003 solar masses per cubic light year, which equates to two protons per teaspoon.
- However, this measurement applies only to large-scale volumes (like millions of light-years), not smaller scales like inside a house.
- The distribution could either be uniform or in lumps, with varying spacings between dark matter particles depending on their mass.

Dark Matter and Its Mass Limit

- Dark matter is an invisible substance that makes up five-sixths of the universe's matter.
- It must have non-zero mass to allow for the formation of the dense structure of matter on cosmic scales.
- For decades, the minimum mass of dark matter particles was thought to be 10-31 times the mass of a proton.
- However, in May 2024, this limit was revised upward to 2.3 × 10-30 proton masses.

The Impact of Particle Mass

- If dark matter particles are heavy (around 100 proton masses), they would be spaced by around 7 cm, possibly existing within your house.
- Heavier particles (up to 10-19 proton masses) would have spacings of 30 km, with dark matter particles occasionally passing through a house.
- For lighter particles (10-31 proton masses), the wavelength is larger, up to 200 light years, which would affect how dark matter interacts with dwarf galaxies.

Findings from New Research

- A May 2024 study used data from the dwarf galaxy Leo II to infer dark matter density and discovered that particles of 10-31 proton masses could not account for the observed mass in the galaxy's inner regions.
- This suggests the need for heavier particles to explain the dense mass in those areas.

PYQ : UPSC Prelims : 2015

Ques : "In the context of modern scientific research, consider the following statements about 'IceCube', a particle detector located at the South Pole, which was recently in the news:

1.It is the world's largest neutrino detector, encompassing a cubic kilometre of ice.

2.It is a powerful telescope to search for dark matter.

3.It is buried deep in the ice.

Which of the statements given above is/are correct?

(a) 1 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

Ans : d)

Page : 11 : GS 3 : Science and Technology

A speed gun measures the speed of moving objects using electromagnetic radiation and the Doppler effect.

Quick action: Traffic police have started using speed guns to crack down on speeding vehicles in Puducherry in September, 2023. S.S. KUMAR

The principle behind the working of a speed gun, used for motion tracking

A speed gun is a device to measure the speed of a moving object without having to be in contact with the object. Speed guns are widely used by law enforcement officials to monitor traffic speed, by coaches to gauge the performance of their athletes, and in various other industries

Amartya Srinivasan
Vasudevan Mukunth

The world of today is a world in motion. People constantly want to get somewhere. The heavens are filling up with satellites, our skies with airplanes and rockets, our seas with ships and submarines, and our land with cars, bikes, and trains. Humans have developed laws, rules, technologies, and subsequently entire industries to make sure all these vehicles move smoothly, without harming humans or each other. A small but significant piece of this picture is the speed gun.

What is a speed gun?

A speed gun is a device to measure the speed of a moving object without having to be in contact with the object. To achieve this, the device bounces electromagnetic radiation of a specific frequency off the object, capturing the reflection and using the Doppler effect to infer the object's speed. Speed guns are electronic, and use complex circuitry to emit the radiation used to make the measurement.

These devices are widely used by law enforcement officials to monitor traffic speed, by coaches to gauge the performance of their athletes, and in various other industries in need of accurate motion tracking.

What is the Doppler effect?

The Doppler effect is named for the Austrian physicist Christian Doppler and relies on the simple concept of relative velocity. Say there's a man sitting at the centre of a field blowing a whistle. The sound waves move out in a circular, concentric pattern with the whistle at the centre, and evenly spread out. A woman standing at the edge of the field will receive these waves at frequent intervals – as and when the waves' crests reach her. (Since sound waves move at 343 m/s in air, human ears can't hear the gaps.)

Each wave has a frequency and a wavelength. A higher frequency produces a higher pitch and vice versa.

Now, say the whistling man is moving around the field on a buggy. If the buggy is moving towards the woman, the waves in front of the vehicle become bunched up. In other words, from the woman's perspective, the waves would have acquired both the speed of the buggy in addition to the speed of the sound wave. Thus the waves will reach the woman more frequently, and she will perceive a higher pitch. (For the same reason, the sound will have a lower pitch in a direction behind the buggy.)

This is why, when a train moves into a station, people on the platform will hear the horn blowing at a higher pitch than when the train is leaving the station. This effect is the Doppler effect.

