Indian MOM (Mars Orbiter Mission)

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MARS ORBITER MISSION
Objectives : Indian Mars Mission

To develop the technologies required for design, planning, management, and operations of an interplanetary mission.

A) Technological Objectives:

✓ Design and realisation of a Mars orbiter with a capability to survive and perform Earth bound manoeuvres, cruise phase of 300 days, Mars orbit insertion / capture, and on-orbit phase around Mars.
✓ Deep space communication, navigation, and management.
✓ Incorporate autonomous features to handle contingency situations.

B) Scientific Objectives:

Exploration of Mars surface features, morphology, mineralogy and Martian atmosphere by indigenous scientific instruments.
<table>
<thead>
<tr>
<th><strong>MOM Spacecraft</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lift-off Mass</strong></td>
</tr>
</tbody>
</table>
| **Propulsion**    | Bi propellant system (MMH + N\textsubscript{2}O\textsubscript{4})  
Propellant mass : 852 kg |
| **Thermal System**| Passive thermal control system |
| **Power System**  | Single Solar Array - 1.8m X 1.4 m - 3 panels  
840 W Generation (in Martian orbit) |
| **Antennae**      | Low Gain Antenna (LGA), Mid Gain Antenna (MGA), and High Gain Antenna (HGA) |
| **Launch Date Time & Site** | 5 Nov. 2013 at 14.28 Indian Time  
Sriharikota, India |
| **Launch Vehicle**| PSLV - C25 |
Indian Mars Orbiter Mission Spacecraft after integration with the fourth stage of Polar Satellite Launch Vehicle (PSLV-C25)

@MST in Shriharikota (SHAR)
MOM integrated on the PSLV-C25 launch vehicle
'T zero' – 14:38 Indian Time  
05 Nov. 2013
The mission consists of following three phases:

1. Geo-Centric Phase
2. Helio-Centric Phase
3. Martian Phase

Mars Orbiter Mission Trajectory

**Trans Mars Injection (TMI):** Executed on December 1, 2013 at 00:49 hrs. IST

- Mars position, Dec 1, 2013
- Departure from Earth Dec 1, 2013
- Earth Orbit
- Earth position Sep 24, 2014
- 224 million km
- Mars Orbit
- Mars orbiter trajectory
- 666 million km

**Mid Course Corrections**

1. Dec 11, 2013
2. Apr 2014 (Jun 11, 2014)
3. Aug 2014 (Not required)
4. Sep 14, 2014 (Sep 22, 2014)

**Mars orbit Insertion (MOI):** September 24, 2014 at 07:30 hrs. (IST)
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Activity</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Uploading of commands</td>
<td>14-09-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15-09-14</td>
</tr>
<tr>
<td>2</td>
<td>Verification of uploaded commands</td>
<td>14-09-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15-09-14</td>
</tr>
<tr>
<td>3</td>
<td>Entry into Sphere of Influence of Mars</td>
<td>22-09-14</td>
</tr>
<tr>
<td>4</td>
<td>Fourth Trajectory correction manoeuvre and test-firing of Main Liquid Engine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duration: 3.968 seconds</td>
<td>22-09-14</td>
</tr>
<tr>
<td></td>
<td>Fuel consumption: 0.567 kg</td>
<td>@1430 Hrs (IST)</td>
</tr>
<tr>
<td></td>
<td>ΔV: 2.142 m/s</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Health Monitoring &amp; checks</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>
Liquid Engine Test Firing
Sep 22, 2014

The 4th Trajectory Correction Manoeuver is also configured to verify the operation of the Main Liquid Engine which has been idle for about 10 months.
# The D Day - 24th September, 2014

**Mars Orbiter Mission**

<table>
<thead>
<tr>
<th></th>
<th>When?</th>
<th>IST</th>
<th>What?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T-3 hours</td>
<td>04:17:32</td>
<td>Change over to Medium Gain Antenna</td>
</tr>
<tr>
<td>2</td>
<td>T-21 minutes</td>
<td>06:56:32</td>
<td>Forward rotation starts</td>
</tr>
<tr>
<td>3</td>
<td>T-5 minutes 13 seconds</td>
<td>07:12:19</td>
<td>Eclipse starts</td>
</tr>
<tr>
<td>4</td>
<td>T-3 minutes</td>
<td>07:14:32</td>
<td>Attitude control with thrusters</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>07:17:32</td>
<td>Liquid Engine Burn starts</td>
</tr>
<tr>
<td>6</td>
<td>T+4.3 minutes</td>
<td>07:21:50</td>
<td>Mars occult starts</td>
</tr>
<tr>
<td>7</td>
<td>T+5 minutes</td>
<td>07:22:32</td>
<td>Telemetry OFF</td>
</tr>
<tr>
<td>8</td>
<td>T+ 12.5 minutes</td>
<td>07:30:02</td>
<td>Confirmation of Burn start</td>
</tr>
<tr>
<td>9</td>
<td>T+19.48 minutes</td>
<td>07:37:01</td>
<td>Eclipse ends</td>
</tr>
</tbody>
</table>

