India's Mars and Moon Missions: Implications for National Security

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The Moon and Mars have stirred the imagination of space scientists since ages because of their relative proximity to Earth, as compared with other heavenly bodies. The Moon, located at a distance of 38,000 km, is the heavenly body nearest to the Earth. It is natural that our satellite remained the object of the first research since the beginning of the Space Age. Mars, the fourth planet in the solar system after Earth, has a year of 687 days and a day which differs from the Earth-day by a little less than half an hour; it is smaller as well as lighter than the Earth and less dense too with its gravity just about 38 percent of the gravity on Earth. It has two satellites: Phobos and Deimos. Soon after the dawn of the Space Age in 1957, both the US and erstwhile USSR initiated numerous projects to carry out wide-sweeping reconnaissance of the solar system, including the Moon and Mars, during the 1960s and 1970s. This was followed by increasing European and Japanese activities in the area of interplanetary exploration in 1980.[1] Since then, there has been an overall continuity in nations attempting interplanetary exploration. India, with its robust space programme, has been making steady progress in deep space exploration, along with other space-faring nations right from the beginning.

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Evolution of Interplanetary Exploration

Since 1957 (the year in which Sputnik I was launched)[2], space-faring nations have made sustained efforts towards interplanetary exploration to Mars, Venus and minor bodies such as the Martian moons, asteroids and comets. Between 1960 and 1985, a total of 19 Soviet probes were sent to Venus. Some of the spacecraft (most notably Veneras 11 and 12), which reached the planet's surface, transmitted black and white as well as colour photographs of the planet, soil analyses and radar imaging maps of the Venusian surface. Similarly, several lunar exploration programmes were undertaken by the space-faring nations in the 1970s and 1980s. These activities were targeted to establish a manned lunar base, which could then be followed by sending a mission to Mars. Various outer planets exploration missions were sent to Jupiter and Saturn in the 1990s by the US and the erstwhile USSR. Exploration of outer space has indeed become integral to the global and national socio-economic development activities of most progressive space-faring nations.

Renewed Interest by Space-Faring Nations on Missions to Mars/Moon

The last few years have seen a revival of the focus of major space-faring nations on missions to Mars/ Moon aimed to extend their strategic leverage in space, besides the national prestige that such endeavours provide. In 2004, the National Aeronautics and Space Administration (NASA) declared its intention to withdraw from the International Space Station (ISS) programme and aim for the Moon instead. Unlike the ISS, the technological components of the future lunar infrastructure are reportedly planned to be developed by the USA largely domestically, with the involvement of very few other nations or overseas contractors. In July 2011, the US closed down its Space Shuttle programme and paved the way for private companies to run the same. A major chunk of the NASA money, thus, available was redirected to fund robotic missions to Mars as

well as asteroids (between Mars and Jupiter) to be followed by manned missions.

These endeavours by the US and other space-faring nations are a clear indication that missions to Mars/Moon will remain the arena of future space endeavours. Manned missions to the Moon and expeditions to Mars are duly factored in the long-term planning of these space-faring nations. India, which possesses the capability to design and develop satellites as well as satellite launch vehicles, took note of this trend quite early and is well on board towards carrying out such deep space missions.

The aim behind the Mars/Moon missions needs to be clearly understood.[3]Control of portions of outer space, be it planets such as Mars/Moon or other planets/comets, is a natural extension of other forms of territorial control. Hence, control of key geographical regions in space and exploiting these for one's own strategic advantage is the thrust area for all space-faring nations. These strategic areas in space include libration points, huge areas where the gravity of one planet counter balances the gravity of another planet. Libration points are, therefore, devoid of any gravity and can house space objects in vacuum-like conditions with minimal requirements of fuel. In 2011, the European Space Agency (ESA) placed the Herschel Space Observatory in one such libration point located 11.5 lakh km away from Earth.

Other goals for the lunar/martian programme could include establishment of a habitat, mining of natural resources and construction of low gravity production lines, and transfer of dangerous manufacturing operations from Earth to the Moon. Even construction of a power system that runs from lunar resources or establishment of propellant production/ astronomical facilities on the Moon/ Mars is envisaged in the future. Which country will be the first to build a permanent outpost/ habitat on the Mars/ Moon or on the other parts of the solar system? These are questions, the answers to which will provide a clue to the nature/ ownership of habitats in space.

