Hop, Skip and Jump

The Moon to Mars Mission

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THE Moon has not seen humans on its soil since 1972. Apollo 17 was the last crewed mission to our cosmic companion, after which, NASA got busy sending probes to the other planets, although several robotic lunar missions continued in the background.

Along with exploring the solar system far and wide, NASA was eyeing to colonise Mars. Before sending people to the Red Planet, NASA and its space partners dispatched several probes, landers and rovers to the planet to scout the surface and study it in detail for habitation. Funds were channelled for building of a special spacecraft for carrying humans to Mars by the 2030s.

However, a direct crewed mission to Mars did not receive an immediate impetus in the subsequent goverment. Instead, in December 2017, NASA was given the directive to "Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities."

As a part of this directive, the Moon rose to prominence once again for NASA and so was born the Moon to Mars mission.

The Five-point Plan

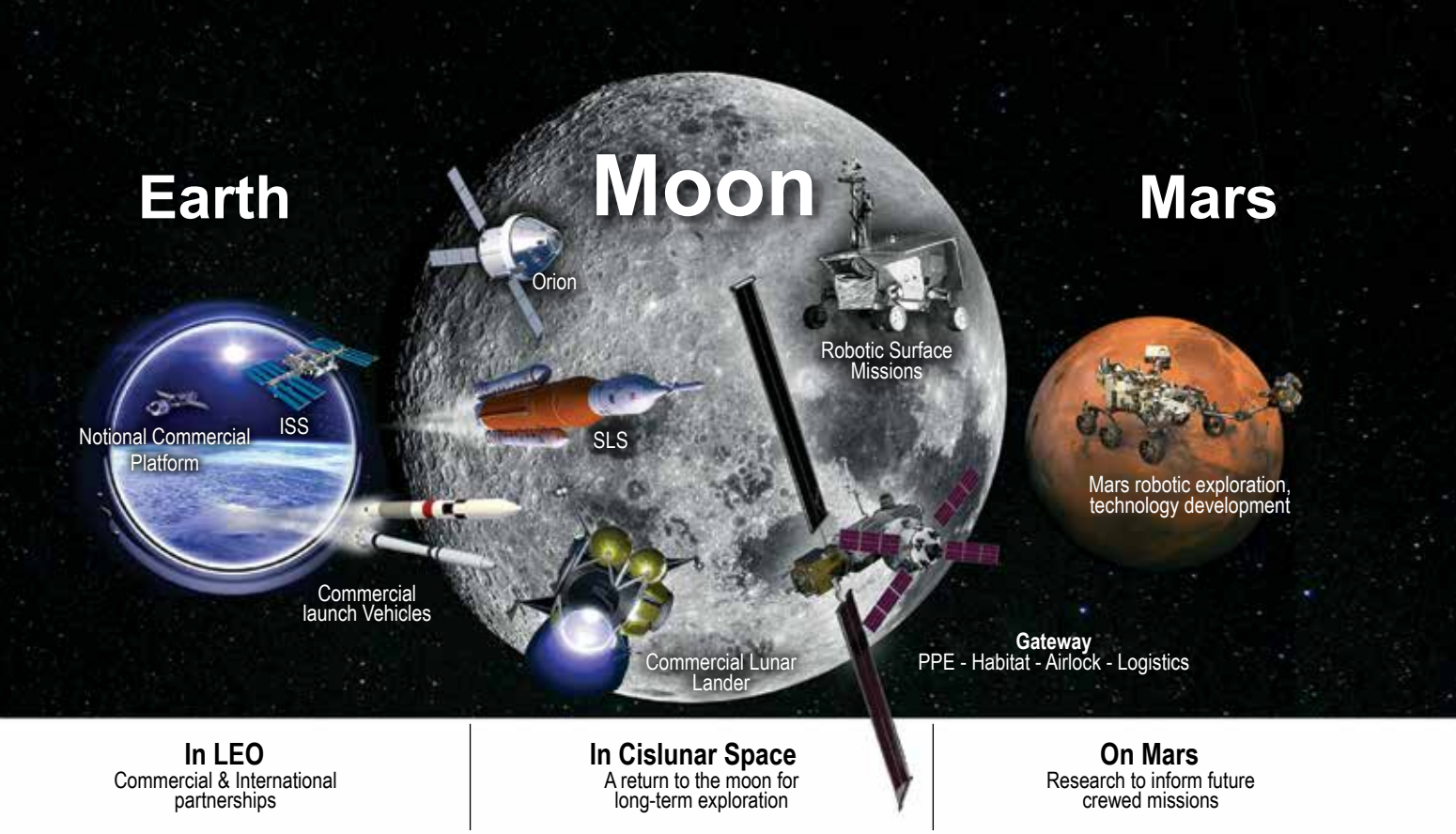
In response to the challenging task, NASA came up with its proposal under the National Space Exploration Campaign, presenting a five-point strategy, aimed at overhauling the International Space Station for commercial activities; focusing on Moon activities; harnessing lunar resources; returning people to the Moon, and sending astronauts to Mars.