The speed gun was originally developed during World War II for military use and applies the effect using radio waves rather than sound waves. A speed gun has a radio transmitter and a receiver. The transmitter emits radio waves, which the person holding the speed gun can direct at an object. The receiver collects the waves reflected by the object back in the direction of the speed gun.

If the object is approaching the speed gun, the frequency of the returning waves will be slightly higher than that of the transmitted waves. A simple computer in the gun can deduce the object's speed based on this difference.

How are the speed and the effect linked?

All electromagnetic waves have a fixed speed – equal to the speed of light in that medium. In vacuum, this value is denoted c: 299,792,458 m/s. Any change in the frequency the speed gun detects directly corresponds to the Doppler shift caused by the object's motion. This principle is powerful because it allows the speed gun to work accurately over a wide range of distances and velocities without being affected by air resistance.

A speed gun can calculate the speed of a moving object by multiplying the difference (between received and emitted frequencies) with c and dividing by the emitted frequency times 2.

This relationship shows how the difference is directly proportional to the speed of the object: the faster it moves, the more pronounced the difference will be. In other words, the only condition is that the object should be moving much slower than the speed of light – which is the case in most, if not all, practical applications of the speed gun.

Do speed guns have shortcomings?

The technology to emit radio waves is ubiquitous today. The principle is simple: when an antenna is excited by an alternating current with a radio-wave frequency, it emits radio waves. Radio-wave frequency is in the range of 30 Hz to 300 billion Hz.

For a long time, the equipment to produce the waves was bulky. This changed when scientists invented transistors in the 1940s. Electronic circuits built using transistors considerably simplified the process of producing radio waves and also made the transmitters much smaller.

However, radio waves have intrinsic shortcomings that transmitters can't fully adjust for. For example, radio waves diverge as they move through the air. If an antenna is 5 cm long, the waves it emits will diverge by 22° to either side, producing a beam that is 44° wide overall.

Such a beam could strike more than one moving vehicle and produce inaccurate speed readings.

A continuous-wave radar – which emits radio waves and tracks their reflections continuously – may also produce readings due to multiple vehicles.

Engineers have developed systems to compensate for these errors but the resulting setups have been more sophisticated and more expensive.

For such reasons, LIDAR speed guns have been replacing radar counterparts. The name is short for 'light detection and ranging'. LIDAR uses laser light instead of radio waves; the gun's operation is otherwise similar. Laser light has very low divergence and thus offers better targeting.

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- It has applications in law enforcement, sports, and other industries.
- While effective, its limitations in accuracy have led to the use of LIDAR technology.

What is a Speed Gun?

- A speed gun is a device that measures the speed of a moving object without physical contact.
- It uses electromagnetic radiation, typically radio waves, which bounce off the object to calculate its speed using the Doppler effect.
- Speed guns are commonly used by law enforcement, sports coaches, and various industries to track motion accurately.

The Doppler Effect

- The Doppler effect, discovered by Christian Doppler, describes the change in frequency of waves due to the relative motion between the source and the observer.
- As a moving object approaches, the frequency of waves (like sound or light) increases, creating a higher pitch; as it moves away, the frequency decreases, resulting in a lower pitch.
- This effect is used in speed guns to calculate the speed of moving objects based on the shift in frequency of the waves.

How Speed Guns Work

- Speed guns emit radio waves, which are reflected by the moving object.
- The frequency difference between the emitted and reflected waves is used to determine the speed of the object.
- The speed is calculated using the formula: (frequency difference * speed of light) / (2 * emitted frequency).
- The speed of light in a medium is constant, allowing for accurate speed measurement over long distances.

Limitations of Speed Guns

- Radio waves emitted by the gun diverge as they travel, potentially causing inaccurate readings if multiple objects are within the radar's beam.
- Continuous-wave radar can result in errors due to reflections from multiple vehicles.
- LIDAR speed guns, which use laser light instead of radio waves, offer improved accuracy with minimal beam divergence, overcoming these limitations.

India faces a significant broadband penetration gap, hindering its digital growth.

Will satellite broadband services truly be a game-changer?

As the race to provide satellite Internet heats up, questions on cost, pricing, spectrum allocation, viability and potential pop up; back in India, Forrester Research said satcom may be dead by the time it arrives in 2025, stating companies may be hard pressed to compete in terms of pricing

NEWS ANALYSIS

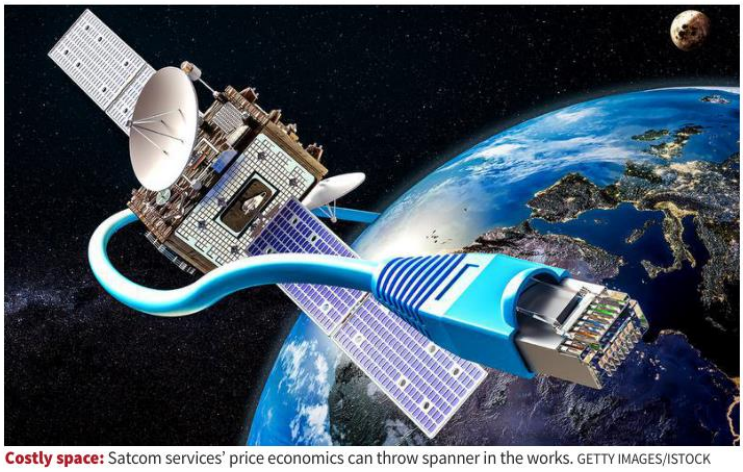
Vallari Sanzgiri

India is 48% lacking in terms of broadband penetration today, even after 25 years of terrestrial mobile services. If we continue to behave the way we are (blocking the entry of new players), we will remain in this state for another 25 years and Viksit Bharat can go out of the window – Debashish Bhattacharya, Senior Deputy Director General, Broadband India Forum (BIF)

"What they want is that existing operators pay for this spectrum through the nose, invest a lot of capex but the new operator should be given a red carpet, free spectrum to start competing. This kind of demand should not have come." – Ravi Gandhi, regulatory executive, Reliance Jio Infocomm Ltd.

The race to provide satellite broadband connectivity in India is leading to some fiery exchanges. Mr. Gandhi and Mr. Bhattacharya were but two of the voices heard during the Telecom Regulator of India's (TRAI) open house discussion in November. The heated discussions centred over spectrum allocation for satellite-based communication (satcom) services.

There are a whole set of other discussions too on satcom starting from cost, pricing, spectrum allocation to even voices asking about if was really viable.



Costly space: Satcom services' price economics can throw spanner in the works. GETTY IMAGES/ISTOCK

Answer to digital divide

Lt. Gen. A.K. Bhatt (retd.), Director General, Indian Space Association (ISpA) takes on the question on the need for satcom. "It can overcome the digital divide in difficult geographies where the cost of putting fibre is too high. Satellites are like fibre in space. In urban areas, it is useful for backhaul services, for additional capacities." Satcom technology connects various points on the Earth using the satellites orbiting in space, able to reach remote hinterlands of the world.

On the issue of spectrum allocation, the feelings run high because of the enormous investments gone in. A KPMG report of 2023 stated satcom had reached a valuation of $2.23 billion and was predicted to reach $20 billion by 2028. Even legacy telcos like Bharti Airtel Ltd. referred to the "lakhs of crores of rupees" of investment made by them over the past three decades. It is this investment that made the legacy players push for auction of spectrum, citing concerns of an uneven playing field and undue advantage to new players like Elon Musk's Starlink or Amazon's Kuiper.

> A KPMG report in the year 2023 stated that satcom had reached a valuation of $2.23 billion and was predicted to reach $20 billion by the year 2028

Administrative method

Meanwhile, those against the idea of auction point out that world over spectrum is authorised by the administrative method. For now, it appears the government is leaning in favour of allocating spectrum. Yet, it is worth asking whether the technology deserves all the fanfare considering satcom is to be complementary to existing fibre or wireless connections rather than compete with existing services. Even Sateliot, one of the first satellite operators based in Spain to offer IoT connectivity, has been working since 2018 and is only hoping to go commercial in 2025.

In the U.S., companies like AT&T state that satellites can complement the existing terrestrial services but not work in isolation. As it explained in an investor call, ""For a customer to only use satellite-based service, one needs enough satellites in space that are engineered with that amount of radio frequency. Also, the antenna array of those satellites needs to be large and strong enough to ensure the level of service a customer expects. The cost per bit is also very high currently for satellite-based services to make it operationally viable."

