India's Mars Mission Success: Foundation for Future Challenges

by Ramtanu Maitra

Sept. 27—The transfer from a heliocentric to a Mars orbit, of India's first interplanetary spacecraft, named Mangalyaan (Sanskrit for "Mars craft"), was carried out with clockwork precision, and is a demonstration that Indian space science has achieved a high level of excellence. It also shows what a focused program, with a limited budget, can achieve. By far the most important scientific event of 2014 in India, it should serve as an inspiration for India's millions of youth to participate in the challenging scientific activities that are opening up, and to conquer the scientific frontiers that lie ahead, which will ensure India's rightful position in the community of nations.

Before Mangalyaan began its journey to the Red Planet, Prime Minister Narendra Modi had made clear, both during his electoral campaign and following his election last May, that the future belongs to India's youth, and that that future could be made fruitful only through the advancement of science and technology to eliminate poverty, and attain a higher level of economic prosperity for its 1.2 billion people.

A Spectacular Achievement

The process of Mangalyaan's successful journey to Mars orbit is indeed spectacular. Achieved with a budget of $75 million—much less than the cost of producing space movies in Hollywood—it was a scientific triumph. That triumph was built upon a foundation that is rock solid. Mangalyaan is a "technology demonstrator" project, aiming to develop the technologies required for design, planning, management, and operation of an interplanetary mission. It carries five instruments, one of which in particular, a methane detector, will advance knowledge about Mars.

Beginning in the 1970s, the Indian Space Research Organization (ISRO) developed a series of launch vehicles, and now has settled on two basic vehicles, the Polar Satellite Launch Vehicle (PSLV) and the Geo-Stationary Launch Vehicle (GSLV) for sending satellites and spacecraft into orbits. Mangalyaan was launched into Earth orbit by PSLV 25 on Nov. 5, 2103. PSLV and GSLV routinely launch navigation, communication, and Earth observation satellites. The success

PIB of India

Prime Minister Modi, addressing the nation from Mission Control at the Indian Space Research Center following the successful launch into Mars orbit of Mangalyaan, told the scientists, "Through your achievements, you have honored our forefathers, and inspired our future generations, and through your brilliance and hard work, you have made it a habit of achieving the impossible."

rate of these launches is extremely high, indicating a high level of excellence of the larger ISRO team.

In 2008, ISRO launched a Moon orbiter, Chandrayaan-1, its first lunar probe, which operated for almost a year. ISRO also has a plan to send a Moon orbiter, a lander, and a rover, packed inside the Chandrayaan-2 spacecraft in the coming years. The plan calls for launching the orbiter-lander-rover pack into a lunar orbit of 100 km x 100 km. The lander would separate from the orbiter in lunar orbit. The orbiter, with scientific payloads, will continue to orbit the Moon, while the lander will soft-land on the Moon at a specified site, and deploy the rover. The scientific payloads onboard the orbiter, lander, and rover are expected to perform mineralogical and elemental studies of the lunar surface.

The Chandrayaan 2 orbiter, lander, and rover would be launched as a composite stack into the Earth Parking Orbit (EPO) by GSLV-Mk II. The orbiter would then boost the stack toward the Moon to achieve lunar orbit insertion (LOI).

India's Thorium Reactor

The year 2014 is also notable for India's advancement in another frontier technology—nuclear power generation. Last February, the chairman of India's Atomic Energy Commission, Dr. R.K. Sinha, announced the design completion of its long-sought thorium-fueled nuclear reactor, known as the Advanced Heavy Water Reactor (AHWR). The AHWR is slated to form the final stage in India's three-stage fuel-cycle plan. The building of a 300-MW prototype reactor will begin in 2016, and the first megawatt of electricity is expected to be generated by 2025. The AHWR will be fueled by a mix of uranium-233—which will be converted from thorium by previously deployed and domestically designed fast breeder reactors—and plutonium, generated by the second-stage fast breeder reactors now under development. This design completion has placed the Indian nuclear science program in the forefront of the world's nuclear development.

India's second-stage reactor, a 500-MW prototype fast breeder reactor (PFBR), is now at an advanced stage of development, and is scheduled to be operational later this year. It will be one of only three commercial-size, sodium-cooled, fast operational reactors in the world. The Russian BN-800, which is also sodium-cooled, is reported to be scheduled for commissioning at the end of the year. The BN-800's predecessor, the BN-600 at Beloya, has a capacity of 600 MW, and is fully operational.

