Mars Orbiter Mission

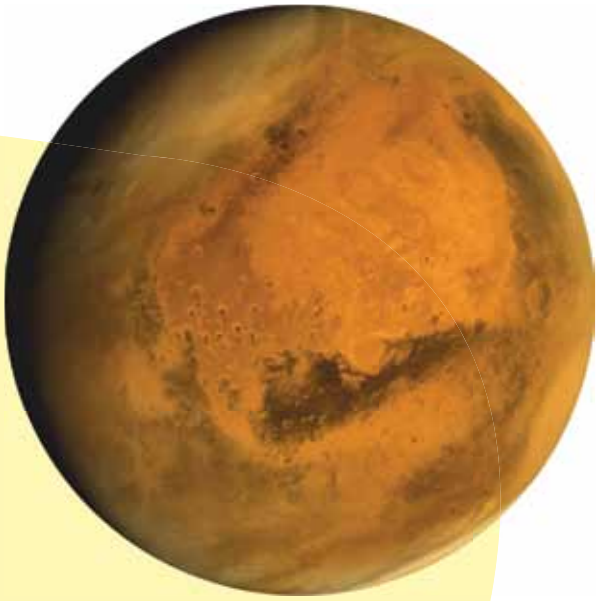
India's Triumphant Odyssey to

the Red Planet

by
B R Guruprasad

The exciting story of India's quest to explore Mars using a robotic spacecraft

Mars: The Most Interesting Planet

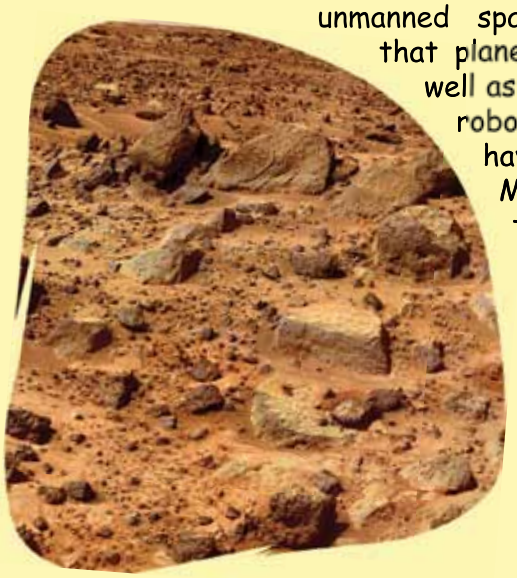


Mars. This planet appears as a red dot in the night sky. It is the second nearest planet to us. Named after the Roman God of war, this red planet caught the attention of ancient humans because of its colour and the way it moved in the sky. Even today, it arouses the interest of modern man for a different reason.

Compared to the other planets (Mercury, Venus, Jupiter, Saturn, Uranus and Neptune) of the solar system, Mars resembles Earth in many important ways. This has made humans to think of it as the most likely place to search for extra-terrestrial life (life outside the Earth) in our solar system.

Though Mars was familiar to ancients, details about that planet began emerging only after the invention of telescope. But, Telescopic observation of Mars also led to many misconceptions about the situation on that planet. Prominent amongst them was the mistaken belief that Mars had intelligent life, which was far more capable than humans.

But the true nature of Mars began emerging after unmanned spacecraft started travelling to that planet. Those robotic spacecraft as well as the landers and rovers (wheeled robotic vehicles) carried by them have revealed many things about Mars in great detail. At the same time, they have raised more questions for which scientists are struggling to find answers. Thus, Mars has not yet revealed all its secrets.



Surface of Mars as seen by a lander sitting on its surface

Picture courtesy: NASA

To further broaden our knowledge horizon about Mars, robotic spacecraft are being sent to the red planet even today.

India's Mars Orbiter Spacecraft, which started circling planet Mars on **September 24, 2014, successfully completed six months in its orbit around Mars on March 24, 2015.** With this, the primary objective of Mars Orbiter Mission has been realised.

Mars Orbiter spacecraft is an essential part of the effort across the globe to further understand this very interesting and exciting planet.

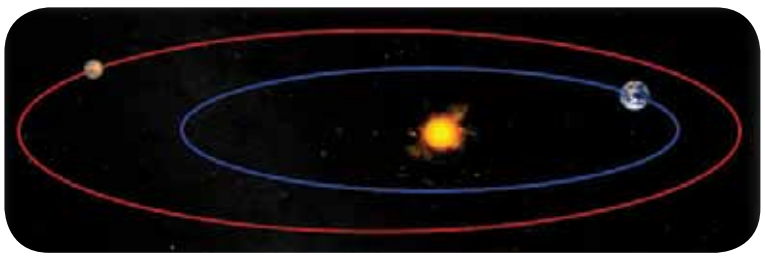
Mars: The Most Earth like Planet

Like Earth, Mars is a large spherical body that revolves round the Sun. It is also a 'terrestrial planet' which means that it has a solid surface like Earth. Compared to this, Jupiter, Saturn, Uranus and Neptune does not have solid surface at all!

Mars has a diameter which is a little more than half that of the Earth. And, planet Mars has a mass which is one tenth of the Earth's mass. Its smaller mass and diameter result in lower surface gravity. Thus, if you weigh 100 kg on Earth, you will weigh only 38 kg on Mars!

The yellowish red colour of Mars is due to presence of Iron Oxide there. On Earth, it is known as rust. So, the surface of Mars has 'rusted' away!

The orbit of Mars lies outside the orbit of Earth around the Sun. And the orbit of Mars is more oval shaped compared to Earth's orbit. The average distance of Mars from the Sun is about 230 million km compared to ours, which is 150 million km.



Mars comes very near to Earth than any other planet, except Venus. When Earth and Mars are very near to each other, they are still separated by a distance of 56 million km!

One year on Mars is 687 days as the red planet takes that much time to revolve round the Sun once. The Earth does the same in 365 days, isn't it?

Surprisingly, one 'day' on Mars is a little more than a day on Earth. If you want the exact value, then it is 24 hours 37 minutes. And, the tilt of the axis of Mars is about 25 deg, which is very near to the Earth's tilt of 23.5 deg.

Like on Earth, one can see plains, plateaus, mountains, volcanoes, valleys, etc., on Mars. In fact, the surface features of Mars are so similar to Earth that in many pictures sent from the surface of Mars by robotic landers and rovers, one cannot immediately make out that it is alien landscape. But, not even a small plant or a tiny lizard is visible in those pictures!

And, those pictures do not reveal the hostile conditions that exist on Mars. The atmosphere of Mars mostly contains the carbon di oxide which we cannot breathe. Besides, Martian atmosphere is extremely thin with the surface pressure being about 100 times less than that on Earth. Since Mars does not have Ozone layer, harmful ultraviolet (UV) rays from the sun reach the surface of Mars without any hindrance. So, we cannot survive on Mars without wearing a protective space suit and Oxygen supply system.

Because the entire surface of Mars is sterilised by UV rays, chances of life (as we know it on Earth) on its surface is very small.

One striking similarity between Earth and Mars is related to water. Mars has water on it. But, it is there in the form of ice or snow and water vapour.

Mars before the Space Age

The great civilisations of the ancient world, including Sumerian, Egyptian, Indus Valley, Chinese, Vedic, Greek and Roman civilisations, had observed Mars. They saw it as a bright yellowish orange dot in the night sky moving slowly against the background of fixed and twinkling stars. They named that heavenly body after their gods. Since its colour reminded them of blood, the ancient Romans named that 'wandering' dot of light after Mars, their god of war.

Mangala

In ancient India, Mars was called 'Mangala' and to this day, the same name is retained by many Indian languages. Mars was also known as 'Angāraka' and was referred to as the 'Son of the Earth' in ancient Indian texts.

The ancient people were puzzled by the movement of Mars in the night sky. Sometimes, it appeared to reverse its direction of movement and again resumed its normal course later.

During the renaissance, due to great scientific developments, human understanding of the heavens got changed. Mars, like Earth, came to be seen as a planet that travelled round the Sun. Galileo observed the planet Mars in his telescope and later astronomers found that Mars too showed phases like the moon. German astronomer Johannes Kepler stated the laws that explained the motion of planets around the sun, including that of Mars.

Using telescopes, later astronomers mapped surface features of Mars including its polar ice caps. They also worked out the time Mars took to spin around its axis once as well. In addition, astronomers found that the tilt of the axis of Mars was very much similar to that of the Earth. And, the two small satellites of Mars (later named as Phobos and Deimos) were also discovered through telescopic observation.

There was great excitement after a 19th century Italian astronomer talked about straight line like features on Mars which he had observed. He called them 'canali' (channels in Italian).

A drawing of Martian Canals!

It was mistranslated to English as 'canals', which meant they were artificially built. Following this, an American astronomer named Percival Lowell passionately argued that 'canals' of Mars were constructed by super intelligent beings of that planet to bring water from polar areas to the dry equatorial areas!

The famous science fiction writer H G Wells wrote about the invasion of Earth by Martians in his book 'War of the Worlds' published in 1898. When a dramatised version of that novel was broadcast in 1938 over radio in America, many believed it and ran out of their houses in panic!

Martian Attack in fiction!

It was time for getting a proper picture of the situation on Mars. The dawn of the space age in 1957 made it possible.

Mars: Exciting Exploration in the Space Age

On October 4, 1957, a huge rocket rose from Kazakhstan in the Soviet Union. A few minutes later, the rocket travelled beyond the Earth's atmosphere and provided sufficient speed to a 84 kg metal sphere sitting on top of it. With this, the sphere started circling the Earth on its own and became the first artificial satellite of the Earth. The space age was born.

Mars as seen by Mariner 4

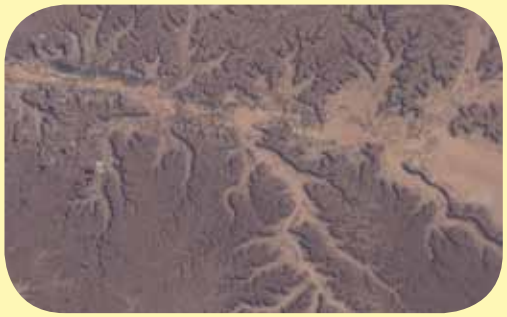
Picture courtesy: NASA

A few years later, both the United States and the Soviet Union began attempts to launch unmanned spacecraft towards Mars. In exploring Mars, the United States has scored many spectacular successes, while the former Soviet Union and today's Russia has not been very successful. Besides, the European Space Agency, Japan, China and India have built robotic spacecraft to explore Mars.

The soviet Mars-3 Lander

The first spacecraft to successfully explore Mars was the American Mariner 4. It flew near Mars in 1965 and sent black and white pictures in which the surface of Mars was uninteresting and showed many craters.

In 1971, a Soviet spacecraft safely landed on Mars. But after communicating with Earth by radio for about 15 seconds, suddenly became silent. The mystery of Mars got further deepened.



Flow of water on Mars in the past?

Picture courtesy: NASA

A few months later, the American Mariner 9 spacecraft started sending breath-taking pictures of the surface of Mars from its orbit around that planet. Those pictures showed giant volcanoes, a gigantic system of valleys and features which appeared to indicate that large quantities of water had flowed on Mars long ago. But, canals or other indications of intelligent life, which were imagined by many, did not show up in those pictures!

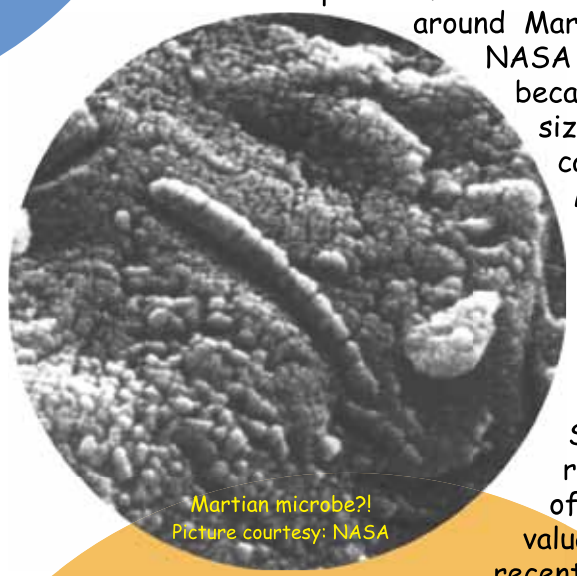
In 1976, two American Viking spacecraft went to Mars and started orbiting it. Later, each successfully sent a lander to the surface of Mars. In the pictures sent by Viking landers, the surface of Mars resembled the deserts of the earth, but neither vegetation nor even small forms of life were visible.

Part of a Viking Lander on Mars
Picture courtesy: NASA

Viking landers also took the samples of Martian soil and performed biochemical tests on those samples to find out whether microscopic life was present in it. But, most scientists feel that those tests did not conclusively detect any signs of microscopic life.

Mars generated worldwide excitement in 1996. Strangely, the reason was not a robotic spacecraft but a meteorite called ALH84001. NASA scientists who studied that meteorite opined that it had come from Mars and there was enough proof for that. But, what was more exciting was their view that the material inside that piece of space rock appeared to strongly suggest that it contained fossils of Martian microorganisms! But many scientists have not accepted this view.

In the 1990s, NASA successfully sent a robotic spacecraft called Mars Global Surveyor into an orbit around Mars. But, Mars Pathfinder, a small NASA spacecraft became more famous because it landed a microwave oven sized rover (wheeled robotic vehicle) called Sojourner on the surface of Mars.



Martian microbe?!
Picture courtesy: NASA

Between 2001 and 2012, many spacecraft have travelled to Mars. Some of them are orbiting while most others have landed rovers on the Martian surface. Spirit and Opportunity, the two rovers that reached the surface of Mars in 2004, have provided valuable information about Mars. More recently, Curiosity, the NASA rover which landed on Mars in August 2012, has triggered a worldwide interest in Mars. Carrying a large array of scientific instruments, it is exploring Mars in a systematic way.

Europe's Mars Express spacecraft

Picture courtesy: ESA

On September 22, 2014, NASA's MAVEN spacecraft entered into an orbit around Mars. **Two days later, India's very first attempt to make a spacecraft to go round Mars became a total success when its Mars Orbiter Spacecraft began circling the Red Planet in the planned orbit.**

Curiosity rover on Mars

Picture courtesy: NASA

Mars: Unending Mysteries Demand Continued Exploration

It is true that robotic spacecraft equipped with many scientific instruments have explored Mars in a detailed way while circling the red planet. Besides, landers which have gently settled down on the surface of Mars have sent breath-taking pictures of the Martian surface. They have also sent weather reports from the surface of Mars and analysed the soil and rock samples of Mars for signs of extinct life or living microorganisms. And, the rovers have explored not only the surroundings of their landing site, but areas which are many kilometres away as well and provided strong evidence about the presence of liquid water on Mars in the past.

But, many mysteries associated with Mars have not yet been resolved. Even today, scientists are very actively pursuing answers to such questions like:

How long was Mars really warm and wet in its history?

Why and how Mars became a dry desert from a watery paradise?

Did Mars have water on its surface continuously for a long time or did bursts of water flow on its surface for brief periods repeatedly?

Did life originate on Mars when it was wet?

Has microscopic life survived today on Mars?

Is there Methane in the atmosphere of Mars and how was it generated?

To seek answers for these important questions, further exploration of Mars is very much necessary. This is the reason why humans are continuously launching spacecraft whenever the opportunity comes. India's Mars Orbiter Spacecraft is one amongst them.

India's Strength to Explore Mars

Today, India is considered as one of the few countries with many achievements in space which are quite remarkable. The reason for this is the prominent successes scored by India's giant rockets and satellites, especially the role of satellites in bringing about rapid and revolutionary progress in many essential fields. The Indian Space Research Organisation (ISRO) implements the country's space programme.

The valuable services provided by our communication satellites today include simultaneous relay of thousands of telephone calls and countrywide telecasting including the provision of DTH services. Similarly, our meteorological satellites provide valuable information required for generating accurate weather forecasts.

A weather picture from INSAT-3D Satellite

Today, our remote sensing satellites are circling the Earth at hundreds of kilometres height. They offer services like providing information necessary for the accurate crop yield prediction, searching groundwater and minerals, increasing fish catch, estimating our forest wealth, monitoring environmental pollution, and so on.

Artist's concept of a communication satellite telecasting educational programmes

Recently, the country has entered the world of satellite navigation with the successful launch of four navigation satellites (by April 2015). They are part of the Indian Regional Navigation Satellite System consisting of seven satellites. Together, they are intended to benefit our transportaion sector, including air transportaion by providing very accurate position, velocity and time information to the vehicles. This can make their journey more safe and efficient.

Southern India and Sri Lanka, as seen by an Indian Remote Sensing Satellite

Chandryaan-1
around the Moon

Los Angeles Times NATION

Evidence suggests water exists on the moon

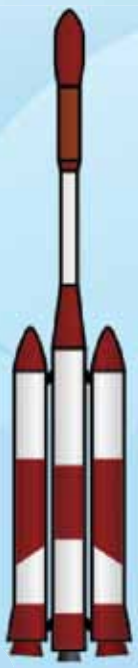
Research teams from Brown University, the University of Maryland and the U.S. Geological Survey used spectroscopic measurements taken of the lunar surface by NASA's Cassini and Deep Impact spacecraft, as well as India's Chandrayaan-1 satellite. The instruments on

Indian space programme is mainly focused towards the development of space technologies that are mainly intended for the rapid and overall development of the country. But, the scientific satellites and spacecraft like Chandrayaan-1 and Mars Orbiter Spacecraft of our country have made valuable contribution towards further enhancing our knowledge about the universe.

For example, in November 2008, India became the only fourth individual country to reach the surface of the Moon when a probe which was as big as a TV set and carried by Chandrayaan- 1 into an orbit around the moon, successfully hit the lunar surface.

Later, by carefully studying the scientific information sent by Chandrayaan-1 spacecraft, scientists conclusively (without any doubt) discovered extremely small quantities of water on the moon!

Satellite Launch
Vehicle-3 (SLV-3)



Augmented Satellite
Launch Vehicle (ASLV)

Encouraged by the success of Chandrayaan-1, ISRO took up the far more challenging Mars Orbiter Mission. The main goal of this is to demonstrate the country's capability to build, launch and send an unmanned spacecraft to Mars.

Importance of Rockets

The ability of satellites to bring about significant improvements to our lives is without any doubt. But, to enable them to perform their assigned task properly, it is essential that those satellites have to be taken into space and placed in proper orbits around the Earth.

Giant rockets called 'launch vehicles' having many stages, perform that task. But, perfecting the launch vehicle technology is an immensely difficult and challenging task. Thus, only a few countries possess it.

PSLV on the First Launch Pad

GSLV equipped with indigenously developed Cryogenic Upper Stage Magnificiently lifts-off

Till now ISRO has developed five launch vehicles (SLV-3, ASLV, PSLV, GSLV and LVM3 which is also known as GSLV Mk-III) and mastered the technology of rockets that use solid, liquid as well as cryogenic propellants (fuel-oxidiser combination).

Many of our satellites and spacecraft were launched by our own Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV). These include Chandrayaan-1 and Mars Orbiter Spacecraft, which were passengers on-board PSLV.

In fact, PSLV has launched more foreign satellites than Indian ones. This indicates the confidence the outside world has in PSLV. During October 1994-April 2015 period, PSLV has scored 28 successes without a break!

One major milestone of the Indian space programme occurred on January 05, 2014. On that day, the mighty GSLV, standing as tall as a seventeen storey building, roared into the sky from the Satish Dhawan Space Centre at Sriharikota island, which is the spaceport of India. In that flight, GSLV's third stage was a 'cryogenic' rocket stage developed by ISRO. It used super cooled rocket propellants. Some 18 minutes after the launch, GSLV placed the GSAT-14 satellite in the intended orbit very accurately.

A cryogenic rocket stage, though extremely complex, works very efficiently. With this success of GSLV, ISRO's mastery of rocket technology was quite complete.

Now, ISRO has taken up many more challenging tasks for the future. This includes the development of LVM3 (GSLV Mk-III), which is more efficient and capable than the GSLV.

The first experimental flight of LVM3 was conducted successfully on December 18, 2014 from Sriharikota. In that flight (LVM3-X), only the two large solid rocket boosters as well as the liquid core (central) stage of the vehicle were successfully tested. The third (cryogenic) stage which is still being developed, was not tested.

LVM3 carried the 3,775 kg 'Crew Module Atmospheric Re-entry Experiment (CARE)' to a height of 126 km in that flight. After that, CARE module successfully re-entered the Earth's atmosphere and safely landed over Andaman Sea with the help of its parachutes.

LVM3-X Lift-off

Mars Orbiter Mission:
Clear-cut Objectives, Tough Challenges

Any major effort undertaken should have a very clear goal or a set of objectives. Throughout human history, we see many examples of this. In the space field, this becomes very crucial because of the careful planning required to allocate the necessary human skill and money to realise the goal with split second accuracy.

The unimaginable speeds achieved and the temperature, forces and risks experienced during the journey of a rocket and a satellite in space make this inevitable. Thus, only a few countries are successful in mastering various technologies necessary for spaceflight. It is a matter of pride that India is one of them.

The main objective or goal of Mars Orbiter Mission (MOM) is the demonstration of India's capability to build a spacecraft capable of travelling to Mars and survive in an orbit around the red planet. Thus, the main goal of MOM is mainly technological.

But that does not mean MOM does not have any scientific objectives. The mission also intended to gather useful scientific data about that planet during the spacecraft's journey to Mars, and more importantly, from a suitable orbit around that planet later.

The scientific data which is now being collected, is about the surface of Mars, its very thin atmosphere as well as the space near Mars.

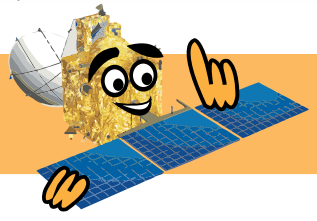
The cost of Mars Orbiter Mission was estimated to be about 450 crore Indian Rupees (about 80 million American Dollars).

The spacecraft built for realising Mars Orbiter Mission is known as Mars Orbiter Spacecraft.

Compared to many other unmanned spacecraft that have explored Mars in the past, the goals of India's Mars Orbiter Spacecraft look quite modest. But, considering the innumerable difficulties involved in launching a spacecraft towards another planet, as well as India's lack of prior experience in this regard, the challenges that confronted ISRO scientists were very tough indeed.

Nevertheless, the successful entry of Mars Orbiter Spacecraft into a planned orbit around Mars on September 24, 2014 glaringly demonstrated the capability of India's space scientists and engineers to the outside world. After that, the spacecraft successfully completed six months in its Mars orbit. This indicated the total realisation of the primary objective of Mars Orbiter Mission.

In the history of Mars exploration, India is the only country to achieve total success in its very first attempt itself!



You see, I have well defined goals, which are already realised!

Mars Orbiter Spacecraft:
India's First Robotic Messenger to Mars

Following the Prime Minister's announcement on August 15, 2012 about India's intention to send a robotic spacecraft to Mars, Indian space scientists began working with new vigour. They had to build a spacecraft capable of travelling to Mars in about a year or so. This was a great challenge indeed.

Scientists working on Mars Orbiter Spacecraft's structural 'skeleton'

But hundreds of ISRO scientists overcame this challenge by sheer dedication and focussed their skills towards building a reliable Mars exploration spacecraft. Many Centres of ISRO scattered in different parts of India came together and contributed their might. The spacecraft started taking shape at ISRO Satellite Centre in Bangalore.

First, the 'skeleton' of India's Mars Orbiter Spacecraft was made ready. Then, it was taken to a huge 'clean room' and other parts of the spacecraft were brought there and assembled to the spacecraft in carefully planned steps.

A robotic spacecraft like Mars Orbiter Spacecraft functions like a human body in certain respects. It too needs a comfortable temperature range and energy (in this case it is electrical energy) to function properly. Such a spacecraft needs an electronic brain and sensing devices for coordination and stability. It faithfully reports its findings as well as information about its health to Earth through radio.

To change its path or to reorient itself, the robotic spacecraft needs rocket power. And to perform its assigned task, it carries scientific instruments or 'payloads', like a doctor carries a stethoscope and a thermometer.

The structure 'subsystem' of the Mars Orbiter Spacecraft resembles the skeletal system of the human body. It was built using various alloys and a special plastic material called 'Carbon Fibre Reinforced Plastic' or CFRP for short. CFRPs have high strength and are relatively lighter compared to metals.

Mars Orbiter Spacecraft during its construction at ISRO Satellite Centre

To enable the spacecraft to work in a safe temperature range, many coverings, special mirrors, paints, tapes and heaters were used. Of these, the one which is glaringly visible is the golden coloured 'thermal blanket' which resembles a chocolate wrapping!

Three solar panels of the spacecraft generate the electric power by converting sunlight to electricity. And, the large dish antenna of the spacecraft essentially helps it to communicate with the earth. Folded to the sides of the spacecraft during its journey in PSLV, these are deployed (made to spread out) in space.

Like any electrical device, say, a mobile phone, Mars Orbiter Spacecraft needs electrical power to work. Its three solar panels generate about 800 Watts of life giving electrical power near Mars (They generated more power near the Earth, which is much nearer to the Sun!). A rechargeable Lithium-Ion battery supplies power to the spacecraft when sunlight is not falling on the solar panels.

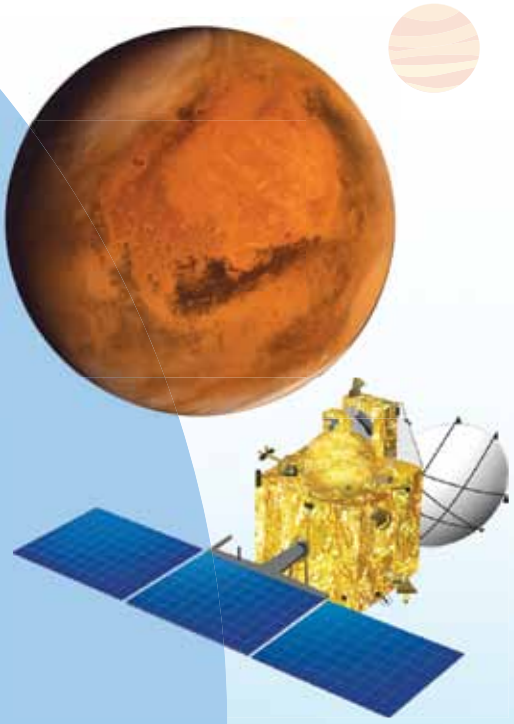
The 7 ft dish shaped antenna of the spacecraft essentially acts as its sensitive ear and mouth. It can transmit the information about the health of the spacecraft as well as the gathered scientific information and receive the radio commands sent from the Earth. The antenna also sends information that help scientists to accurately find out the position and movement of the spacecraft in during its Mars Odyssey.

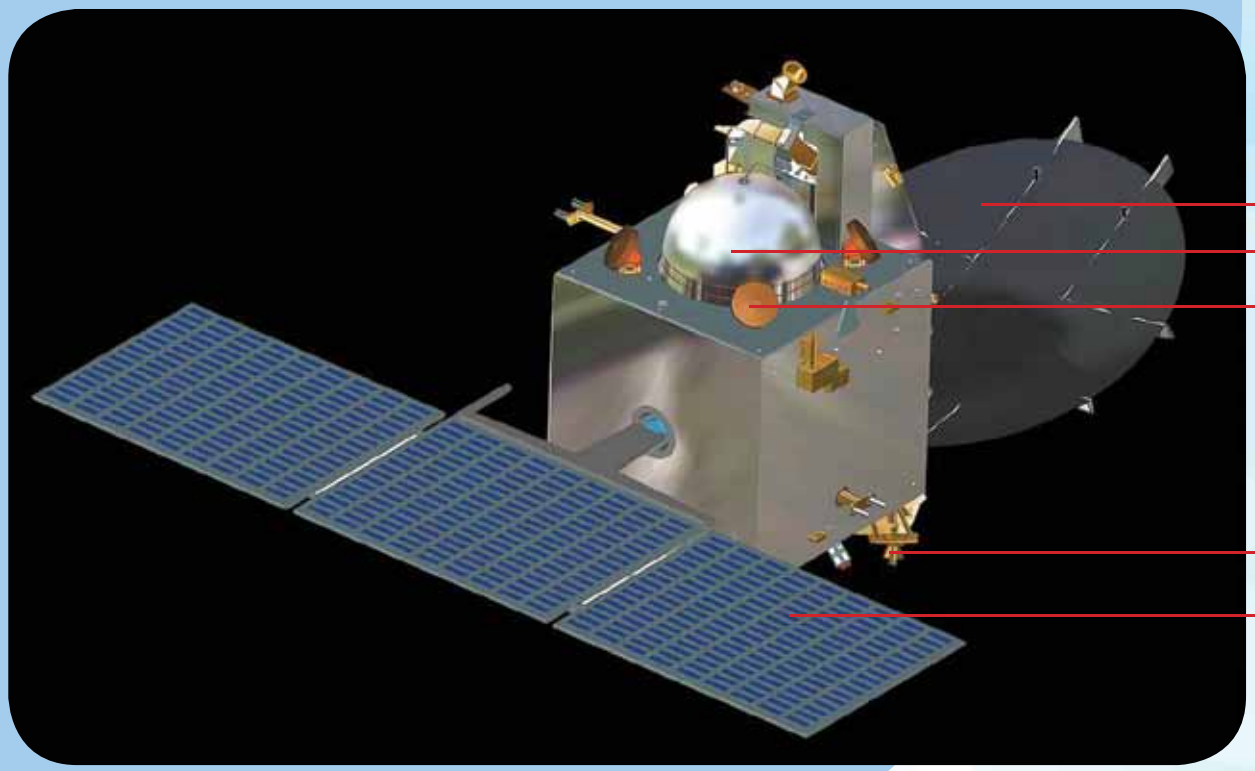
Scientists readying Mars Orbiter Spacecraft for a test at ISRO Satellite Centre, Bangalore