Hence, AT&T plans to offer satellite as a complementary to fiber/wireless service to its customers. This is a company that has so far launched five commercial satellites, called BlueBirds.

Use cases, potential

Back in India, Forrester Research has stuck its neck out and said that satcom may be dead by the time it arrives in 2025, stating while many companies are warming up to the idea of satcom, they will be hard pressed to compete in terms of pricing. The research firm predicted that its use cases in India will be limited to aviation, shipping, connecting remote locations, NDMA.

"Considering the 5G coverage in India is widespread, the space that we have for satellite coverage to grow is very limited. The second thing, if you look at the space, it is price economics. If you come to retail, things start to fall apart. In Kenya, when Starlink launched, it struggled to get any customers. In one or two years, they got around 4,500 customers. In India, customers are equally pricey. It's very, very difficult for something like this to grow," said Ashutosh Sharma, VP and research director, Forrester.

However, Pranav Roach, president of Hughes Network Systems India Ltd. disagreed stating that even in the U.S., satellites still accounts for 20-25% of the network utilisation.

"From a consumer point of view, availability increases tremendously. So, there will be a significant uptake for satcom. But it will coexist with other technologies. Technical feasibility and cost is a function of the options available and what you need to do in case of an emergency.

"Right now, we're still waiting for rules from TRAI for spectrum allocation. Once that comes out, we can determine the cost and prices," said Mr. Roach.

Similarly, Sateliot, said satcom as an affordable solution could prove to be a game-changer for India.

(The writer is with The Hindu businessline)

- The ongoing debate over spectrum allocation for satellite-based communication (satcom) has sparked concerns among legacy telecom operators and new satellite players.

- While satcom is seen as a potential solution for remote areas, challenges related to cost and competition persist.

Current State of Broadband Penetration in India

- India is currently facing a broadband penetration gap of 48%, despite 25 years of terrestrial mobile services.
- The lack of progress in expanding broadband services could persist for another 25 years if the regulatory environment remains unchanged.

Debate on Spectrum Allocation for Satcom

- The allocation of spectrum for satellite broadband services has sparked heated debates.
- Legacy telecom operators are opposing new players, like satellite broadband companies, receiving preferential treatment regarding spectrum access.
- Some industry players argue for the auctioning of spectrum to ensure fair competition, given the substantial investments made by existing telecom companies over the years.
- Others suggest that spectrum should be allocated administratively, as is the common practice globally.

Satcom as a Solution to the Digital Divide

- Satellite communication (satcom) is seen as a potential solution to bridge the digital divide, especially in remote areas where the cost of laying fibre is prohibitive.
- Satcom can complement urban services by providing additional capacity for backhaul services.
- Satellites offer connectivity in areas that terrestrial networks cannot reach, making them particularly valuable for remote locations in India.

Global Perspective on Satcom

- Internationally, companies like AT&T view satellites as a complementary service to existing terrestrial services rather than a replacement.
- A significant number of satellites and a robust infrastructure are necessary to deliver consistent satellite service.
- The cost per bit for satellite-based services remains high, making them less viable for standalone use.
- AT&T plans to integrate satellite services with fiber and wireless services to offer customers a comprehensive connectivity solution.

Satcom in India

- **Challenges for Satcom in India**
  - Despite optimism for satcom in India, several challenges hinder its widespread adoption.
  - A research firm predicts that satcom could struggle in India due to pricing issues and competition with existing services like 5G.
  - Satcom's potential use cases in India are likely to be limited to aviation, shipping, remote locations, and emergency services.
  - For example, when Starlink launched in Kenya, it struggled to attract customers due to high pricing, a trend that could be repeated in India.
- **Potential for Satcom in India**
  - Despite challenges, there is potential for satcom to play a role in India's digital ecosystem.
  - Satcom could offer substantial improvements in availability and network utilization, especially in rural and remote areas.
  - It will likely coexist with other technologies, such as fibre and wireless, providing more options for customers.
  - However, the success of satcom depends on spectrum allocation rules and the ability to address the cost challenges.

Conclusion

- The future of satcom in India remains uncertain but promising.
- Regulatory decisions on spectrum allocation will determine whether satellite broadband can contribute to expanding India's digital infrastructure, particularly in underserved regions.
- While challenges remain, satcom is expected to complement existing services rather than replace them, contributing to a more connected India in the long term.

PYQ : UPSC Prelims : 2021

Ques : Discuss the importance of digital infrastructure in bridging the socio-economic disparities in India. How can broadband penetration play a pivotal role in this regard?

In News : Panama Canal

US President Donald Trump accused Panama of unfairly charging the US for using the Panama Canal.

- In a post on Truth Social, he threatened a potential US takeover of the canal if Panama did not comply, labeling the situation a "rip-off."
- Trump also criticized former President Jimmy Carter for "giving away" the canal in 1977 and expressed concerns about China's involvement in Panama's infrastructure, linking it to the Belt and Road Initiative.

Analysis of News:

About Panama Canal:

- It is a constructed waterway that connects the Atlantic and Pacific oceans across the Isthmus of Panama.
- It is one of the two most strategic artificial waterways in the world, the other being the Suez Canal.
- It is approximately 80 kilometers long.

- The canal was built by the United States between 1904 and 1914, and it was officially opened on August 15, 1914.
- It is owned and administered by the Republic of Panama since the oversight of the Canal was transferred from the United States to Panama in 1999.
- The Panama Canal consists of a series of locks that raise and lower the water level to facilitate the passage of ships through the continental divide.

Significance of the Panama Canal

- The Panama Canal, completed in 1914 after a decade of US-led construction, is a vital artificial waterway connecting the Atlantic and Pacific Oceans.
- It significantly reduces shipping costs and travel time by bypassing the southern tip of South America.
- Handling about 6% of global trade annually, the canal remains crucial for international commerce, particularly for US shipping and defense.

US Role in Canal Construction

- The US was instrumental in constructing the canal after France abandoned earlier efforts.
- President Theodore Roosevelt prioritized the project, navigating engineering challenges with innovative "lock" systems to facilitate ship passage.
- However, construction came at a high cost, including over $300 million and thousands of workers' lives.
- The canal's creation involved controversial treaties with Panama, following its US-backed independence from Colombia in 1903.

Transfer of the Canal to Panama

- Tensions over US control of the canal led to the Torrijos-Carter Treaties of 1977.
- These agreements established Panamanian sovereignty over the canal by 1999 while preserving its neutrality under US defense oversight.
- The decision to relinquish control stemmed from rising operational costs, inefficiencies, and diminishing strategic value for the US.

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Daily News Analysis

Page : 08 Editorial Analysis

The global warming fight has a challenge for India

The outcome of the climate conference (COP29) in Azerbaijan has been disappointing. The meeting took place at a time of transition in American politics. While international climate negotiations remain stalemated, nature is moving inexorably towards becoming a hotter planet. The fight against global warming requires reducing emissions. Developed countries have accepted 2050, China 2060, and India 2070 as the deadline for energy transition to net zero emissions by 2070.

There are two developments that will cut short the transition time. The European Union's (EU) Carbon Border Adjustment Mechanism (CBAM), which will be effective from 2026, will result in penal customs duties on imports unless the carbon tax in exporting countries is hiked to the EU level. The second is increasing pressure to accept the 'peaking' of emissions. The G-7 Summit in Hiroshima last year, and Apulia in June 2024, called on the 'major economies' to accept the peaking of emissions by 2025. This was a reference to China and India as the EU and the United States have already accepted 'peaking'.

The incoming Donald Trump administration may take the U.S. out of the climate agreements again. Regardless of this, we must take action to achieve a clean environment, for our own sake. But we cannot ignore India's development imperative. We need more electricity to replace fossil fuels. India's electricity consumption is a third of the global average. While developed countries and China have to diversify to clean energy sources, India has to grow and diversify.

These twin challenges entail much higher costs and require a longer transition time. However, we do not have the luxury of waiting till 2070 as pressure mounts for the 'peaking' of emissions. The 'peaking' year is an intermediate stage where emissions plateau before declining to the net zero stage. China has accepted the goal of peaking by 2030. India cannot remain an outlier indefinitely. At the most, we may have a decade when our emissions will be capped. A more compressed transition schedule means that we have to depend upon existing technologies. Small modular reactors and hydrogen will take more than a decade to become commercially viable.

