FEATURES

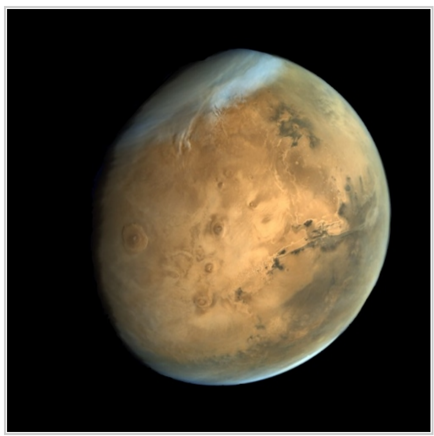
doi:10.1038/nindia.2014.152 Published online 10 November 2014

What is India's Mars mission looking at?

It's been more than a month that India's ambitious Mars Orbiter Mission *Mangalyaan* started orbiting the red planet. *Nature India* takes stock of what the country's first ever inter-planetary mission is doing right now.

GBSNP Varma

On 24 September 2014, Indian Space Research Organisation (ISRO) became the fourth space agency to have successfully placed a probe in the Martian orbit after the Americans, Russians and Europeans. By October 1, all five instruments onboard ISRO's Mars Orbiter Mission (MOM) were activated and the roughly six-month long science mission began. The Mars Color Camera (MCC) sent back pictures of Mars on arrival.



Full view of Mars globe photographed by MCC
© ISRO

In the months ahead, MOM's primary scientific tasks would be to study the Mars surface features, morphology, mineralogy, and atmosphere. MOM has 5 indigenously-built instruments onboard to do all this: Lyman Alpha Photometer (LAP); Methane Sensor for Mars (MSM); TIR Imaging Spectrometer (TIS); Martian Exospheric Neutral Composition Analyzer (MENCA) and Mars Color Camera (MCC). MOM's mission will go on for a nominal period of about 6 months. If there is enough fuel, and the spacecraft doesn't go into a long Mars eclipse, the spacecraft is expected to work for 10 months.

Exploring the Mars-water link

On board MOM is the Lyman Alpha Photometer (LAP) operating in the far ultra-violet region to measure the ratio of deuterium to hydrogen in the Martian atmosphere. The photometer would measure the relative abundance of these elements from emissions in the upper atmosphere of Mars.

Mars once had water and was wet. Later, the water vanished, making it a parched planet. Scientists think the loss of water could be due to the gravity of Mars, which is not powerful enough to retain its atmosphere.

The ratio of two forms of hydrogen in the atmosphere could help estimate how the loss occurred. The hydrogen atom contains one proton (and an electron) in its nucleus. Its isotope deuterium has an additional neutron. Water which contains deuterium is heavier, and thus cannot escape Martian atmosphere, like the lighter hydrogen. A higher deuterium to hydrogen ratio, therefore, could indicate higher loss of water.

Analysing why Mars loses its atmosphere

With a 3.56 kg neutral mass spectrometer called the Mars Exospheric Neutral Composition Analyser (MENCA), scientists are studying the composition of Mars' upper atmosphere and exosphere. "The exosphere is a region where molecules and atoms do not collide, and MENCA will study the gases present there in the molecular or atomic form and tell us what they are," says Anil Bhardwaj, MENCA's principal investigator at the Space Physics Laboratory, Vikram Sarabhai Space Centre, Trivandrum.

The Martian atmosphere is composed of 95% carbon dioxide (making it unfit for life), nitrogen, oxygen, argon, and carbon monoxide. It also has some hydrogen and deuterium. They don't collide with each other and the atmospheric density is low. Where MOM is orbiting, mostly lighter species are expected.

"One of the major aims of MENCA is to find out how these densities are distributed as you go away from Mars," Bhardwaj says. The instrument measures the atomic mass of these thermals in the range of 1 AMU to 300 AMU (atomic mass unit).

Knowing their distribution can help the scientists construct a radial profile of gases. This profile can help pinpoint locations where these atoms have thermal energy higher than their gravitational binding energy. If the former is more than the latter, atoms/molecules escape, draining the Martian atmosphere.

Another way Mars loses its atmosphere is due to the impact of solar winds, the Sun's energetic plasma that perpetually rains down on the Mars surface at around 400 km per second. It bombards the gases in the Martian atmosphere, splitting elements and gases, stoking their velocities, and making them escape the Martian atmosphere.

All of this happens because Mars has no magnetosphere. The Earth, on the other hand, has a magnetosphere extending close to 60,000 km – an armor protecting Earth from solar wind all the time.

Following the methane

It has been the endeavor of rovers and orbiters, especially that of NASA's Curiosity rover, to find out if Mars could ever have supported life.

