1. Deep Space Optical Communications (DSOC) experiment

Introduction

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

The spacecraft is on its way to a unique metal-rich asteroid, orbiting the Sun between Mars and Jupiter. Scientists believe this asteroid is the nickel-iron core of an early planet, studying which could provide unique insights into the impenetrable iron core of our own planet.

Simultaneously, it will also carry out another mission that might hold the key to future space exploration. What is this mission, and what does it have to do with 'space lasers'

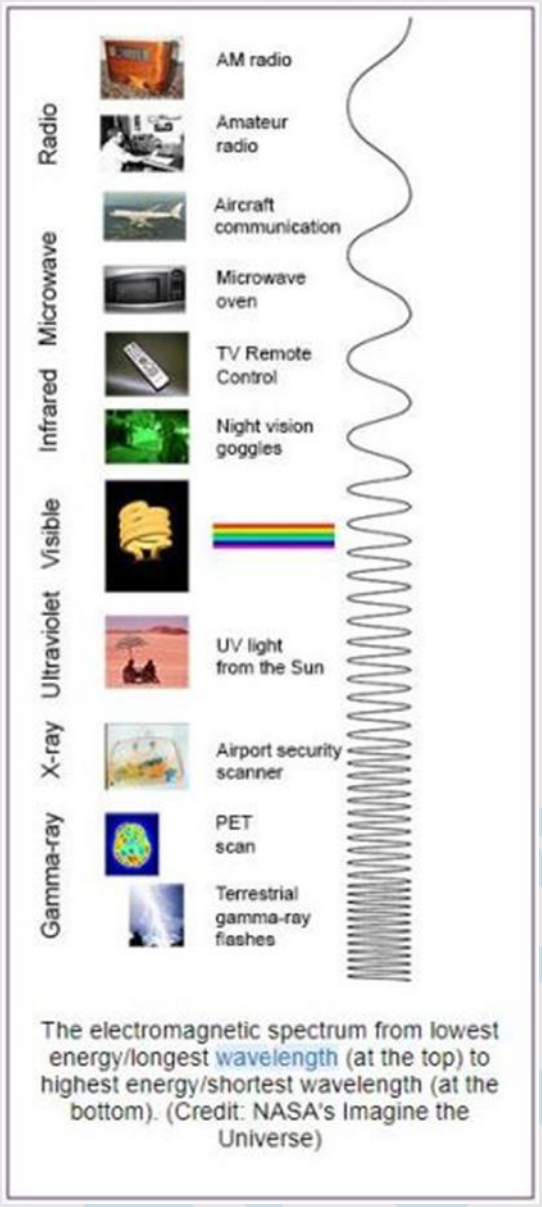
Space communication's data rate problem

Communicating with spacecraft far away from Earth poses many challenges, of which the problem of data rates might be the most critical. Simply put: how does a spacecraft transmit vast amounts of data over extremely long distances, all while itself moving at rapid speeds?

Like wireless communications on Earth, spacecraft encode data on various bands of electromagnetic frequencies. Currently, most space communication is carried out using radio waves — having the highest wave lengths but lowest frequencies in the electromagnetic spectrum.

However, higher bandwidths (range of frequencies) carry more data per second. Thus, scientists would ideally like to transmit data at the highest bandwidths possible to increase the rates of data transfer. But this throws up its own set of challenges.

Radio waves are more widely used for communication than other electromagnetic waves primarily because of their desirable propagation properties, stemming from their large wavelength. What this means is that they have the ability to pass through the atmosphere regardless of weather, pass through foliage and most building materials, as well as bend around obstructions. Shorter wavelengths tend to scatter when in contact with any interference.



The electromagnetic spectrum from lowest energy/longest wavelength (at the top) to highest energy/shortest wavelength (at the bottom). (Credit: NASA's Imagine the Universe)

NASA's revolutionary new technology

This is where NASA's Deep Space Optical Communications (DSOC) experiment comes in — pioneering the use of near-infrared laser signals for communication with spacecraft. Much like fibre optics replacing old telephone lines on Earth, NASA says that DSOC will allow data rates at least 10 times higher than state-of-the-art radio telecommunications systems of comparable size and power, enabling higher resolution images, larger volumes of science data, and even streaming video.

The Psyche spacecraft is the first to carry a DSOC transceiver, and will be testing high-bandwidth optical communications to Earth during the first two years of the spacecraft's journey to the main asteroid belt. The tech demo achieved "first light" in the early hours of November 14 after this transceiver locked onto a powerful uplink laser beacon transmitted from the Optical Communications Telescope Laboratory at the NASA's Table Mountain Facility near Wrightwood, California.

