MARS ORBITER MISSION

MARS Exploration - Significance

- Of all the planets in the solar system, Mars has sparked the greatest human interest as the conditions in Mars are believed to be hospitable since the planet is similar to Earth in many ways. Mars has surface features reminiscent of both the impact craters of the Moon and volcanoes, deserts and polar ice of Earth.

- Mars and Earth have almost equal period of revolution around its axis. Mars takes 24 hours and 37 minutes to complete one revolution around its axis. While Earth takes approximately 365 days to orbit around the Sun, Mars takes 687 days for the same. The gravity of Mars is roughly one- third of Earth's gravity and it has a thin atmosphere with a pressure of 1 % that of Earth.

- For ages, humans have been speculating about life on Mars. Recent discovery of Methane on Mars suggest that life could exist on Mars. It entails more and more understanding of the Martian surface, its topography, geology, landforms, mineralogy, and its upper atmosphere to understand the evolution of universe.

- The Indian Mission to Mars is primarily intended to establish Indian technological capability to reach the Mars, orbit around it and also provide an excellent opportunity, to the scientific community, to further understand the Martian Science. Also, having demonstrated the technological capability in reaching the Moon, the next logical step go forth into interplanetary space is Mars.

Indian MARS Orbiter Mission

- Mars Orbiter Mission is ISRO's first interplanetary mission with an orbiter craft designed to orbit Mars in an elliptical orbit of 366 km x 80000 km. Mars Orbiter Mission (MOM) is a complex technological mission considering the critical mission operations and stringent requirements on propulsion, communications and other bus systems of the spacecraft.

- Being the first Indian mission to the planet Mars, the primary technological objective is to design and realize a spacecraft with a capability to - perform Earth Bound Manoeuvre, reach Mars (*Martian Transfer Trajectory*) with the least amount of fuel, Mars Orbit Insertion and then to orbit around Mars. It has been configured to undertake limited scientific studies during the orbital life of the spacecraft, using the five Indian scientific instruments onboard to study the Mars surface and its atmosphere.

Scientific Instruments (Payload) on the Orbiter

Science Theme	Payload	Primary objective
Atmospheric studies	**Lyman Alpha Photometer (LAP)**	Measures relative abundance of deuterium and hydrogen. Measurement of Deuterium /Hydrogen (D/H) Ratio allows understanding of the loss process of water from the planet.
	Methane Sensor for Mars (MSM)	Measures Methane (CH4) in the Martian atmosphere with high level of accuracy and map its sources.
Plasma and Particle environment studies	**Mars Exospheric Neutral Composition Analyser (MENCA)**	Map neutral composition in exosphere, Martian upper atmosphere
Surface Imaging studies	**Mars Color Camera (MCC)**	This tri-color Mars Color Camera gives images of Martian surface. It is useful for monitoring the dynamic events and weather of Mars. It will also be used for probing the two satellites of Mars – Phobos and Deimos.
	TIR imaging spectrometer (TIR)	Measures thermal emission and can be operated during day & night. It will map the surface and mineral composition of Mars.

Technological Challenges of Mars Orbiter Mission

- To provide robust thermal environment and augmented radiation shielding to the spacecraft & payloads to cope with a wide range of thermal environment (*from Near Earth conditions to Mars conditions*) and harsh radiation conditions due to prolonged exposure.

- To build a robust and reliable propulsion system (*Liquid Engine*), which needs to restart after almost 300 days of voyage to insert the spacecraft into an orbit around Mars.

- To build high level of onboard autonomy within the Orbiter to deal with communication delay of the order of 40 minutes. Autonomy logics manage the spacecraft when communication interruptions occur when – (i) the spacecraft is occulted by planet Mars; (ii) Whiteouts/ Blackouts due to Sun; (iii) spacecraft enters Safe-mode

- To augment Deep Space Network to be able to command the spacecraft from the ground station when it is at a distance of nearly 400 Million km, which is 1000 times more than the distance Moon and earth.

Launch and Post Launch Orbit Maneuvers

- The country witnessed with pride, when India's first interplanetary spacecraft “Mars Orbiter” was successfully launched on November 05, 2013 at 2:38 pm by India's Polar Satellite Launch Vehicle PSLV-C25 from Satish Dhawan Space Centre. Mars Orbiter was precisely injected into an elliptical earth orbit (with a perigee of 248.4 km and an apogee of 23,550 km, inclined at an angle of 19.27 deg to the equator).

- Subsequent to the six orbit-raising manoeuvres, crucial the Tran-Mars Injection Manoeuvre was precisely executed on December 1, 2013 and the Spacecraft was placed on course to the Red Planet along a helio-centric path of 680 million km.

Mars Orbit Insertion on 24th Sep 2014

- After a 300 days journey in deep space, on September 24, 2014, India's Mars Orbiter Spacecraft successfully entered into an elliptical orbit around planet Mars by firing its 440 Newton Liquid Apogee Motor along with eight smaller liquid engines.

- With successful Mars Orbit Insertion, ISRO became the fourth space agency to successfully send a spacecraft to Mars orbit and India became the first country in the world to do so in its first attempt.

