MARS ORBITER MISSION: SCIENCE DATA PRODUCTS AND ARCHIVE PIPELINE. S.Manthira Moorthi*, A.S.Arya, Kurien Mathew, R.P.Singh, Prakash Chauhan, S.S.Sarkar, Sampa Roy, Arvind K Singh, Meenakshi Sarkar, Ajay Kumar Prashar, K. Suresh, Indranil Misra, Rajdeep Kaur Gambhir, Arpita Gajaria, Ashutosh Gupta, Tanul Gupta, D.Dhar, T.P.Srinivasan,K.Padia, R. Ramakrishnan, B.Gopalakrishnan,S.Chowdhury,A.S. Kiran Kumar, Space Applications Centre, Indian Space Research Organization, Ahmedabad–380 015 (India), smmoorthi@sac.isro.gov.in*

Introduction: Mars Orbiter Mission (MOM) achieved intended orbit around Mars on 24th September, 2014.It carries five scientific instruments onboard for surface, lower and upper atmospheric studies [1]. Science data processing activities are streamlined to facilitate data analysis by science teams. This paper highlights data processing activities that are carried out operationally before arriving at scientific results from MOM including the value addition to instrument data sets. MOM science data processing activities include, transforming telemetry data comprising both primary and ancillary into different levels of science data products processed for radiometry and geometry aspects following established universal standards to incorporate all acquisition, calibration information, processing context details to be archived for long term use.

Mars Orbiter Mission Data Pipeline: The ground segment for MOM comprises four major elements, namely Deep Space Network (DSN), Spacecraft Control Center (SCC), Indian Space Science Data Center (ISSDC) and Payload Operations Centre (POC). The ground segment is responsible for making the data available for the scientists along with auxiliary information, in addition to storage of payload, spacecraft data and product to identified users [3]. Science and housekeeping telemetry arrives at the ISSDC in form of telemetry packets. Within the ISSDC the raw science data is transformed into Level-0 data product that is uncalibrated in Planetary Data Standards (PDS) compatible files. Spacecraft transmits data both primary (instrument data) and auxiliary (house keeping data) in a manner through onboard hardware and received using identified specialized ground systems known as Payload Data Acquisition System (PACQ) as shown in Fig-1. If the primary data or science data is compressed onboard for reducing data rates, will be decompressed in ground processing. Both primary and ancillary data is placed to the storage identified at data archive centre ISSDC.

MOM data processing system (Fig-1) is an automation-intensive in-house developed software solution to streamline the work flow in a processing chain for Methane Sensor for Mars (MSM) a differential radiometer based on Fabry-Perot etalon filter, Thermal Infrared Imaging Spectrometer (TIS) using an uncooled micro bolometer and Mars Color Camera (MCC) RGB bayer camera, Lyman Alpha Photometer (LAP) and Mars Exospheric Neutral Composition Analyser (MENCA) data sets. Data processing system processes instrument data for edited and calibrated, derives meta data about mission events, spacecraft operations, instrument operations, processing parameters, orbit and housekeeping details from ancillary data to generate data products following PDS standards. Data Processing system also produces "Active Archive" for raw and calibrated data for instruments mentioned above, is minimum PDS compliant which will be accessed by instrument specific Principal Investigator (PI) community; this archive will reside at ISSDC as well as payload operations centres. The onboard data handling system handles all five payload data and auxiliary data. Quick Look Display (QLD) uses packet data to provide a quick display of data as a first quality check (Fig.1). First processing step for MARS mission captures all packet processing requirements of payload data and auxiliary data and transfers decompressed, formatted, time tagged payload data with OAT and HK information to next level processing steps involving radiometric processing, geometry tagging and PDS conversion.

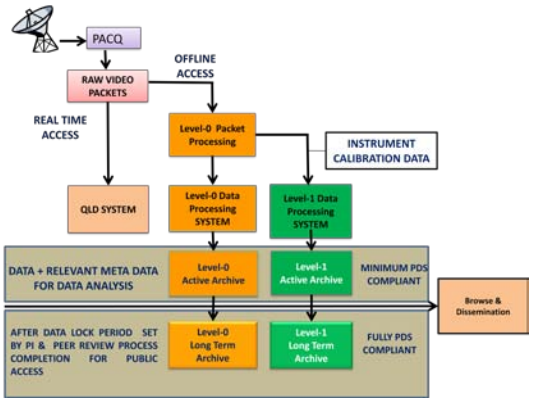

Fig-1: MOM Data processing system

Earth Bound Phase Datasets: During the Earth Bound Phase of Mars Orbiter Mission, almost all instruments were turned on to acquire data about earth and its neighbourhood to verify the instrument' output. In addition to standard correction steps, reference data sets and utilities are used to ascertain radiometric and geometric accuracies, and to produce a high dynamic range color image from multiple MCC frames called bracketed exposures to improve visual

appeal and interpretability [2]. TIS and MSM data collected during earth phase has been also processed for validating the experiments, for calibration and instrument working.

Mars Orbital Phase Data Sets: Since 24th September, 2014, all the five instruments aboard MOM have been acquiring data over Mars' surface and atmosphere except the time of Siding Spring closest encounter with Mars. Also Phobos and Deimos were caught in MCC images few times. Due to the illumination conditions, MOM apoareion imaging happened more than the periareion imaging. MCC images were obtained at altitudes of 2500 km to 77000 km (Fig.2, 3, &4).

Fig-2: High Dynamic Range image produced out of multi frame MCC Bayer data sets captured on 4th Oct, 2014 over Mars from an altitude of 76680 km

Value Added Processing: MCC images are geometrically and photometrically corrected to produce many large area mosaics (see Fig.2 & 3). The global views are also rectified to produce a full mars surface mosaic. There will be gaps in the South Pole region as the MOM orbital inclination is such (150 deg). High Dynamic Range Images are produced out of multi frame data sets acquired with different exposures (Fig.2) to improve visual quality.

PDS Archive: PDS is the underlying data standard for planetary missions data archives practiced world over for preparing planetary or solar system data for Long Term Archive based on an information model that advocates meta data organization in a specific way that planetary scientists are used to. MOM data archive will be prepared based on this data standard practice. The PDS archive planned will house not only primary instrument data, but also instrument calibration details, data, satellite position velocity information, and all other ancillary information either original or derived to be provided to the planetary scientists to take up their analysis tasks neatly arranged in a folder hierarchy.

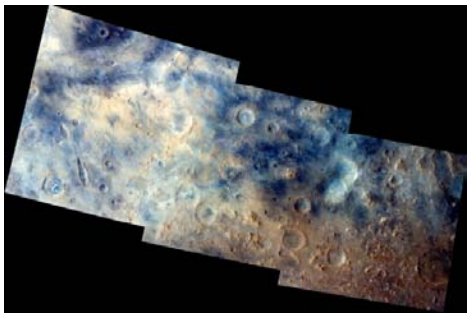

Fig-3: Image Mosaic of MCC frames acquired on 11th October, 2014 from altitude of 3906km.

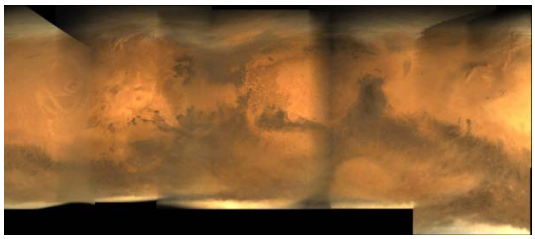

Fig-4: Mars Global Mosaic at 4km resolution generated out of MCC apoareion coverages obtained during Sep & Oct, 2014

Summary: Planetary Data Processing activities go parallel with every mission activity since inception through various operational stages and continue to stay in focus even beyond the mission life into posterity. Science finding from the data sets and experiments is the prime focus of the planetary missions; need to be supported by data processing activities. Science driven data management approach has yielded lot of benefits to the planetary science community, enabling to integrate finding across missions and handle complex science objectives, in addition to supporting long term usability. Mars Orbiter Mission data processing activities are progressing in a manner befitting the mission profile. Initial phase data is trusted with only PI teams till the data sets are matured and validated.

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Reference: [1] Kiran Kumar, A.S and Prakash Chauhan, (2014), Scientific exploration of Mars by first Indian interplanetary space probe: Mars Orbiter Mission, Curr. Sci.,07(7), 10. [2] Arya, A. S. and Kiran Kumar, A. S., (2014), Curr. Sci., 106(5), 661.[3] Mars orbiter Mission Archive Plan, MOM-DAP SAC-01, Rev 1.a, June,2013.