Preparing for the future of space travel

In 2013, NASA's Lunar Laser Communications Demonstration tested record-breaking uplink and downlink data rates between Earth and the Moon using similar technology. DSOC, however, is taking optical communications into deep space, paving the way for high-bandwidth communications far beyond the Moon and over a 1,000 times farther than any optical communications test to date.

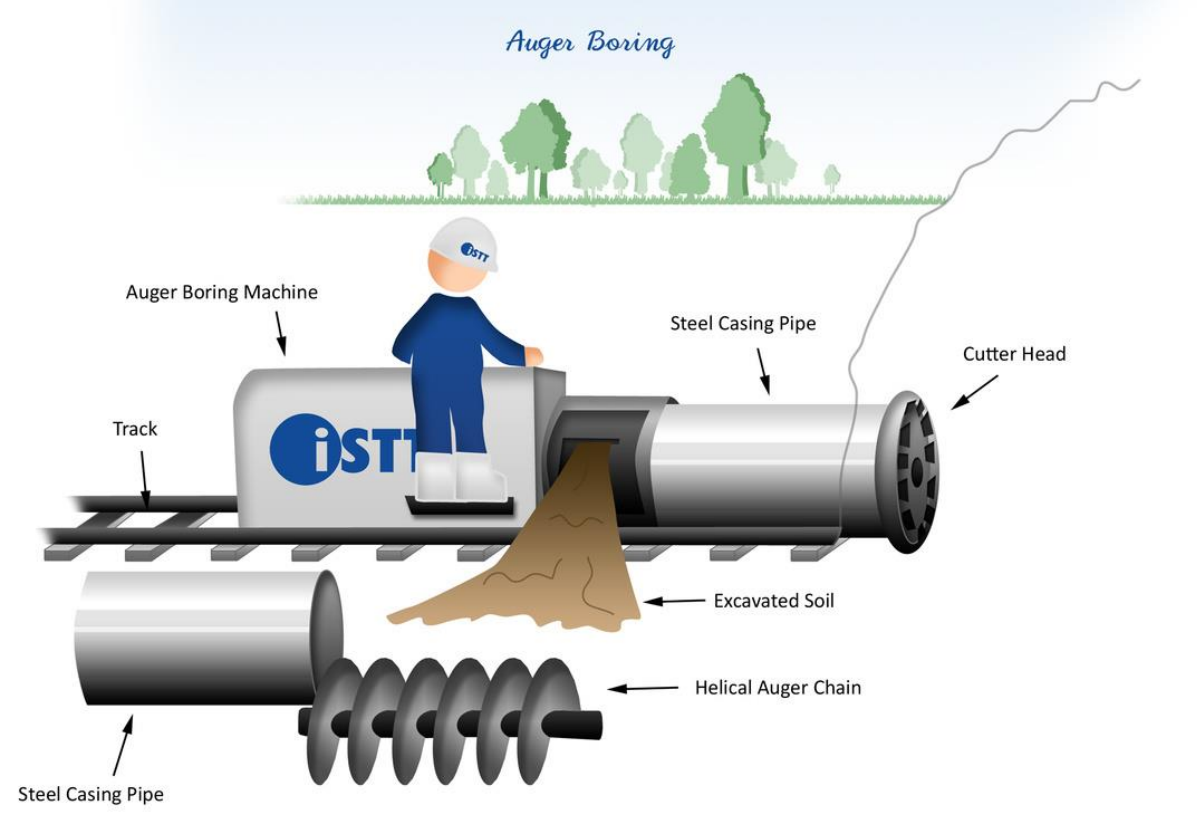
Why does this matter? With humanity's ambitions to travel in space, far beyond the Moon, improving communications technology is crucial.

Relevance: GS Prelims & Mains Paper III; S & T
Source: The Indian Express

2. Uttarakhand tunnel rescue: What is an auger machine, what went wrong, and what's next?

Introduction

The operation to save 41 men trapped in the Uttarkashi tunnel witnessed a setback on Saturday when the auger joint of the drilling machine broke inside the rescue pipes and blocked the passage.



What is a horizontal auger machine?

A horizontal auger machine, often called a horizontal boring machine or directional drill, is a specialised tool to create horizontal bores or underground tunnels without disturbing the surface. It typically consists of a rotating helical screw blade called an auger, attached to a central shaft or drill, which penetrates the material by rotating. These machines are commonly employed in construction, utility installations such as laying pipes or cables, and infrastructure projects.

For the machine to work, it is positioned at the starting point of the bore, usually on the surface. It consists of a drill head with an auger or a drill string attached to it. The auger at the front of the machine rotates and cuts through the soil, rock, or other materials underground. Hydraulic or mechanical systems power this rotation.

As the auger advances, it removes the material from the tunnel, and it is usually flushed out by a drilling fluid or mud pumped through the drill string. This fluid serves to lubricate the drilling process, cool the cutting head, and carry excavated material back to the surface. The machine also has a steering system that allows operators to control the direction and angle of the bore.