Ramp up generation

Can we escape pressure for early peaking? While targets in climate negotiations may be voluntary, they will be enforced through bilateral tariff measures and international financing conditions. The peaking level will determine the quantum of energy available for future growth. We need to rapidly ramp up electricity generation to establish our claim to an energy level that is sufficient to sustain future growth before we are constrained to accept the peaking of emissions. China has 200 GW of new coal-based power plants sanctioned or under construction.

D.P. Srivastava

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India's development needs cannot be ignored; as it has to grow and diversify to clean energy sources, this would mean higher costs and a longer transition time

Reaching net zero emissions (NZE) will entail growth in demand for electricity based on clean sources, as new sectors such as transport and industry are brought under electrification. This increase will be of a much higher order of magnitude than existing trends which are derived from the power sector alone. What is the minimum quantum of electricity needed to reach NZE? Which is the cheapest generation mix needed to achieve the minimum level? A Vivekananda International Foundation (VIF) Task Force on India's Energy Transition in a Carbon-Constrained World mandated IIT Bombay to answer these two questions based on mathematical modelling.

It estimated the minimum quantum of demand for electricity as 21,000 Terawatt hours (TWh) by 2070. An International Energy Agency report has pegged India's energy demand at 3,400 TWh by 2040. Different timelines make a comparison difficult. But it is worth keeping in mind that India's energy consumption in 2020 according to NITI Aayog data was 6,200 TWh. Is it realistic to peg its energy demand two decades later at half the level of 2020, the pandemic year, when the economic activities were slow? This is a prescription for energy deficit and slow growth.

The Economist has suggested decoupling growth with energy. The West has not followed this paradigm. Will India's service economy minimise the need for energy? Server banks needed to power the digital economy require a huge amount of energy. Generative AI will increase energy demand exponentially. This is why Microsoft and other tech giants are turning to nuclear power, which is the only source of clean, firm power at scale.

Cost and land

For energy transition, the choice lies between renewables and nuclear, the two forms of energy that are emission-free. But which of the two entails lower cost and land? The current renewables tariff does not fully take into account storage and transmission costs. A paper by the Central Electricity Authority last year acknowledged that the cost of renewables round the clock ranges from ₹4.95 per unit to ₹7.5 a unit (on the assumption of only six hours of storage). This is higher than the tariff for nuclear power at ₹3.80 a unit. The VIF-IIT Bombay study has also brought out that the renewable high option will cost the most ($15.5 trillion), while the nuclear high option will cost the least ($11.2 trillion) by 2070.

The VIF report has shown that the renewable high approach will require 4,12,033 square kilometres – double the total surplus land of 2,00,000 sq.km available in India. The nuclear high approach will require 1,83,565 sq.km. The renewable route for the production of green hydrogen will increase the demand for electricity for electrolysis and make land constraints worse.

On the margins of COP28 in the United Arab Emirates, a group of over 20 countries, including the U.S., France, and Japan have pledged to triple nuclear power by 2050. Nuclear power already provides 20% of electricity generation in the U.S. and 70% in France. Japan joined this group despite the legacy of the Hiroshima and Nagasaki bombings, and the Fukushima accident. In India's case, there is a need for a sharper increase, as the share of nuclear power in generation is as low as 3%.

Ramping up nuclear power requires government support, as resources on this scale cannot be internally generated by the Nuclear Power Corporation of India Limited (NPCIL). Nuclear power also needs to be given the status of green energy as it is emission-free. Besides operationalising existing joint ventures between the NPCIL and public sector units, public-private partnerships with industries in hard-to-abate sectors should be encouraged given the looming EU deadline for enforcing the CBAM. The bulk of the additional demand for generation will have to be met by larger 700 MW-1,000 MW reactors.

The issue of finance

At COP29, developed countries committed a paltry $300 billion per year from diverse sources by 2035 against the demand by developing countries for $1.3 trillion. Will this distant goal survive the Trump presidency? Most of this will be non-concessional finance. Many developing countries cannot absorb loans. Multilateral development banks have their statutes, which will require amendment.