India's Chandrayaan-1 Mission

On October 22, 2008, India demonstrated its unique Science and Technology (S&T) prowess in the space sector by launching Chandrayaan-1 from Sriharikota, using the indigenously designed and developed Polar Satellite Launch Vehicle (PSLV), and after a four-day journey, injected it in a lunar orbit, 100 km above the surface of the Moon and at a distance of 3.84 lakh km from Earth. Chandrayaan-1 carried 11 instruments, of which six were developed in India, while the balance five instruments came from abroad. Chandrayaan-1 enabled the Indian Space Research Organisation (ISRO) to see the region of the Moon which has not been studied that well and with its better instruments and capability of observation—it signified a major step in the advancement of our knowledge about the Moon.[4]

These measurements brought the Indian scientists closer to understanding the quest for mineral distribution, the topography of the Moon and its meteoric history. ISRO is now working on the launch of the orbiter-rover-lander mission to the Moon, Chandrayaan-2, the scientific payloads for which are ready. The project is now scheduled for launch in 2017. The lander for the project, to be provided by Russia, as per initial plans, is now being developed indigenously by ISRO. Successful completion of the Chandrayaan-1 mission also validated India's capabilities in high end technologies, complex system engineering, culture of team work and potential for frontier research related to other planetary explorations. ISRO is now well poised to evolve its lunar capabilities further towards a manned lunar landing. Moreover, the mission to Mars also beckoned as the natural next destination for ISRO, the mission planning work for which commenced soon after the conclusion of the Chandrayaan-I mission in 2009.

India's Mars Orbiter Mission (MOM)

Although the mission to Mars was contemplated by the ISRO scientists since 2007 and studies for such a mission also commenced during the

same period, the concept of MOM was formulated utilising the experience gained from Chandrayaan-I by the finalisation of the feasibility report in 2010. The study report was prepared in just three months under the guidance of V Adimurthy, Senior Adviser, ISRO and Dean at the Indian Institute of Space Science and Technology. The project was sanctioned on August 03, 2012. The total project cost is about Rs 454 crore, of which the satellite cost is about Rs 153 crore and the rest of the budget has been used for the ground station and other facilities.

The MOM spacecraft began its journey on November 05, 2013, after a flawless lift-off from Sriharikota using the PSLV rocket C25. The spacecraft spent about a month in Low Earth Orbit (LEO), where it made a series of seven altitude raising orbital manoeuvres before making the trans-Mars injection on November 30, 2013. India achieved yet another strategic milestone in space, thereby enhancing its soft power further, when the ISRO scientists successfully manoeuvred their Mars Orbiter Mission (MOM) spacecraft into the martian orbit, after 298 days transit, on September 24, 2014.[5] With the accomplishment of this project, ISRO became the fourth space agency to do so, after the Soviet Space Programme, NASA and the European Space Agency. Keeping in mind the complexity of a mission to Mars as also the high failure rate of previous martian missions of other nations (the success rate of international missions to Mars is only 42 percent), the first successful interplanetary mission of ISRO is indeed laudable. It may be mentioned here that China's Mars mission, Yinghuo-1, as well as Russia's Phobos-Grunt mission to the Red Planet failed in 2011. India also became the first nation to reach the Mars orbit in its first attempt.

Currently, the MOM spacecraft is orbiting Mars just 421.7 km at its closest point and about 76,993.6 km at the farthest point in an elliptical orbit. The spacecraft is being monitored from the Space Craft Control Centre at the ISRO Tracking, Telemetry and Command Network (ISTRAC) in Bangalore, with support from the Indian Deep Space Network (IDSN) antenna at Byalalu. The 475-kg spacecraft has

five scientific instruments on board to study the surface of Mars for water, methane and its mineral and chemical composition. An important objective is to establish the presence of methane, which, if confirmed, will provide an indication about the existence of life on the Red Planet in some form.[6] The mission is a 'technology demonstrator' project to develop the technologies for design, planning, management and operations of an interplanetary deep space mission. It may be highlighted that a unique aspect of India's MOM project is the cooperation and support that India has received from NASA, whose MAVERN spacecraft was injected into the martian orbit exactly three days before MOM, on September 21, 2014. On September 30, 2014, NASA and ISRO officials signed an agreement to establish a pathway for future joint missions to explore Mars. One of the joint objectives is to explore potential coordinated observations and science analysis between the MAVERN orbiter and MOM as well as other current and future Mars missions.