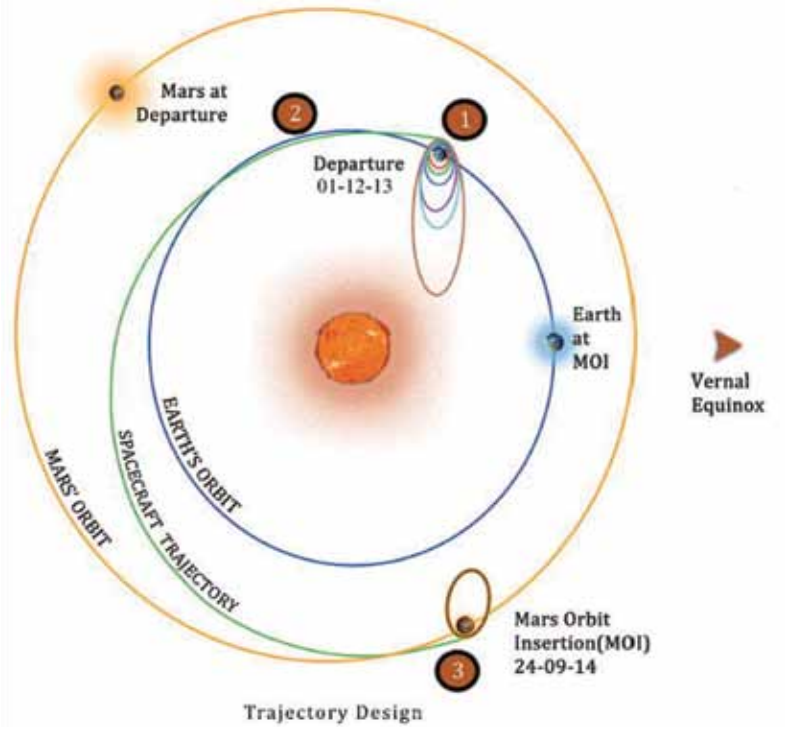
Prime Minister Modi is relying on these successes to provide electricity to the nearly 400 million Indians who are still without it, and to provide potable water to the many millions who lack it. In addition, he hopes to make India one of the the world's foremost centers for manufacturing industrial products. He was present at the ISRO's Mission Control Center, along with the space scientists, as Mangalyaan successfully entered Mars orbit on the morning of Sept. 24.

Elated by the success, Modi addressed the scientists in Hindi, mixed with English. Congratulating the assembled scientists, he said, "Through your achievements, you have honored our forefathers, and inspired our future generations, and through your brilliance and hard work, you have made it a habit of achieving the impossible."

Then, he quoted from Rabindranath Tagore's (1861-1941) oft-cited poem that honors the human spirit and aspirations:

> "Where the mind is without fear and the head is held high
> Where knowledge is free
> Where the world has not been broken up into fragments
> By narrow domestic walls
> Where words come out from the depth of truth
> Where tireless striving stretches its arms toward perfection
> Where the clear stream of reason has not lost its way
> Into the dreary desert sand of dead habit
> Where the mind is led forward by Thee
> Into ever-widening thought and action
> Into that heaven of freedom, Father, let my country awake."

What is indeed necessary, is the awakening of India. It is time for the Indian Space Research Organization to reach out to youth, the way NASA has done, to inspire students around the globe, who now dream of joining the cutting-edge space research of NASA. Already, the Planetary Society, India (PSI) has begun to utilize India's Mars Orbiter Mission to set up awareness groups in city schools, beginning November 2013, when Mangalyaan was launched. "We have received a very good response from school students who have displayed a lot of interest in astronomy. A concerted effort along with government agencies to make astronomy popular is needed," a PSI official said.



ISRO

The Mangalyaan mission consists of three phases: 1. a geocentric phase of looping around the Earth using an energy-efficient Hohmann Transfer Orbit; 2. a heliocentric phase, tangentially departing Earth orbit, and tangentially entering Mars orbit through a half-ellipse around the Sun; and 3. a Martian phase, looping around the planet in a hyperbolic orbit.

The conditions for encouraging such efforts are indeed ripe. Premier Modi, in addition to participating in Mangalyaan's final journey with the scientists, was also present when ISRO launched five foreign-owned satellites into orbit on June 30. At the time, he urged ISRO to develop a SAARC (South Asian Association for Regional Cooperation, including Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka) satellite which can be dedicated as a "gift" to its neighbors. "Today I ask you, the space community, to take up the challenge of developing a SAARC satellite that we can dedicate to our neighborhood as a gift from India," he said from ISRO's Mission Control Room. "Such a satellite will be helpful in SAARC nations' fight against poverty and illiteracy, the challenge to progress in scientific fields, and will open up avenues to provide opportunities to the youth of SAARC countries."

Modi's commitment to nation-building centers on science and technology, and especially on involving the youth. At the BRICS Summit at Fortaleza, Brazil, in mid-July, he said BRICS should in fact be driven by "people-to-people" contact. "Our youth, in particular, must take a lead in this. BRICS should explore developing innovative mechanisms of youth engagement. A positive initiative could focus on nurturing innovation, by establishing a BRICS Young Scientists' Forum."

The BRICS nations' commitment to science and technology, and in developing the younger generation to further those frontiers, along with Modi's eagerness to promote these policies, have begun to generate results. This month, Russian Vice-Minister of Education and Science and Technology Alexander Povalko, on a visit to India, discussed closer collaboration between the two nations in scientific education and economic growth. In New Delhi, he met with Minister of State for Science and Technology and Earth Sciences Jitendra Singh; the Russian minister agreed to develop joint India-Russia science and technology centers, and to promote technology transfer between them. He also invited Indian scholars to make use of the newly established Skolkovo Institute of Science and Technology, outside Moscow.

The Skolkovo Institute will provide graduate education programs in scientific research, entrepreneurship, and innovation. Skoltech will award Masters and PhD degrees in its five education programs, corresponding to the priority areas for the Skolkovo project: Information Technology; Energy Science and Technology; Biomedical Science and Technology; Nuclear Science and Technology; and Space Science and Technology.

A new book by Stanford University researchers, *University Expansion in a Changing Global Economy: Triumph of the BRICS?*, reports on how four of the BRICS, Brazil, Russia, India, and China, are pouring money into their elite colleges in an effort to create world-class institutions, which will prepare their graduates to compete with the United States and Europe.

"In the past 20 years, university systems in these big countries have just exploded," said co-author Martin Carnoy, a Stanford professor of education. These four nations together increased the number of undergraduate students from about 19 million in 2000, to more than 40 million in 2010. The largest increase was in China, which went from fewer than 3 million, to almost 12 million bachelor's degree students during that period, the Stanford study said.