Through this plan, NASA envisions to hop to the moon first, use it as a layover hub, and then jump on to Mars by the 2030s.

Off to Stay on the Moon!

Previous robotic missions to the Moon have yielded valuable data which presents us the opportunity to explore and utilise its potential in depth. Ahead of sending people to the moon, NASA proposes to use new tools, technologies and robots to conduct advanced science experiments and demonstrate the feasibility of a human habitat on the moon.

In a media presentation, NASA's administrator Jim Bridenstine said: "We will go to the Moon in the next decade in a way we have never gone before. We will go with innovative new technologies and systems to explore more locations across the surface than was ever thought



possible. This time, when we go to the Moon, we will stay. And then we will use what we learn on the Moon to take the next giant leap – sending astronauts to Mars."

By incorporating these techniques, future astronauts will be able to reside on the Moon, by exploiting the local resources. The Moon to Mars project kicks off this year with NASA inviting and finalising proposals for design, development and manufacture of the required technology for the project.

Moon's Hospitality

Moon resources project prospective sustainability for humans to reside on its surface for extended periods. For example, the Moon rock samples brought back from the Apollo expeditions along with the scientific data from the numerous probes encourage the belief that the Moon holds enormous amounts of water-ice at its poles. The information directly translates into the harnessing of liquid water and oxygen for sustenance.

Also, a plethora of options arise for utilising the water-ice for manufacturing rocket fuel and commercial purposes. Along with this, the Moon holds valuable mineral resources for space commerce activities.

It is also proposed that superior and advanced technology will harness solar energy to drive these outposts and meet the power requirements for their functioning.

In it Together

Before a surface habitat, the NASA-led venture proposes an orbiting platform around the Moon, called the Lunar Orbiting Platform-Gateway (LOP-G) or Gateway for short. This facility is like the International Space Station (ISS) albeit 384000 kilometres away rather than in low earth orbit.

All the 14-nation partners of ISS have come forward to establish the lunar Gateway — the European Space Agency (ESA), NASA (USA), Japanese Aerospace Agency (JAXA), Canadian Space Agency (CSA) and the Russian ROSCOSMOS.

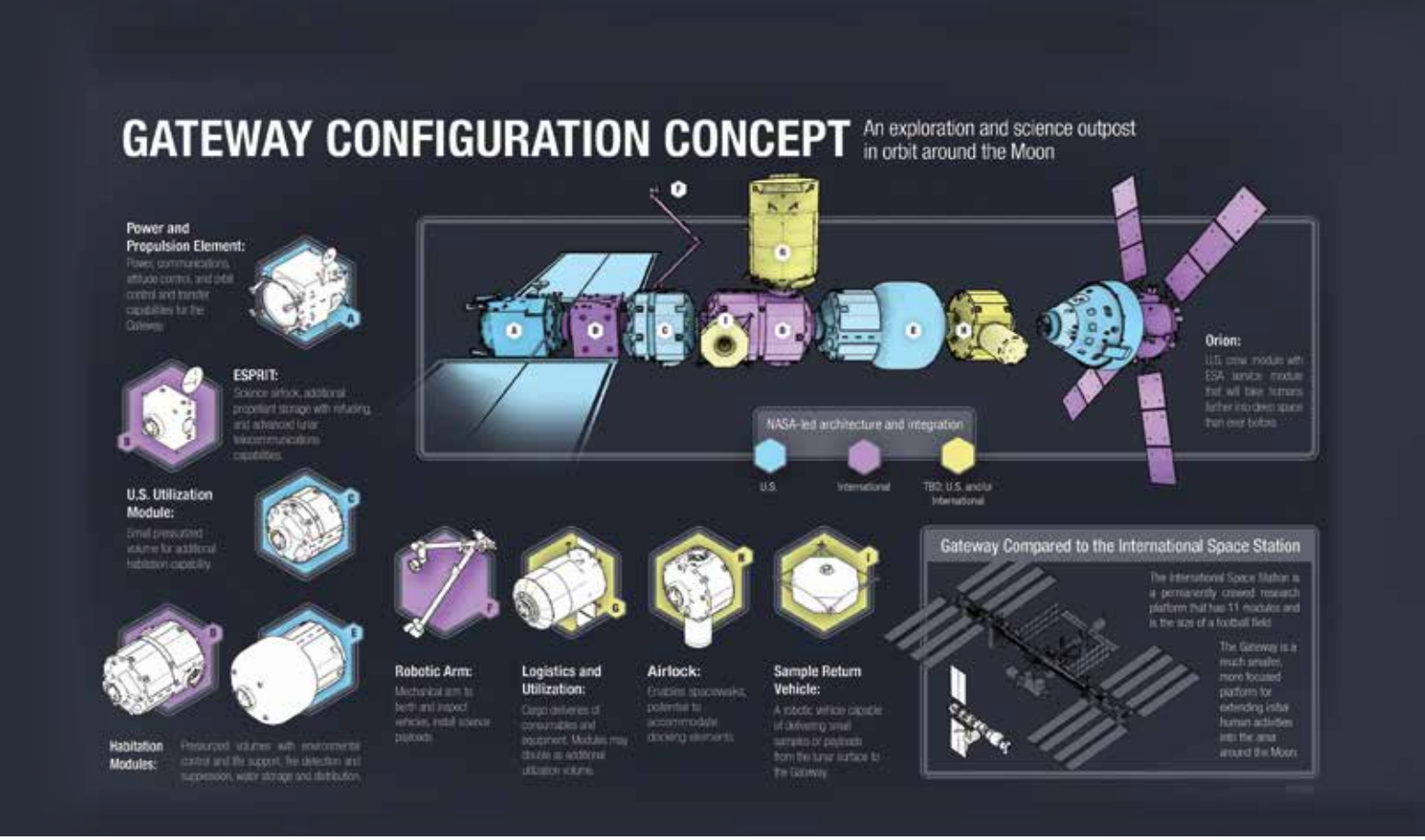
While each agency is still finalising their proposals and the role they will play at the outpost, there is a collaborative effort to make this a global participation for economic reasons and a collective effort to represent united Earth in space.