Apart from water, methane is a signature of life, and so, scientists have always tried to 'follow the methane'[1] in their search for signs of life. "*Mangalyaan*'s arrival at Mars presents a unique opportunity for simultaneous observations of the upper atmosphere of Mars by MOM and NASA's MAVEN mission. It will also help study the synergy between MOM and the MSL/Curiosity rover, particularly concerning methane, a potential signature of life," says Sushil Atreya, Director of the Planetary Science Laboratory at the University of Michigan.Of the 1850 parts per billion of methane in the earth's atmosphere, 90-95% is of biological origin, he adds.

MOM has a Methane Sensor for Mars (MSM) which can sniff methane. Weighing 2.95 kg, the instrument measures the column density of methane in the atmosphere of Mars. By scanning the Mars disc, MSM can get a global map of methane within few orbits. MSM's principal investigator Kurian Mathew of Space Application Center (SAC), Ahmedabad, says they are already analyzing two frames of data received from MSM.

"There is no unanimity of opinion among planetary scientists about the presence of methane in the Mars atmosphere or its origin. Methane may be of biotic or abiotic origin," Mathew says. MSM measurements will not give any direct answer to this question. But by correlating the spatial and temporal distribution of methane to other geophysical parameters, the scientists are hoping to get further insights.

Scratching the Martian surface

What are the various types of surfaces on Mars? MOM scientists are seeking answers to this by measuring the thermal inertia of the Martian surface. They plan to do this by employing a 3.2 kg thermal infrared imaging spectrometer (TIS) that detects electromagnetic radiation from the surface of Mars between 7 and 13 micrometer wavelength.

A heated body emits electromagnetic radiation at different wavelengths. A spectrometer is used to pick up this radiation in specific wavelength regions. Higher emitted radiance observed from blackbody surface generally means high brightness temperature; less emission means less brightness temperature of the surface. Emitted thermal infrared spectra from Mars contain specific absorption features. Precise detection of specific spectroscopic features allows estimation of surface composition and atmospheric parameters of a planet.

"Since temperature change is because of the varying incident solar radiation and property of the surface, TIS can help in knowing the thermal inertia of the surface by observing diurnal variation in temperature,"says TIS principal investigator Raghavendra Pratap Singh of SAC, Ahmadabad. "Thermal inertia property helps us to know about the surface types on Mars."

The instrument is aimed to detect temperature variability of the planet and study the surface composition.

Profile pictures worth thousands of 'likes'

By far the most visible of MOM operations, the Mars Color Camera (MCC) has been sending some breathtaking pictures from right after orbital insertion.

"We have got the full disc, the full globe of Mars," says Ashutosh S. Arya, MCC's principal investigator from SAC, Ahmadabad. MCC took the picture close to equatorial region (30 degrees) of Mars. There's only one camera, other than MCC, currently capable of capturing theentire planet in a single frameand that is theVisual Monitoring Camera (VMC) onboard the Mars Express which usually sends half-lit or crescent phase pictures over the poles. So MCC is unique in sending pictures that cover the maximum illuminated surface area of the Mars disc regularly. It is also closest to the equatorial plane unlike any other contemporary camera system.

Phobos, the natural satellite of Mars
© ISRO

The 1.27 kg instrument, size of a standard laser jet printer, zoomed in on Mars from the same hemisphere view as theHubble telescope did in 2003. The MCC image has better clarity and details, Arya says.

"MCC will study the morphological features, and cloud / dust patterns of Mars in different time frame & seasons. By comparing multi-temporal pictures, we will be able to know how long, and where and why a particular phenomenon such as dust storm occurs and lasts," Arya adds.

The scientists are studying formation, development and disintegration of dust clouds over a given period of time. Circling Mars in an elliptical orbit, MCC comes closest to Mars at an altitude of 425 km when it can take pictures with 20-23 metre resolution. When the instrument goes as far away as 76,000km, it can take pictures of 3.5-3.6 km resolution. That helps, Arya says, in comparing pictures taken at different times, weeks, and months and will help in knowing how the Martian atmosphere changes or how it behaves in different seasons.

Philosophy behind the suite of instruments

Somya S. Sarkar, Associate Project Director of MOM Payloads and his team made the three instruments – TIS, MSM, and MCC – at SAC. "For each of these instruments, we developed three models: verification, qualification, and flight," he says.

All these instruments were chosen to support each other's science gigs. MCC and MSM require reflected sun light to take images and measurements. MCC and TIS are complementary. MCC takes photos in the region of approximately 0.5 micrometer (visible light), MSM picks up distinct spectra in the region of 1.650 micrometer (short wave infrared region, SWIR) and TIS detects them in relatively higher wavelength in the region of 7 to 13 micrometer thermal infrared region.

"It gives a handle to analyze various processes. The basic philosophy of the suite of instruments is to observe in distinct spectral regions such as visible, short wave infrared and thermal infrared electromagnetic region," Singh says.

References

1. Sanderson, K. Planetary science: A whiff of mystery on Mars. *Nature* **463**, 420-421 (2010) doi: 10.1038/463420a

natureINDIA

Home | Archives | Our picks | Jobs | Events | Blog | Forum | Special features | About

Nature India EISSN: 1755-3180