MARS COLOR CAMERA ONBOARD MARS ORBITER MISSION: SCIENTIFIC OBJECTIVES & EARTH IMAGING RESULTS. A.S. Arya*, R.P. Rajasekhar, Prakash Chauhan, S.S. S arkar, S. Manthira Moorthi, Vishnu Patel, Sampa Roy, Indranil Misra, Rajdeep Kaur Gambhir, Kamlesh K Patel, Ajai, A.S. Kiran Kumar, SpaceApplications Centre, Indian Space Research Organization, Ahmedabad, India. *arya_as@ sac.isro.gov.in.

Introduction : Mars Orbiter Mission (MOM), the interplanetary mission of Indian Space Research Organisation (ISRO), launched on November 5, 2013 is a maiden Indian attempt towards sending orbiters to other planets of our solar system**.** The mission has a highly elliptical Martian orbit imaging from 372 km (Periareion) to 80,000 km (Apoareion). The designed mission life is six months after Mars insertion on September 24, 2014**.** MOM has many laurels to its credit in terms of cost-effectiveness, weight-budget, short period of realization, miniaturisation of five heterogeneous science payloads, text book precision of launch and post launch maneuvers.

The Payload: Mars Color Camera (MCC) operates in visible range (0.4 to 0.7 µm) and uses RGB bayer pattern. Its IGFOV varies from 19.5 m to 4 km. The detector array has 2048x2048 elements on a pixel pitch of 5.5µ. The sensor is driven by a custom built electronics designed around the detector [1]. MCC (Fig. 1) is among the five science payloads onboard MOM. It has 16 different modes of exposures, aimed at imaging the Mars surface with moderate scientific objectives.

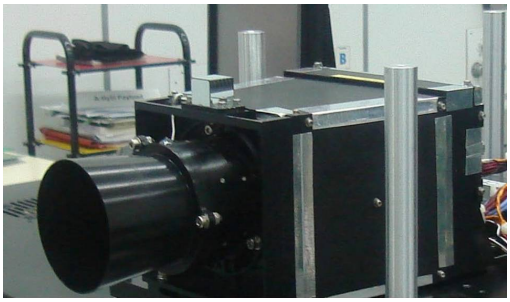

Fig. 1 : Mars Color Camera – Flight Model

Scientific Objectives : MCC is expected to meet the following scientific objectives: -

Surface features: To image the surface features of Mars with varying resolution and scales using the unique elliptical orbit. This includes the craters, mountains, valleys, sedimentary features, volcanic features, rift valleys, mega faults etc. on the surface of the Mars.

Methane Source : To map the geological setting of area around Methane sources picked up by the fellow sensor onboard MOM, the MSM (Methane Sensor for Mars).

Polar Ice Caps**:** To map Martian polar ice caps and its seasonal variations.

Dust Devils : To monitor dynamic behaviour of the dust `devils' or dust-storms over six months.

Exo-Mars studies : Besides Mars, there will be attempt for opportunistic imaging of Phobos and comet during the elliptical orbit around Mars.

Context Information : One of the most important task of MCC is to provide contextual information for other science payloads onboard MOM. This will help interpret the science from the other sensors in a better way. Due to highly dynamic nature of Martian atmosphere and surface every mission needs to carry its own imaging camera and hence MCC.

Data Product Schema : An MCC image is a Bayer filter mosaic, a color filter array (CFA) for arranging RGB color filters on a square grid of photo sensors. The demosaicing algorithm is employed to reconstruct a full color image. Level-1 product (calibrated data) generation involves detector wise photo response non-uniformity model correction as understood from pre launch laboratory calibration exercises; line/pixel loss correction and tagging the geographic coordinates to each pixel. Level-1, corrected are generated for users. The software pipeline produces calibrated data to generate minimum Planetary Data System (PDS) compliance product.

Earth Imaging Experiments (EIE): EIE were conducted during the Earth Orbit Phase (EOP) in order to assess the application potential of MCC vis.a.vis the objectives envisaged. Three imaging sessions on two different dates viz. Two sessions on 19th November and one session on 23rd November 2013, were conducted. This included imaging from varying – altitudes, spatial resolution, illumination conditions, taking multiple snap-shots of a given area of interest (AOI) in order to view Physiographic, Morphologic and other geological details of our planet so as to ascertain the expected results from highly elliptical Mars Orbit. The imaging sessions were chosen to get favorable sun angle/ Spacecraft Yaw axis / Phase angle combination. During EIE, there were five major objectives – (1) To image India for outreach purpose (2) To image Earth from Mars Apoaxis equivalent (about 60,000 – 70,000 km) and (3) To Image at resolution of 1 km. The altitudes, spatial resolutions and exposure modes required for

selected science targets on Mars have been assessed, qualified and ascertained in terrestrial orbit.