Mars Mission's Contribution to India's National Security

Another relatively unknown dimension of India's space programme is the vision of ISRO in creating an indigenous industrial base. ISRO has been very successful in indigenous development of technologies, executing technology transfers and ultimately pulling through manufacturing, testing and assembling in Indian industries, both private as well as public industry. This has also percolated to India's ground segment for telecommunication and remote sensing wherein about 20,000 persons are always employed by ISRO. This has helped considerably in the manpower management within ISRO, which allows the premier agency to task the ISRO scientists to concentrate more on meaningful R&D, and the routine manufacture, with good quality and reliability, has been handed over to the industry. Currently, more than half of ISRO's budget is expended by the Indian private industry, proving beyond doubt the substantial use of Indian private industry. There are about 500 odd

industries in the country, small, medium and big, which are used for India's space programme. As regards MOM, as many as 125 Indian firms participated in the project, in areas such as making of the space launch vehicle, payload or ground systems.[7]

India, along with China, leads the world in the development of space-based telemedicine and distance education applications. The Indian model of autonomous space development has inspired many emerging space powers such as Brazil and Turkey.[8] ISRO has demonstrated how through focus and dedication, Indian talent can be harnessed to international levels, catching up with much more advanced nations in a highly technical and sophisticated field. In space technology, Indian scientists stand shoulder to shoulder with the best in the world and the expertise acquired by the Indian space programme over the decades has made ISRO a very important player in any future space related development. Moreover, a viable and vigorous Indian space industry has become a key part of the increasing self-reliance of India. It continues to pursue excellence in every facet of the space/industry relationship to ensure that the industries supporting the space sector are efficient and internationally competitive.[9] ISRO is also taking inspiration from Arianespace, a commercial satellite launch company representing 10 European countries, to create a similar entity in India in the near future. By 2019, it is expected that space related products will start coming out from such an entity.

Lessons for Indian Defence R&D

India, which has excelled in the space sector and which aspires for membership of the Security Council, will have to achieve self-reliance in defence related technology sooner rather than later. As such, the economic and strategic significance of the Indian defence sector is growing day by day due to the dynamic geo-political situation. To achieve substantial self-reliance in the design, development and production of systems required for the defence force, the Indian military needs to adopt the ISRO model. India needs a strong defence industry which is able to

manufacture and help maintain the capabilities which are fundamental for the defence of India.[10] The successful launches and orbital deployment of Chandrayaan-I as well as MOM has not only put India on a high pedestal amongst the select comity of space-faring nations, but has also paved the way for accelerated development of ISRO's future goals such as landing of an unmanned rover on the Moon, human space flight, ASTROSAT, etc. The resounding success of India's Mars mission has demonstrated the country's capability of designing an autonomous spacecraft that travelled for 300 days before entering the Mars orbit.

This validation of India's growing capability to design and develop space related components, will ultimately contribute to enhanced national security in many ways. In future, India along with other space-faring nations, would be aspiring to further hone its technological capabilities in the exploration of the Moon and Mars to improve the national security environment and national technological prestige. Given its brilliant track record, the day is not far off when ISRO will eventually design, develop and launch a lunar as well as martian lander that will deliver a rover and subsequently humans on the surface of the Moon and Mars.

Notes

1. Ronald D Humble, *The Soviet Space Programme* (New York: Routledge, 1988), pp. 106-112.
2. Wilson WS Wong and James Fergusson, *Military Space Power* (California: Praeger, 2010), pp. 2-3.
3. Joseph A Angelo Jr, *Space Technology* (New Delhi: Pentagon Press, 2009), pp. 282-285.
4. Report cited in *The Times of India* (New Delhi), August 24, 2009.
5. For more details, see *Science Reporter*, Vol. 51, No.11, November 2014, pp. 19-22.
6. For more details, see *India Strategic*, Vol. 9, No. 10, October 2014, pp. 6-10.
7. Cited in *The Hindu*, November 20, 2014, p. 11.
8. "Space 2030: Exploring the Future of Space Applications," *OECD Publications* (Paris), pp. 110-111.
9. Ajey Lele, et al., eds., *Space Security and Global Cooperation* (New Delhi: Academic Foundation, 2009), pp. 68-70.
10. SN Mishra, *Impact of Defence Offsets on India's Military Industry Capabilities and Self-Reliance* (New Delhi: KW Publishers, 2012), pp. 106-107.