Mars Orbiter Successfully handled Solar Conjunction

- Solar Conjunction is a natural phenomenon in which the Mars, the Sun and the Earth get aligned. Such alignment affects all communication signals from Mars Orbiter towards the Earth. Mars Orbiter is built with onboard autonomy to handle such blackout operations.

- Mars Orbiter went under ‘solar conjunction’ at Mars, which means the Orbiter, which is orbiting Mars, is behind the Sun as viewed from the Earth. As a result of this event, which happens once in 2.2 years for Mars, communication signals from the spacecraft are severely disrupted by the Sun’s corona (outer atmosphere).

- Mars Orbiter was under solar conjunction from May 27th to 1st July 2015. The communications from ground to spacecraft were totally stopped with effect from May 28, 2015. No commands were transmitted to the spacecraft during this period and all payload operations were suspended.

- In the month of July, 2015; the Mars orbiter successfully came out of the solar conjunction. It is worth mentioning that No reconfiguration of the spacecraft was required, as the on-board autonomy properly functioned.

Current Status

- India's Mars Orbiter Mission (MOM) has completed one year around Mars on September 24, 2015 and accomplished its planned mission objectives. MOM and all its scientific payloads are in good health and it continues to provide valuable data of Mars surface and its atmosphere. The increased duration of observation of Mars by five scientific payloads will enhance the planetary science data and would also enable coverage of Mars in different seasons.

- The images of Mars captured by the Mars Colour Camera have been received and found to be of very good quality. The Mars Colour Camera has so far produced 513 images.

- Joint morphological studies using MCC and the high resolution mineralogical data with the NASA CRISM data was carried out, which enables the identification of different compounds like sulphates and ferrous based compounds.

- The dust patterns around high altitude regions and in Valles were studied and mean height of dust layer was estimated to be ~1.5 km. Albedo using the 1.65 micron studies of the reference channel of Methane sensor for Mars (MSM) was also estimated.

Significant achievements & Recognitions

- First interplanetary mission realized by India and first Indian spacecraft to incorporate full scale on-board autonomy to overcome the long distances and the communication gaps due to non-visibility periods.

- First Mars mission in the world to succeed Mars Orbit Insertion in first attempt.

- First Indian spacecraft to successfully survive Van Allen belt crossing 39 times. First Indian spacecraft to escape the Sphere Of Influence of Earth and orbit Sun.

- Most economical interplanetary mission in the world and paved way for cost-effective access to deep space.

- Indian Space Research Organization (ISRO) - Mars Orbiter Mission (MOM) team won the US based National Space Society's "Space Pioneer Award" for science and engineering category for the year 2015.

- The Indira Gandhi Prize for Peace, Disarmament and Development is awarded to ISRO in recognition of its path-breaking achievement, culminating in Mars Orbiter Mission, its significant contribution in strengthening international cooperation in peaceful use of outer space.

IRNSS: Indian Regional Navigation Satellite System

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide the position and timing services through an independent Indian regional navigation satellite constellation of seven satellites. The main objective of IRNSS System is to provide positioning services with an absolute position accuracy of better than 20 meters over Indian Land Mass and a region extending to the about 1500 Kms around India.

IRNSS consists of seven satellites in a constellation, three satellites in geostationary orbit (GEO) and four satellites in geosynchronous orbit (GSO) with inclination of 29° to the equatorial plane. Three GEO satellites placed at 32.5°E, 83°E & 131.5°E orbital locations and two geosynchronous satellites each placed in the GSO with an equator crossing at 55°E & 111.75°E with an inclination of 29°.

A first four IRNSS satellites viz., IRNSS-1A, 1B, 1C and ID were successfully launched on July 02, 2013, April 04, 2014, October 16, 2014 and March 28, 2015 respectively and are already operational in orbit. With the operationalisation of four navigational satellites in orbit, it is now possible to provide Position, Navigation and Timing services.

❖ **Launch of Fifth IRNSS Satellite - IRNSS-1E:**

ISRO's Polar Satellite Launch Vehicle, PSLV-C31, successfully launched the 1425 kg IRNSS-1E, the fifth satellite in the Indian Regional Navigation Satellite System (IRNSS) on January 20, 2016 at 09:31 hrs (IST) from Satish Dhawan Space Centre SHAR, Sriharikota. This is the thirty second consecutively successful mission of PSLV and the eleventh in its 'XL' configuration.

IRNSS-1E Satellite was injected to an elliptical orbit of 282.4 km X 20,655.3 km inclined at an angle of 19.21 degree to the equator (very close to the intended orbit). After injection, the solar panels of IRNSS-1E were deployed automatically. In the coming days, four orbit manoeuvres will be conducted from Master Control Facility to position the satellite in the Geosynchronous Orbit at 111.75 deg East longitude with 28.1 deg inclination.

A number of ground stations responsible for the generation and transmission of navigation parameters, satellite ranging and monitoring, etc., have been established in eighteen locations across the country.

❖ **Applications:**

- Terrestrial, Aerial and Marine Navigation
- Disaster Management, Vehicle Tracking , Fleet Management
- Precision timing applications viz. distributed survey systems, power grid synchronization
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers