India's Mars Orbiter Mission in Orbit

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Outline

- MOM – Mission Objectives
- Spacecraft
- Science Payloads
- Launch & Journey
- Mars Orbit Insertion
- Mars colour images
- Implications

Objectives

TECHNOLOGY

- Design & develop an MARS orbiter with a capability to perform earth bound maneuvers, Martian Transfer and MARS Orbit Insertion after nearly 300 days of travel
- Incorporation of autonomous features in spacecraft
- Design, Plan and Operate Deep Space Communication with orbiter (.ca 400 Million km)

SCIENTIFIC

- Exploration of MARS surface features morphology, topography, mineralogy.
- Study of constituents of Martian atmosphere , dynamics of upper atmosphere.
- To detect emanation of gaseous constituents from surface/subsurface looking for clues on geologic or biogenic activities

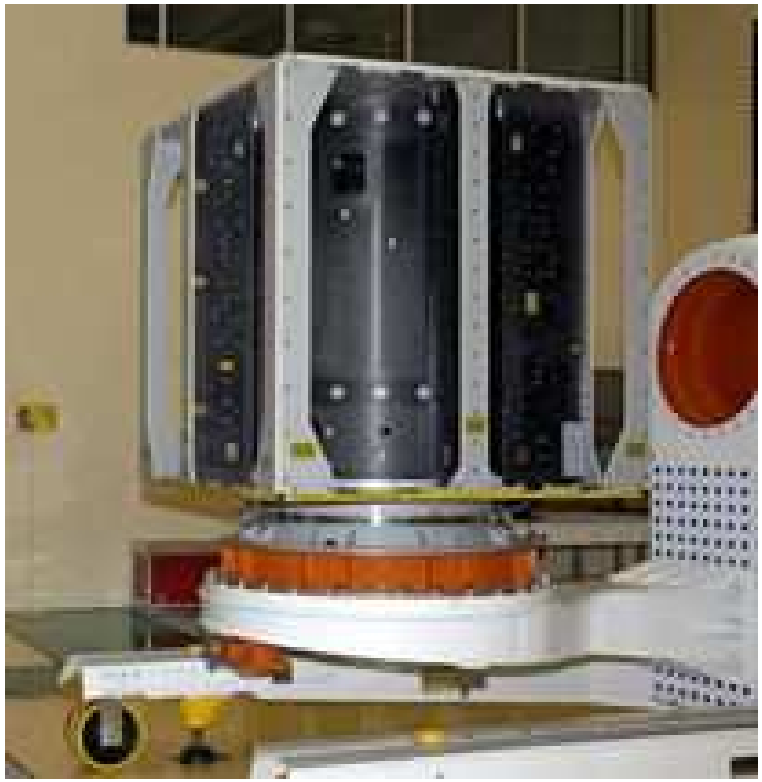
Systems and the Challenges

System	Mission specific changes
Structure	• Heritage: modified 1K bus to suit Launcher. • Incorporation of Communication system elements. • Maximal use of composite elements.
Mechanisms	• Deployment of solar panel array at low temperature of – 60 deg C
Propulsion	• Incorporation of redundancy flow path lines. • Restart of 440N engine after 300 days of dormancy. • Execution of blow down mode operation during real time mission management.
Thermal	• Use of passive thermal control elements. • Thermal Management of mission at various stages by imparting proper attitude changes.

Systems and the Challenges

System	Mission specific changes
Power	• Optimised Power generation both at near earth and Martian conditions. • Direct Power transfer. (No slip ring assembly)
Communication	• Higher ranging tone for tracking accuracy improvements and improved receiver sensitivity. • Delta DOR for plane of sky measurements.
Autonomy	• Full scale on- board autonomy thro Fault Detection and Isolation Logic. • Development of 22 new software modules, modification of 42 modules and usage of 19 existing modules.
Flight Dynamics	• Trajectory generation for all phases of Mission incorporating gravity, atmosphere, solar radiation pressure ,angular momentum desaturation models and relativistic effect due to Sun and atmospheric drag. • Orbit determination software improvements.