All time in Indian Standard Time (IST); IST = GMT + 5:30 hrs = PDT + 12:30 hrs
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</thead>
<tbody>
<tr>
<td>10 T+ 24.23 minutes</td>
<td>07:41:46</td>
<td>Liquid engine Burn Ends</td>
</tr>
<tr>
<td>11 T+ 25.73 to T+ 47 minutes</td>
<td>07:42:46 to 08:04:32</td>
<td>Reverse Manoeuver starts</td>
</tr>
<tr>
<td>12 T+ 27.78 minutes</td>
<td>07:45:10</td>
<td>Occult ends</td>
</tr>
<tr>
<td>13 T+ 30.43 minutes</td>
<td>07:47:46</td>
<td>Telemetry resumes and Doppler measurement to provide first information about total burn performance</td>
</tr>
<tr>
<td>14 T+ 35.23 minutes</td>
<td>07:52:46</td>
<td>Reverse Manoeuver ends</td>
</tr>
</tbody>
</table>

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Getting Into Martian Orbit

- **Re-orienting the Spacecraft**
  MOM is reoriented to align the thrust vector before firing the engines to reduce the velocity.

- **In the Shadow of Mars**
  Because of the Mars-Sun-Earth geometry, the orbit insertion is destined to happen while MOM is in eclipse. MOM enters eclipse 5 minutes before Burn Start.

- **Engine Firing**
  The Main liquid Engine and eight smaller thrusters fire, imparting braking velocity of 1098.7 m/s.

- **The communication blackout**
  The radio link between MOM and Ground station gets blocked by Mars and MOM executes all operations autonomously.

- **Resuming Communication**
  The burn is terminated when the required braking velocity is achieved and MOM is in Martian Orbit. The spacecraft is reoriented to point its Antenna towards Earth to resume communication.

**Orbit Around Mars**

- Periapsis: 423 km
- Apoapsis: 80,000 km
- Period: 76.8 Earth Hours

**Escape trajectory**

**Towards Mars**

**Towards Earth**

**Towards Sun**
Ground Station Support for Mars Orbit Insertion
Nominal orbit around Mars

Mars Orbit Insertion
with Main Liquid Engine + 8 AOCE thrusters

- **Burn duration**: 1454 seconds (24 minutes & 14 seconds)
- **Propellant consumption**: 249.5 kg
- **ΔV imparted**: 1098.7 m/s
- **Nominal Orbit around Mars**: 423 x 80,000 Km
- **Orbital period**: 3.2 Earth days

| Estimated arrival altitude as of now | 723 km |
| Estimated arrival altitude post TCM4/Test firing | 515 km |
Payloads on MOM

MOM carries 5 Payloads

Total Weight 13 kg

SAC, Ahmedabad
- MARS Colour Camera (MCC)
- Methane Sensor for MARS (MSM)

LEOS, Bangalore
- Thermal Infrared Imaging Spectrometer (TIS)

SPL-VSSC, Trivandrum
- Lyman Alpha Photometer (LAP)
- Mars Exospheric Neutral Composition Analyser (MENCA)
Accommodation of Payloads on the Mars Orbiter Mission
Mars Observation Phase

Position of Mars at the Launch and Arrival, and during the mission phases (six-months), and extended mission phase.
C/2013 A1 (Siding Spring) approach to Mars

(Source: JPL Small Body Database Browser)

Comet Closest distance of approach to Mars ~ 131 Thousand km; distance from Sun: 1.399 AU; inclination 129°
The path of no return!
The die has been cast.
MOM has crossed the rubicon,
ever to return to Earth.

MOM has broken free from the shackles of gravity and is on the one way road for a rendezvous with the red planet.

facebook.com/isromom

Stay Tuned!!
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धन्यवाद
Thank You