We humans stand upright and walk on two legs. This orientation is properly maintained by a mechanism in the inner ear of the human body. Similarly, to perform its assigned tasks properly, the Mars Orbiter Spacecraft needs to orient its various faces towards Earth, Mars and Sun. Electronic devices called Sun sensors and Star Sensors as well as gyroscopes provide the necessary reference information for this important task.

Using this information, the electronic brain of the Mars Orbiter Spacecraft does the necessary but highly complex calculations to perform the job of properly orienting the spacecraft. Besides, that brain instructs the four rapidly spinning wheels ('reaction wheels') in the spacecraft or the spacecraft's small rocket engines called 'thrusters' to actually perform that task.

One important feature of Mars Orbiter Spacecraft is its ability to take certain decisions on its own to maintain its working status. This is needed because of the difficulty of the scientists on the ground to immediately identify a problem on the spacecraft and to take suitable action very quickly. This is what they normally do in the case of artificial satellites.

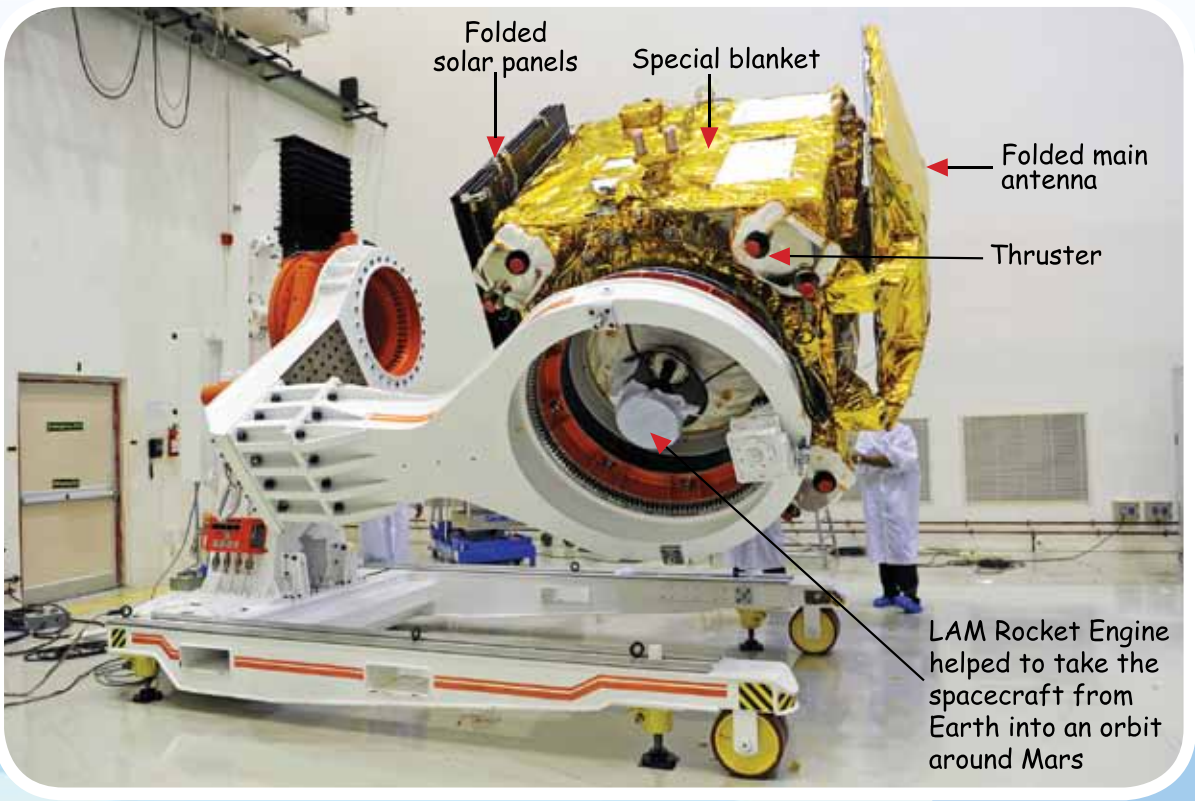




Mars Orbiter Spacecraft details

But, the enormous distance that separates Mars Orbiter Spacecraft and Earth results in considerable delay in the reception of the information sent by the spacecraft through radio. Same thing happens to the radio instructions sent by scientists to the spacecraft. This is the reason why ISRO scientists have put certain 'artificial intelligence' features into the electronic brain of the Mars Orbiter Spacecraft. This makes the spacecraft quite 'autonomous'.

With this feature, the spacecraft is able to identify some of its 'health problems' and can take corrective actions on its own immediately.



Mars Orbiter Spacecraft in a clean room in Sriharikota before its launch