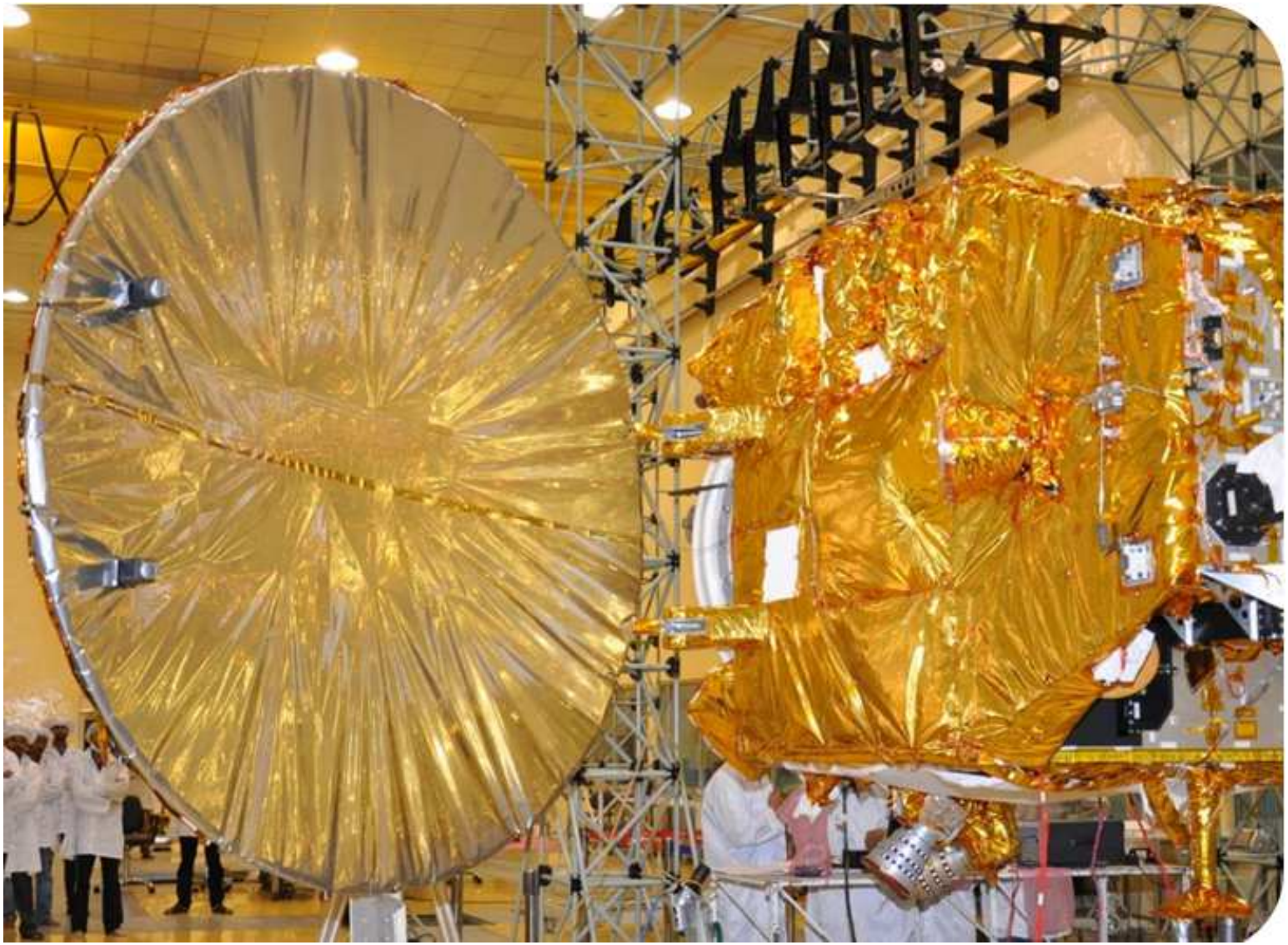
Mars Orbiter Spacecraft



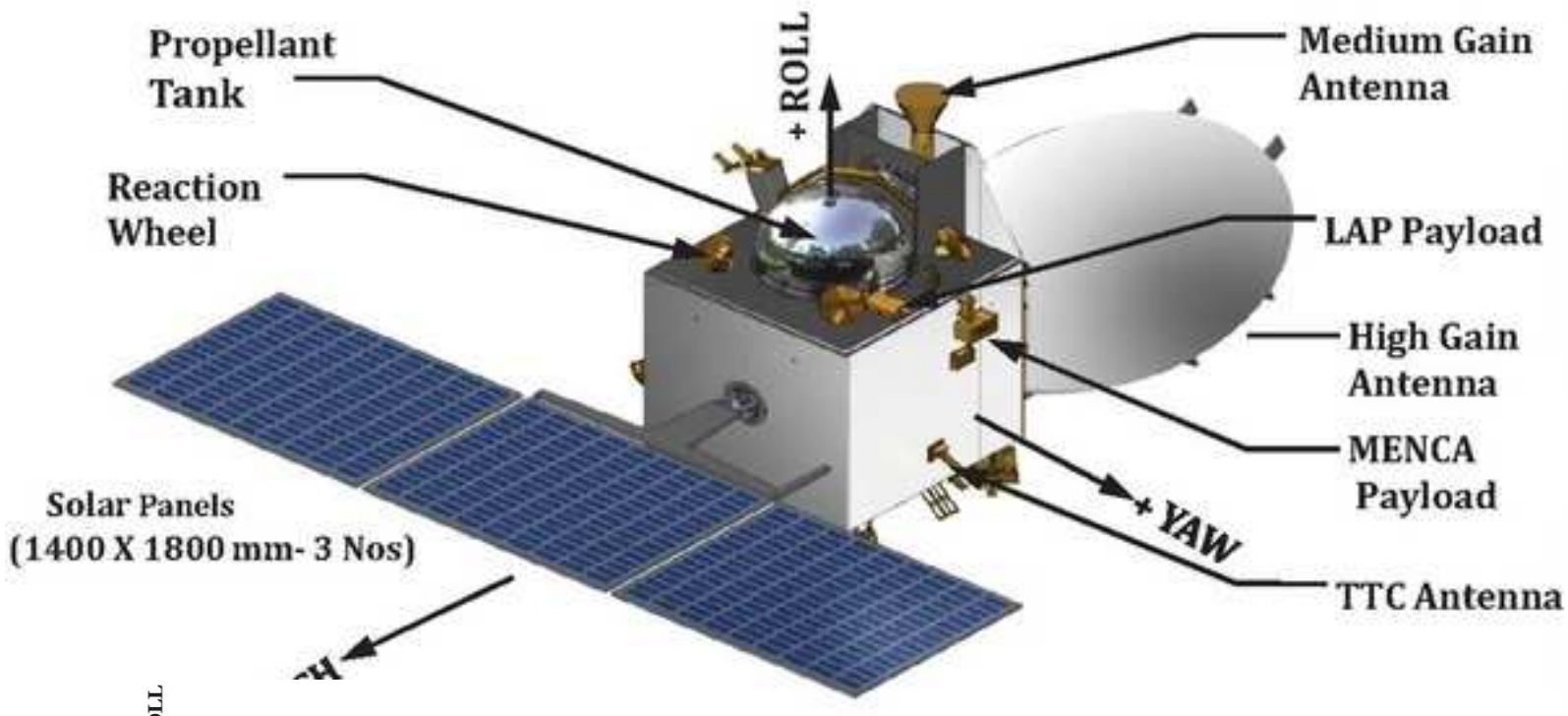
Primary structure in clean room – ready for integration

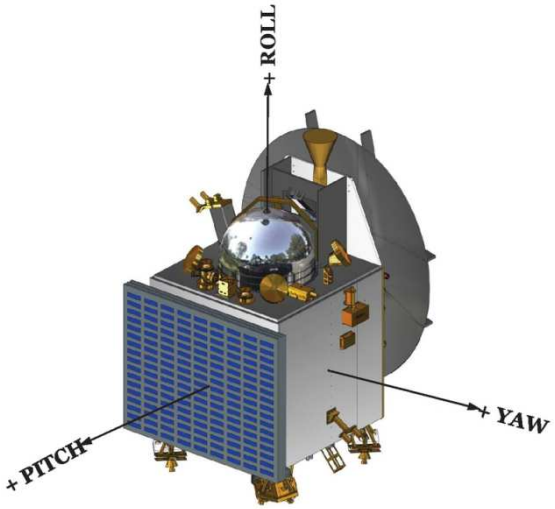
Spacecraft integration

HGA 2.2m CFRP Reflector deployment tests



Mars Orbiter Spacecraft





View from +Pitch/+Yaw axis

View from +Yaw/+Pitch

Science Payloads (15 kg)

Payload	Primary Objective	
Lyman Alpha Photometer (LAP)	Study of Escape processes of Mars upper atmosphere through Deuterium/Hydrogen	
Methane Sensor for MARS (MSM)	Detection of Methane presence	
Martian Exospheric Composition Explorer (MENCA)	Study of the neutral composition of Martian upper atmosphere	
Mars Colour Camera (MCC)	Optical imaging	
TIR Imaging Spectrometer (TIS)	Map surface composition and mineralogy	