EIE Results : The first photograph (Fig. 2) was taken on 19th November, 2013 (0820 UT) from an altitude of 67,975 km with 3.5 km spatial resolution, swath 7,240 km and 0.4 msec integration time. Three consecutive snap shots, separated by one second each, were taken and a high dynamic range product was generated (Fig. 2). The enhanced land surface features in the HDR image are clearly seen. India was imaged with minimal cloud cover.

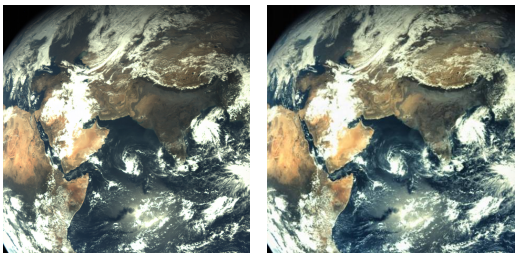

Fig. 2: Single frame (left) and 3-frame high dynamic range images (right)

The major physiographic zones of India viz. Himalayan range (white color), the Indo-Gangetic plains (grayish) , the Thar desert (beige color) and the southern peninsula (dark) were picked up distinctly. The `Helen' cyclone in Bay of Bengal was picked up before its landfall. Other features in the image shows parts of Sahara and Arabian deserts (bright color), Trans-Himalayan Tibetan plateau, fertile Indus valley and variety of cloud patterns. The Modulation Transfer Function (MTF) of an image is estimated at Land / Ocean boundary (Fig.3) was 10.2 % which matched with the pre-launch Lab tests of MCC.

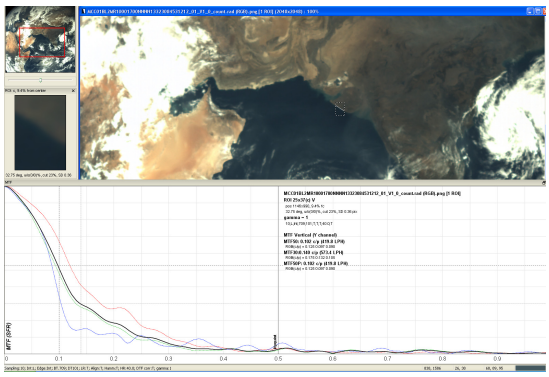

Fig. 3 : MTF estimation across land / ocean boundary

Another imaging session over the Sahara desert was carried out on Nov 23, 2013 (0900 UT) from an altitude of 18,746 km. The spatial resolution was 0.91km. Many Martian morphological analogues like barchans, longitudinal sand dunes, parabolic dunes, volcanic rock outcrops, Aeolian corridors (streaks) could be mapped using this image (Fig 4).

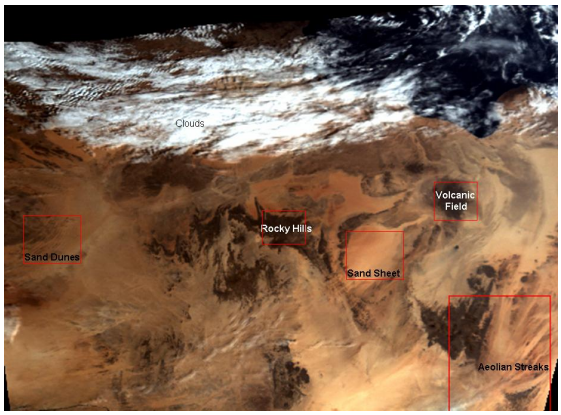

Fig. 4 : MCC image over Sahara desert showing some Martian morphological analogues of eolian and volcanic origin.

The experiment has been successfully conducted and it has yielded satisfactory results. MCC is expected to give images of desired quality during rest of the Mars Mission.

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Reference: [1] Mars Color Camera team (2013), Pre-shipment review (PSR) document of Mars Color Camera of Mars Orbiter Mission, Sensor Development Area, Space Applications Centre (SAC-MOM-04-April 13).