Nuclear Rocket for Space Travel

For Prelims: NASA, Demonstration Rocket for Agile Cislunar Operations, Project Orion, Atomic bomb**,** Perseverance Rover - NASA**,** India's Mars Orbiter Mission**,** UAE's Hope Mars Mission

For Mains: Significance of DRACO, Nuclear Propulsion System

Source: IE

Why in News?

NASA in collaboration with the **United States Defense Advanced Research Projects Agency (DARPA)** is seeking a nuclear propulsion system that could potentially **cut down the travel time to Mars by half.**

- This ambitious initiative, known as the **Demonstration Rocket for Agile Cislunar Operations (DRACO)** and the launch is scheduled for **late 2025 or early 2026.**

What is DRACO?

- **About:** The DRACO project is offering the prospect of shorter travel times between celestial bodies and improved fuel efficiency. Central to DRACO's vision is a nuclear reactor **that utilizes the energy derived from the fission of** uranium **atoms.**
- **Significance:** DRACO hold the potential to revolutionize space travel in numerous ways:
  - **Acceleration and Speed:** Unlike traditional rocket engines that rely on chemical reactions (fuel like hydrogen or methane with oxygen), **nuclear reactions generate far more energy,** enabling the spacecraft to accelerate continuously throughout its journey.
    - This acceleration could significantly **shorten travel times to distant destinations like Mars.**
  - **Enhanced Fuel Efficiency:** Nuclear propulsion systems **yield greater fuel efficiency**, reducing the need to carry excessive propellant.
    - This advantage can drastically lower the duration of interplanetary voyages.
  - **Minimized Exposure:** Expedited travel times translate to **reduced exposure of astronauts to the harsh conditions** of deep space.
    - The potential risks associated with extended space travel, such as **radiation exposure and isolation,** could be mitigated through quicker journeys.
  - **Military Applications:** Beyond its application in space exploration, DARPA's involvement hints at the potential for nuclear propulsion to facilitate rapid maneuvers **of military satellites in Earth's orbit.**
- **Concern:**
  - **Safety Concerns**: One of the primary concerns with using nuclear fuel in space is the potential for **accidents or malfunctions that could release radioactive material into space or back to Earth.**
    - Such incidents could have severe environmental and health consequences.
  - **Launch Risks:** Launching spacecraft with nuclear fuel on board presents risks, as there

is **always a chance of a launch failure or explosion,** leading to the **dispersion of radioactive material over a wide area.**

What is the Historical Context of Nuclear Propulsion and How DRACO is Different?

- Projects like **Orion, Rover, and NERVA** explored nuclear-powered propulsion systems, although these initiatives were not fully realized.
    - Notably, **Project Orion considered using** atomic bomb explosions for acceleration, while **Project NERVA aimed to develop nuclear-thermal engines** akin to the DRACO engine.
- DRACO marks a significant evolution from its predecessors due to several key differentiators:
    - **Fuel Enrichment:** Unlike Project NERVA, which used **weapons-grade uranium,** DRACO employs a **less-enriched form of uranium.**
        - This shift enhances safety and minimizes the risks associated with the use of radioactive materials.
    - **In-Space Activation:** The nuclear reactor within the DRACO engine remains **dormant until it reaches space.**
        - This precautionary measure mitigates the potential for radioactive accidents during launch or on Earth.

Note:

- **Atomic Bomb Explosions**: Atomic bomb explosions involve the **rapid and uncontrolled release of** nuclear energy through a chain reaction of nuclear fission.
    - The core of the bomb contains fissile material, like **uranium-235 or plutonium-239.**
- **Nuclear-Thermal Engines:** Nuclear-thermal engines are propulsion systems that use a nuclear reactor to heat a propellant, usually hydrogen, to high temperatures.
    - The heated propellant is then expelled through a nozzle at high velocity, creating thrust according to **Newton's third law of motion.**

Mars

- **About:** Mars is the fourth planet from the Sun in our solar system. It is often referred to as the **"Red Planet"** due to its reddish appearance caused by **iron oxide (rust) on its surface.**
- **Atmosphere:** Mars has a thin atmosphere primarily composed of **carbon dioxide (95.3%), with traces of nitrogen and argon.**
- **Major Surface Features:**
    - **Olympus Mons:** The largest known volcano in the solar system.
    - **Valles Marineris:** A massive canyon system.
    - **Polar Ice Caps:** Ice caps made of water and frozen carbon dioxide (dry ice) at the poles.
    - **Dusty Surface:** The surface is covered in fine dust and rocks.
    - **Liquid Water:** Liquid water is rare, but evidence suggests past liquid flows.

What are the Major Mars Missions?

- **Perseverance Rover - NASA**
- India’s Mars Orbiter Mission (MOM) **or Mangalyaan (2013)**
- **ExoMars rover (2021) (European Space Agency)**
- **Tianwen-1: China's Mars Mission (2021)**
- UAE’s Hope Mars Mission **(UAE’s first-ever interplanetary mission) (2021)**
- **Mars 2 and Mars 3 (1971) (Soviet Union)**

UPSC Civil Services Examination, Previous Year Question:

Q. Consider the following statements: (2016)

The Mangalyaan launched by ISRO

1. is also called the Mars Orbiter Mission
2. made India the second country to have a spacecraft orbit the Mars after USA
3. made India the only country to be successful in making its spacecraft orbit the Mars in its very first attempt

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: (c)