Integration of MOM with PSLV C25

MOM Spacecraft getting integrated on PSLV-C25

LAUNCH – PSLV C25 XL

- **Technical Challenges**

- Requirement of larger Argument of Perigee (AOP) ranging from 276.4^{o} to 288.6^{o}
- Launch vehicle flight regime was extended to 2560 s (against 1200s for regular PSLV missions)with a long coasting (1580-1800s) before the ignition of the PS4 stage

- The long coasting necessitated the following
- Specific modification and validation of the coast phase guidance algorithm
- On-board battery capacity augmentation

Launch : Ground Stations Support

ST 1&2: Ship-borne Terminals S/C: Spacecraft IDSN: Indian Deep Space Network

The ground segment systems form an integrated system supporting both launch phase, and orbital phase of the mission

Ground Segment

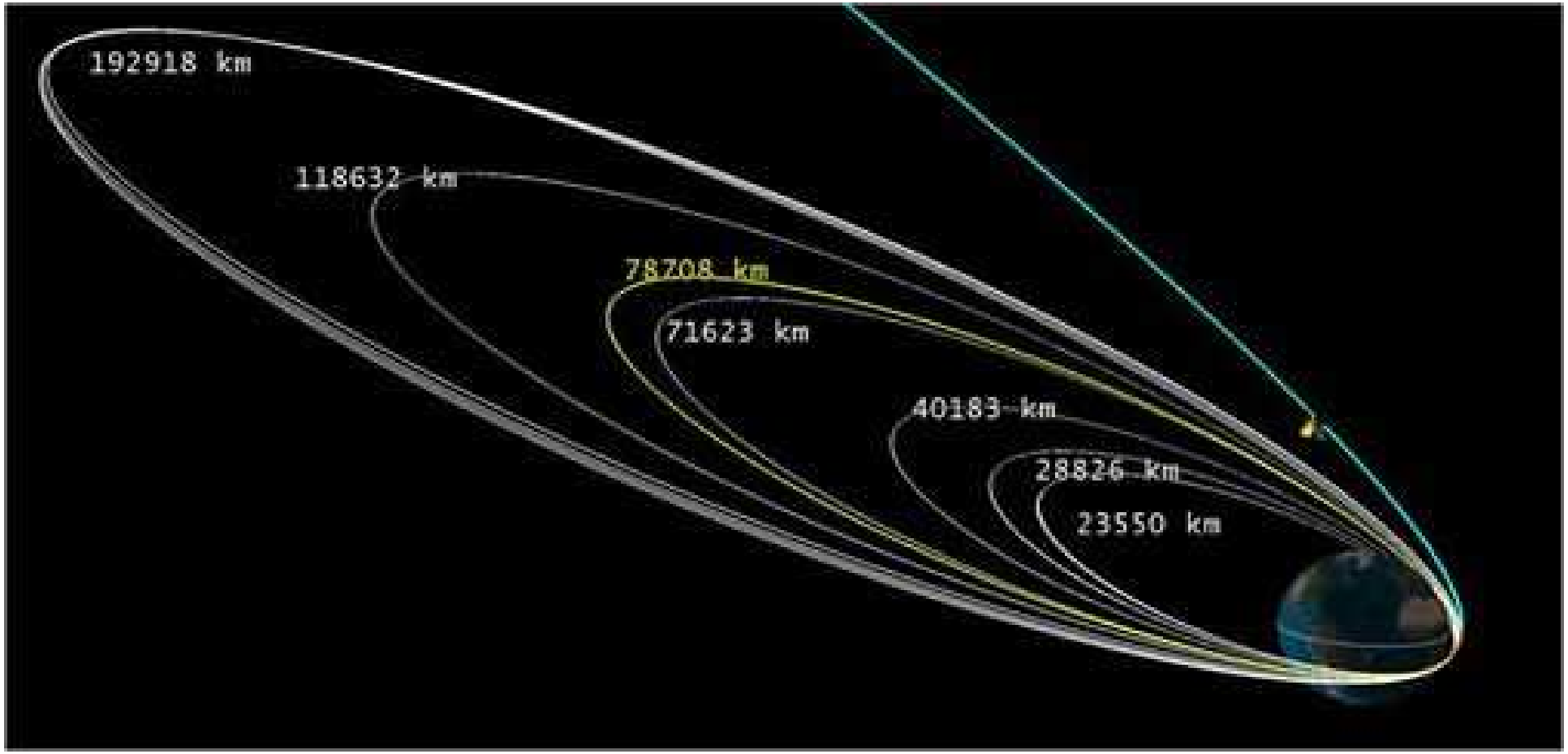
- *IDSN- 32 is the prime Indian deep space station for MOM in addition to JPL DSN stations. The ground segment support continues.*