The conglomerate envisions the outpost as a unified venture: down the line, if other prominent space players like India and China join hands and bring their uniqueness to the endeavour, the Gateway will represent the expansion of the human race in outer space. For this, the partners are drafting standardisation protocol for any nation to send their scientists or utilise the gateway's facilities for science. These guidelines will allow common standards to be maintained by all, across aspects like technology, communications, etc.

Each space agency is finalising its proposals to furnish the various modules that will go into the making of this large platform that will circle the Moon.

The Building Plan

Much like the ISS, the Gateway needs to be constructed in space, however this time around, in deep space rather than low earth orbit. The Gateway will grow,



Special Orbit

- LOP-G will circle the Moon every six days swooping in between 1500 km to 70000 km distances from the surface.
- The Gateway will be placed in a unique orbit called the highly elliptical Near Rectilinear Halo Orbit (NRHO).
- A halo orbit is a three-dimensional periodic orbit operating between the gravitational pull of two planetary objects and the centrifugal accelerations on the satellite.
- Halo orbits utilise the Lagrange points — technical points in orbital mechanics to fix the trajectories.
- Robert W. Farquhar first advocated halo orbits. A spacecraft in such an orbit would be in continuous view of both the Earth and the far side of the Moon.
- LOP-G's trajectory is based on this concept to ensure that it will be at all times in communication with the earth, and avoid the shadow region of the moon.

as each module gets added to it, in the coming 5-10 years.

It will not be a permanently manned platform like the ISS. LOP-G will accommodate a four-member crew for periods of one to three months at a time, and will, at all times be operated autonomously. Unlike the spacious quarters of the ISS, astronauts on LOP-G must make do with smaller, cramped spaces of around 2000 sq ft for economic reasons.

> Another unique feature on LOP-G is a bay that will hold Moon landers and rovers for use by astronauts to hop on to the lunar surface to conduct their experiments and return to the hub as and when required.

Remote operation is also necessitated due to economic reasons — it is expensive to send people to deep space, more so maintain them there; initially, the Earth will have to provide for their sustenance. It is expected, however, that once infrastructural facilities are built on the lunar surface and resources are tapped, extended visits are likely for astronauts.

The platform will circle the moon every six days. The particular orbit called the highly elliptical near rectilinear halo orbit ensures the Gateway is always in communication with the earth avoiding the shadow region of the moon.

Step-by-step

Kicking off the project this year, NASA has declared its agenda for the coming decade: it proposes to build the orbiting platform in 8-10 years; it claims that the Gateway will be ready for astronauts before 2026. The massive assembly will take place in five missions.

2019-2020: The Space Exploration Mission-1 (EM) will see the maiden journeys of the specially designed mega launcher — Space Launch System (SLS), and the Orion spacecraft. This mission will demonstrate the reliability and reusability of Orion for the crewed missions to the Moon and beyond.