Green finance from private sources will come only if the tariff is raised, and the health of DISCOMs is restored. The government cannot bear the fiscal burden of energy transition. The public has to be sensitised to steep hikes in tariffs given the investment in creating new-generation assets. This requires political consensus.

COP29 has finalised the rules for carbon trading. This amounts to rich countries buying the carbon entitlement of the poorer countries to cushion their lifestyle changes. If we cannot diversify to clean sources by the peaking year, we will need carbon for our growth rather than a trade-off.

The energy transition is a fight for limited carbon space. No major economy is likely to diversify to clean energy before the global carbon budget runs out in the next 10 years. An equitable share in the remaining carbon space is crucial for future growth. We must establish our claim by establishing high-generation capacity. The EU and the U.S. have already claimed entitlement to remaining carbon space by unilaterally establishing their peaking levels. China will keep expanding its claim till 2030.

GS Paper 02 : **Geography – Climate Change,**

GS Paper 03 : **Environment**

PYQ: (UPSC CSE (M) GS-3 2021): **Describe the major outcomes of the 26th session of the Conference of the ParSes (COP) to the United NaSons Framework Convention on Climate Change (UNFCCC). What are the commitments made by India in this conference? (250 words/15m)**

UPSC Mains Practice Question: **Discuss the challenges faced by India in achieving a balance between energy transition and economic growth while addressing international pressures for early emission peaking. Suggest measures to ensure equity in the allocation of global carbon space. (250 Words /15 marks)**

Context :

- The COP29 conference highlighted the challenges of global climate negotiations amidst political shifts and increasing environmental urgency.
- Developed nations and the EU are enforcing strict timelines for emissions reduction, while India faces dual pressures of economic growth and energy transition.
- Equity in carbon space allocation remains critical for India's development.

Disappointment at COP29 and Climate Challenges

- The COP29 conference in Azerbaijan failed to achieve significant progress.
- The meeting coincided with a transition in U.S. politics, adding uncertainty to climate agreements.
- Global warming continues to worsen, necessitating emissions reductions.
- Developed countries aim for net-zero emissions by 2050, China by 2060, and India by 2070.

Factors Reducing Transition Time

- EU Carbon Border Adjustment Mechanism (CBAM): Effective from 2026, penalizes imports unless exporting countries align carbon taxes with EU standards.
- Pressure to Peak Emissions: G-7 summits in Hiroshima and Apulia urged major economies, including India and China, to accept emission peaking by 2025.

Challenges for India

- India's electricity consumption is one-third of the global average, requiring significant growth to replace fossil fuels.

- Transitioning to clean energy poses higher costs and a compressed timeline compared to developed countries.
- India must establish a feasible peaking year, following China's target of 2030.

Ramp-Up in Electricity Generation

- Targets may be voluntary but will be enforced through tariffs and financing conditions.
- India needs to rapidly scale electricity generation before being constrained by emission caps.
- A Vivekananda International Foundation (VIF) study projected India's minimum electricity demand at 21,000 TWh by 2070, while the International Energy Agency estimated 3,400 TWh by 2040.

Renewables vs. Nuclear Power

- Renewables and nuclear are the only emission-free energy sources, but nuclear is more cost-effective and requires less land.
- Renewables cost ₹4.95–₹7.5 per unit (with six hours of storage), compared to nuclear at ₹3.80 per unit.
- The renewable approach could cost $15.5 trillion and require 4,12,033 sq.km of land, double the available surplus land in India.
- The nuclear approach would cost $11.2 trillion and require 1,83,565 sq.km.

Global Nuclear Initiatives

- Over 20 countries, including the U.S., France, and Japan, pledged to triple nuclear power by 2050.
- India's nuclear power share in electricity generation is just 3%, necessitating significant growth.

Financial and Policy Challenges

- Developed countries pledged $300 billion annually by 2035, far below the $1.3 trillion demanded by developing nations.
- Green finance depends on tariff hikes and reforms in power distribution companies (DISCOMs).
- A political consensus is needed to sensitise the public about increased tariffs.

Carbon Trading and Equity

- Carbon trading rules allow richer countries to buy entitlements from poorer nations, potentially disadvantaging developing economies.
- India must establish high-generation capacity to claim a fair share of the limited global carbon space.
- Developed nations and China have already set their peaking levels, asserting claims over the remaining carbon budget.