- *Validation of IDSN-32 for range, range rate and Delta DOR jointly by ISTRAC and JPL/NASA carried out successfully and a cross support agreement is on the anvil. TIM planned on April 2015.*

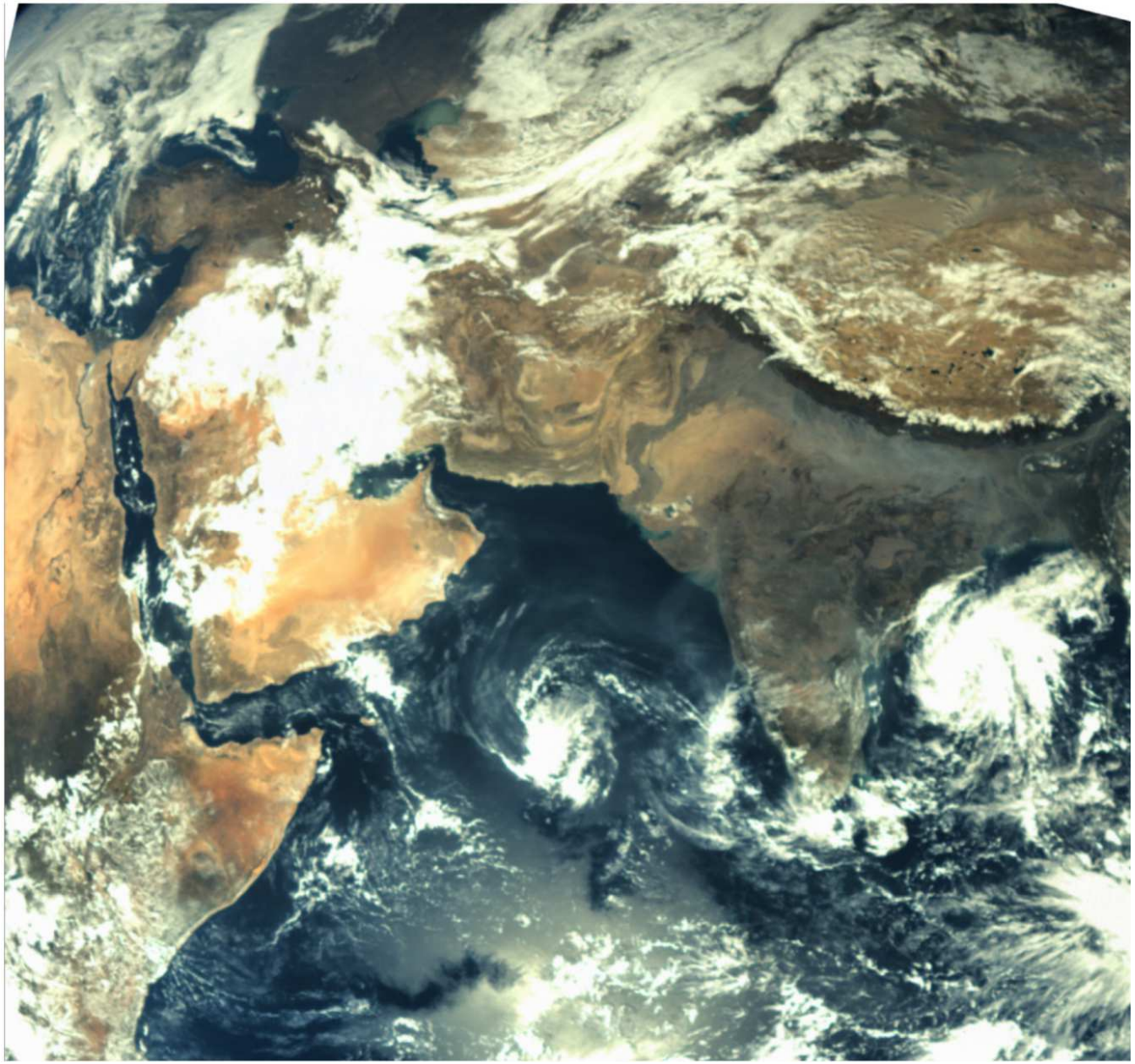
- *International ground stations including JPL DSN stations supported the mission in the non-visible zones. The contingency requirements met by JPL ground segment need a special mention.*

- *The data processing and archival of science data is being carried out flawlessly by ISSDC.*

TRANS MARS INJECTION



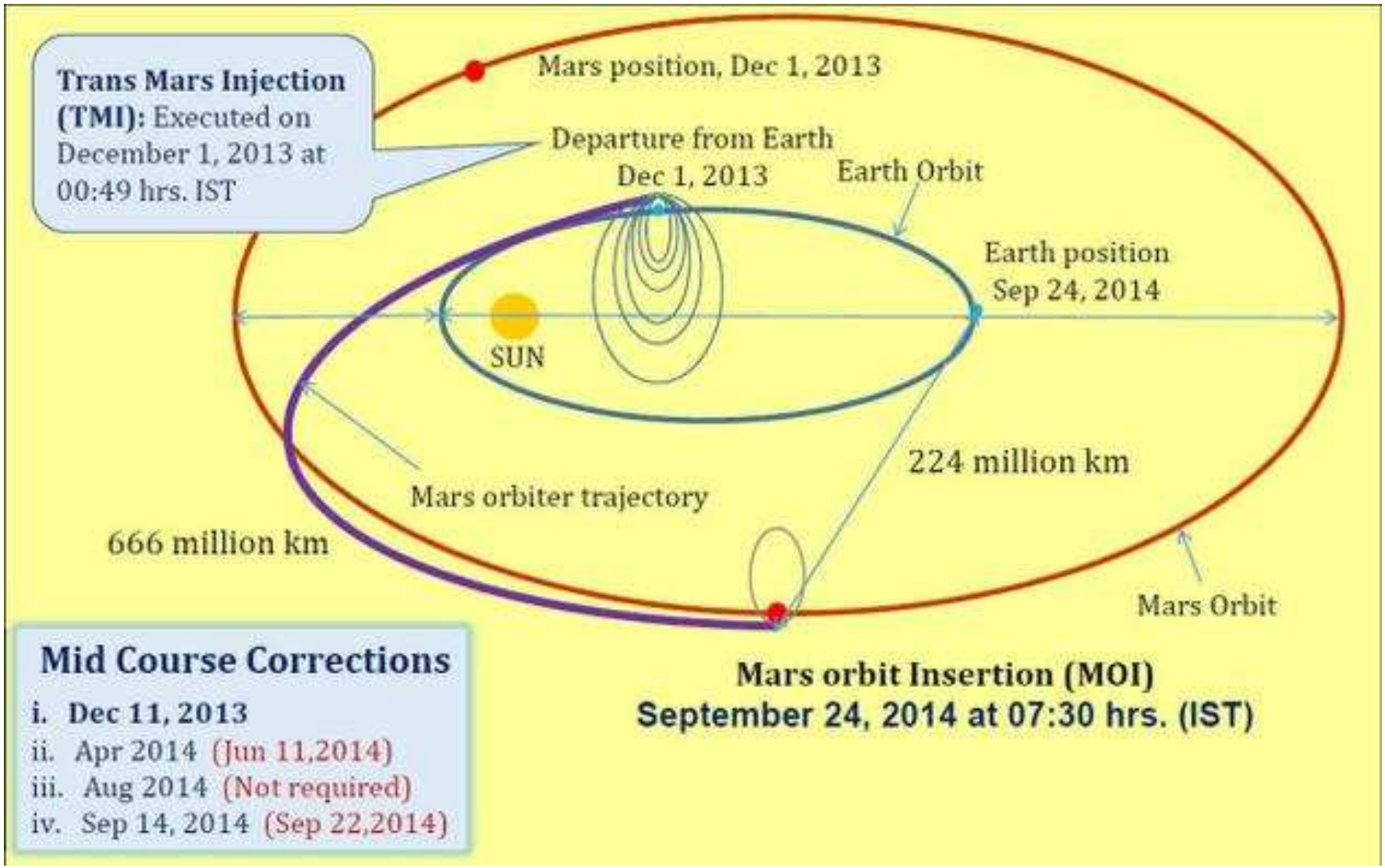
Mars Color Camera : 1st Image