2022: In yet another test flight of SLS and Orion, The EM-2 will carry astronauts for a flyby around the Moon. By the end of the year, commercial launchers will take the first module of the Gateway — the Power and Propulsion Element (PPE), which will demonstrate its performance for a year. NASA plans to send two of these units.

Advanced technology will see the PPE working on alternate power sources: the platform will operate mainly on solar power both for navigation, avionics and running of the modules — a breakthrough for space missions, reducing the burden on Earth sources. Chemical propellants in small quantities will be available on standby. Huge solar arrays will generate electricity to fire the ion-thrusters and engines on the platform. Also, the power generators will store enough electricity for various onboard activities.

2023: Another commercial launch will have a science and experimentation rover landing on the Moon to explore and sample water-ice deposits.

2024: The Cislunar Habitation module is the next member to join PPE, via the EM–3 which will also have a permanent docking port assembled for receiving the Orion Spacecraft.

2026: This year will see the Gateway Logistics module being joined by the EM-4. Along with it will travel Canada's unique Robotic Arm. The Arm has displayed its indispensable use for service and maintenance on the ISS. On LOP-G an advanced version of the Arm, Canadarm 3, will continue the role.

2028: Lastly, Exploration Mission–5 will carry the Gateway Airlock module which will be used for Extravehicular Activities (Spacewalks). This port will also be a berth for establishing Deep Space Transit, which, in due course will launch spacecraft to carry cargo and astronauts to regions beyond the moon.

It is planned to send the first crew to the platform aboard this mission. However, NASA has been asked to advance the date to 2024. It remains to be seen if the deadline will be met.

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2030s: The Gateway will be a sustainable and reusable platform for further space exploration. It is envisioned to make as many activities as possible available and repeatable on the portal by building an open exploration platform. The 30s are slated for Mars missions.

The Workhorses

The Space Launch System is a mega-rocket from NASA. Touted as one of NASA's finest, rugged and reusable launchers, this powerful machine can carry the Orion Spacecraft, scientific payload and cargo in a single mission. The making of the SLS has brought together masterminds from 1000 companies across the US with every NASA centre extending support for its development.

The Orion is NASA's specially designed spacecraft for crewed missions to deep space and back. It has a facility for four astronauts to take them on extended journeys, provide and support them on the long haul.

Reliability is another feature of Orion for deep space travels with specially designed safety systems to bring the astronauts back home in case of emergencies. Despite the long duration and prolonged travel time, Orion is light enough to be launched by SLS.

The Gateway will have a dedicated port for Orion to dock. In the first series of Exploration Mission-1, Orion will make an uncrewed, three-week-long mock journey to several thousand kilometres beyond the Moon to test its capability. After that, several increasingly challenging crewed missions aboard the spacecraft will follow.

Hop on and off

Another unique feature on LOP-G is a bay that will hold Moon landers and rovers for use by astronauts to hop on to the lunar surface to conduct their experiments and return to the hub as and when required.

A multipurpose port will support science and technology demonstrations for onboard payloads or free-flying nearby or on the lunar surface. Science experiments will continue autonomously round the clock. Moreover, a permanent Sample Return port will enable robotic missions to safely deliver samples collected from the Moon, Mars or asteroids, for process and return to earth.

In all, astronauts and robots will hop on and off the Gateway going about their tasks.

Pushing the Boundaries

In a way, the journey to Mars via the Moon would come in handy: given our present travelling speeds, it would take six to nine months for astronauts to reach Mars. Such long hauls come with inherent hazards like radiation exposure and physiological upheavals which need to be ascertained and overcome through continuous experimentation in deep space.

Ongoing research studies aboard the ISS have provided insight for us to develop the safety nets that are required. The astronauts are undergoing continuous training and experimentation for longer durations in space.

Studies on ISS have shown humans adapting to long term space living. By shifting the facility to the Moon, NASA plans to learn further by testing technologies for human space travels and residences for long term durations such as that to Mars. The Moon hub will provide ample opportunity for scientists to test new technologies and resources for deep space travels. The Gateway will help us to learn the response mechanisms of living organisms to radiation, microgravity and other space facets to enable us to colonise Mars in the future.

Envisioning the deep space travels by utilising a stopover at the Moon would give the scientists ample time and opportunity to prep the astronauts for the long journey beyond. So, a typical lunar habitat will witness humans and robots working together to extract, 3-D print, manufacture and build as much of the infrastructure as possible on the moon itself, along with preparing to jump to Mars.

There is much to look forward to in the coming few years as this mission opens new vistas. All that we imagined in sci-fi may soon be a reality.

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