Horizontal auger machines often use advanced guidance systems, such as GPS and electronic tracking, to ensure accuracy in direction and depth while drilling underground. Once the machine has bored the desired length, the auger is retrieved, and the tunnel is ready.

Why was it used in this case?
In the Silkyara-Barkot tunnel rescue operation, the initial plan to remove the debris blocking the tunnel exit using heavy excavators did not work.

It was later decided that an auger machine could be a good option because if used properly, it can create a passage through the debris with minimum disturbance to the surface. To keep that passage intact, the rescuers are pushing 900 mm and 800 mm wide mild steel pipes along with the auger blade. Once the passage is complete, the auger blade could be pulled back from inside the pipes.

In the current operation, the rescuers are using the American Auger 60-12000, a large and powerful horizontal directional drilling (HDD) machine manufactured by American Augers, a company specialising in trenchless underground construction equipment. The numbers “60-1200” refer to its drilling diameter capabilities. The machine can drill holes ranging from 5 feet to 10 feet in diameter.

What is the new hurdle?
In order to use the auger machine, the central shaft or drill stays outside, and the auger blade is attached to it to penetrate through the debris. In this case, the auger blade is passing through the mild steel pipes used to keep the passage intact.

After some hurdles faced in the last few days, the machine was reassembled and all augers were reinserted by 2.30 pm on Friday. Pushing for the 10th pipe started at 4.25 pm and the auger was already in by over 45 metres. According to a worker at Trenchless Engineer Services, the company that provided the machine, auger blades come in different lengths – 8, 6 and 3 metres. To reach a length of over 45 metres, several blades were attached to each other, using joints.

On Friday, a new obstruction was observed. When similar situations were faced earlier, the machine and the auger blades were pulled out so that someone could enter the pipes and check the obstruction manually.

The same thing was planned in this case. Rescuers started pulling back the machine to clear the pipes for manual inspection. But it appears that the tip of the blade was still stuck in the obstruction, and after pulling back around 15 metres, an auger joint broke. Around 32 metres of the auger blade is left inside the pipes, blocking them.

What needs to be done now?
Because there is no way to pull the broken auger blade, rescuers need to enter the 800 mm wide pipes, and cut the 32 metres long auger blade piece by piece to clear the path.

The rescuers have also called for a plasma cutter from Hyderabad, and it is expected to reach the tunnel site. A plasma cutter is a tool used for cutting various types of electrically conductive materials, such as steel, aluminium, stainless steel, copper, and other metals. It works by creating a high-velocity jet of ionised gas, known as plasma, to melt and cut through the material.

According to the authorities, using the plasma cutters will increase the speed of cutting the machine. Currently, they have been able to cut the stuck auger just around 1.5 metres in an hour. With the plasma cutter, they can cut it around 4 metres in an hour. Once the broken auger blade is removed, new auger blades will be used in its place.

Relevance: GS Prelims & Mains Paper III; Disaster Management
Source: The Indian Express & The Hindu

3. Four Convicted in Soumya Vishwanathan Murder Case Receive Life Sentences

Overview
After 15 years, a Delhi court sentenced four men to life imprisonment for the murder of journalist Soumya Vishwanathan, along with charges under the Maharashtra Control of Organised Crime Act (MCOCA). The fifth convict received a three-year jail term.

Timeline of Events

September 30, 2008: Soumya Vishwanathan, a 25-year-old journalist, was killed while heading home. Robbers in a WagonR chased and shot her at Nelson Mandela Marg, causing her car to collide with the footpath. She succumbed to her injuries.

Initial Investigation: The incident was reported at Vasant Kunj police station, but no breakthroughs were made in the first six months due to a lack of CCTV cameras and witnesses unable to identify the assailants.

March 23, 2009: Three men—Ravi Kapoor, Amit Shukla, and Baljeet Malik—were arrested in connection with another robbery-murder case, revealing their involvement in Soumya's murder during interrogation.

Evidence: Police matched the bullet found in Soumya's car to the weapon recovered from the arrested men and located the WagonR used in the crime.

Serial Offenders: The accused were found to be serial offenders targeting taxi drivers or lone women, leading to the introduction of MCOCA charges in 2011.

MCOCA Complexity

The case faced complications as MCOCA charges required proving the involvement of the men in an organised crime gang. After years of trial, in October of the current year, the court found Ravi Kapoor, Amit Shukla, Baljeet Malik, and Ajay Kumar guilty of murder and committing organised crime under the MCOCA. Ajay Sethi was convicted for receiving stolen property and conspiring to abet, aid in, or knowingly facilitate organised crime under the MCOCA.

Relevance: GS Prelims & Mains Paper I; Social Issues
Source: The Indian Express and The Hindu