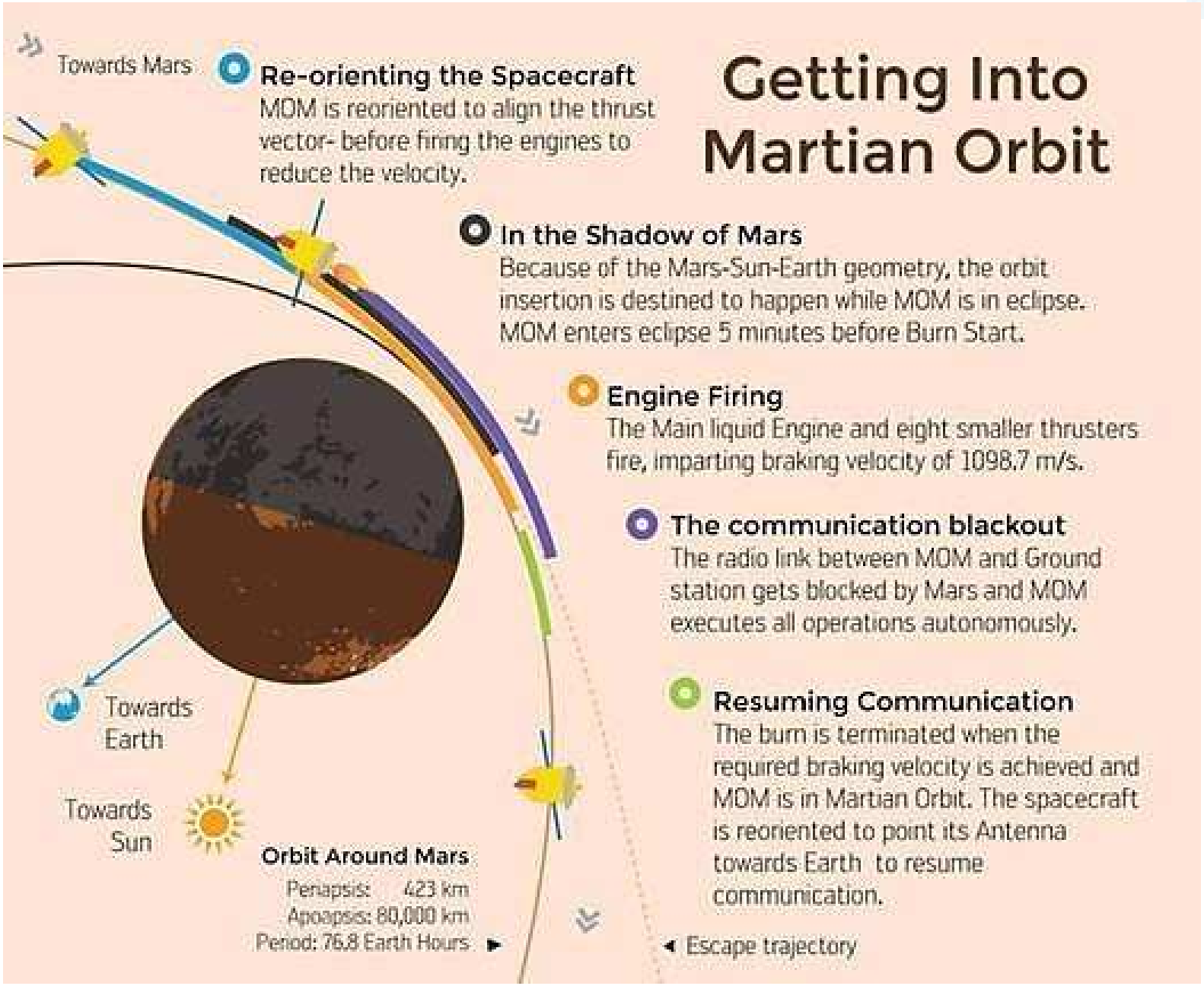
19th November 2013, 0820 UT 13:50 hrs

Indian Subcontinent imaged at an altitude of 70,000 km above earth with a spatial resolution of about 3.5 km

MARS MISSION PROFILE



Mars Orbit Insertion

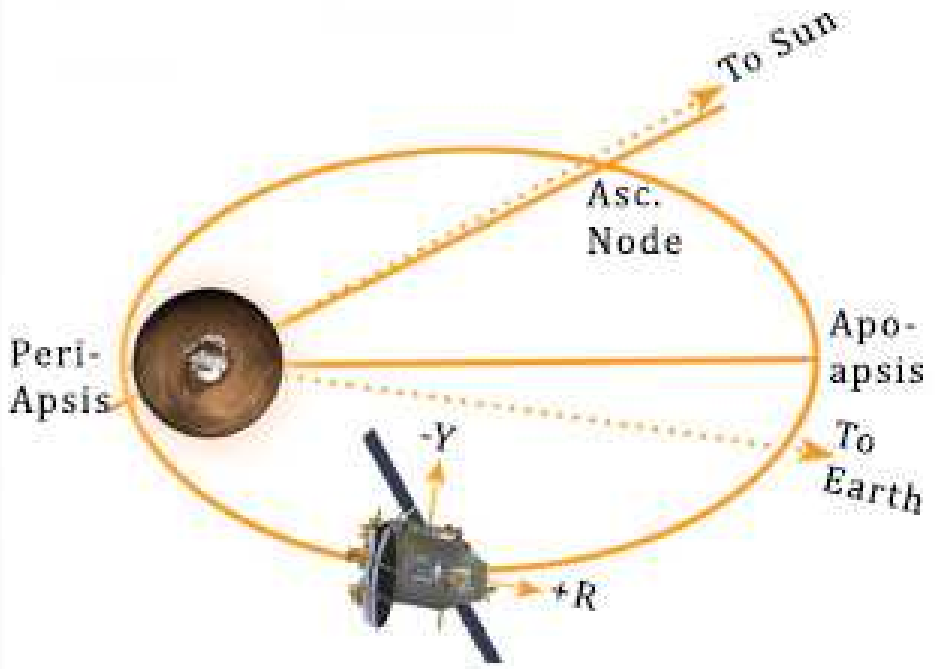


Mars Orbit

Major events before MOI

Activity	Date
Uploading of commands	14-09-14 15-09-14
Verification of uploaded commands	14-09-14 15-09-14
Entry into Sphere of Influence of Mars	22-09-14
Fourth Trajectory correction manoeuver and test-firing of Main Liquid Engine • Duration : 3.968 seconds • Fuel consumption: 0.567 kg • ΔV : 2.142 m/s	22-09-14 @1430 Hrs (IST)
Health Monitoring & checks	Ongoing

MOI Epoch : 24-09-2014, 07:18 hrs (IST)
Periapsis : 423 km
Apo-apsis : 80000 km
Inclination : 150.0°
Period : 76.8 hr



Martian Orbit

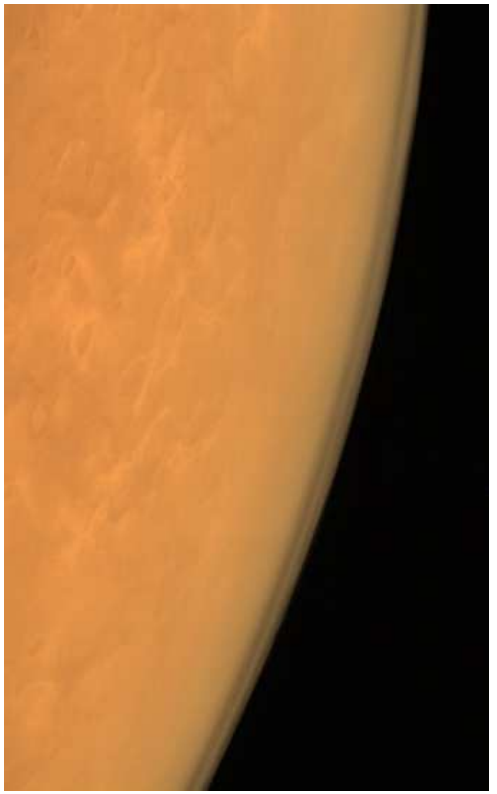
Mars – First Image

Mars Orbiter Spacecraft captures its first image of Mars. Taken from a height of 7300 km; with 376 m spatial resolution

Sample Images

The highest volcano in the solar system – the Olympus Mons and the famous Arsia, Pavonis and Ascraeus collinear mons adjacent to Daedalia Planum. Valles Marineris- the longest canyon in the solar system can be seen

Dark region towards south of the cloud formation is Elysium - the second largest volcanic province on Mars



Taken using the Mars Color Camera from an altitude of 8449 km, this image has a spatial resolution of 439 m and is centered around Lat: 20.01N, Lon:31.54E

Mission Objectives- Compliance

Technological objectives met with still 53 days to go and 37 kg usable propellant left.

Scientific payload Operations fully met.

Deep space mission management successfully executed.

Time, quality, cost and scope met

Implications

- Enhancing Interest in science
- Explaining Scientific concepts
- Youngsters participation through Social Media

Large Appreciation

- **10 Best TIME Magazine Inventions of 2014**
- **Space Pioneer Award of US Space Society**
- **NATURE lists Chairman ISRO among Top 10 Scientists**
- **.... *many others***

Thank You

http://www.isro.gov.in