PSLV-C25 rocket that launched Mars Orbiter Spacecraft only carried it into a large egg shaped orbit around the Earth (not Mars!). From there, the job of taking the spacecraft to distant Mars and to make it to circle the red planet was assigned to the spacecraft's main rocket engine known as LAM.

The liquid propellants (fuel-oxidiser combination) needed for LAM as well as its eight thrusters were stored in the spacecraft itself. It was mainly LAM, supported by the eight 'thrusters', that was responsible for the successful entry of the spacecraft into an orbit around Mars on September 24, 2014.

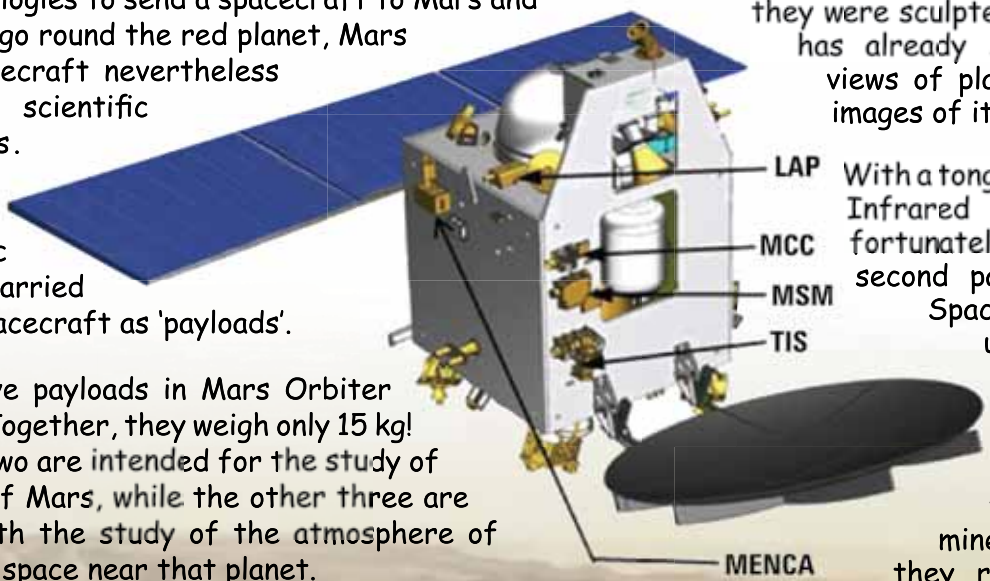
At the time of its launch, Mars Orbiter Spacecraft weighed 1,337 kg. Of that total weight, 850 kg was of propellants. The rocket propellants stored inside the spacecraft are Mono Methyl Hydrazine or MMH and Mixed Oxides of Nitrogen or MON-3.

In this way, Mars Orbiter Spacecraft, which is a confluence of various 'subsystems' (like nervous system, digestive system or circulatory system), functions as a 'system' (human body in many respects).

Scientific Instruments of India's Mars Spacecraft

Despite being a spacecraft built mainly to demonstrate Indian technologies to send a spacecraft to Mars and to make it to go round the red planet, Mars Orbiter Spacecraft nevertheless carries five scientific instruments. Scientists refer to the scientific instruments carried by robotic spacecraft as 'payloads'.

There are five payloads in Mars Orbiter Spacecraft. Together, they weigh only 15 kg! Of the five, two are intended for the study of the surface of Mars, while the other three are concerned with the study of the atmosphere of Mars and the space near that planet.

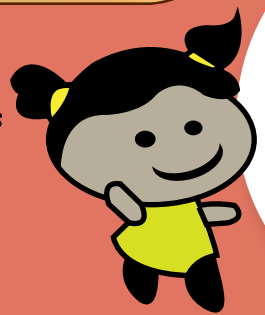


The first payload of Mars Orbiter Spacecraft is 'Mars Colour Camera'. As the name itself indicates, this camera was built to take the pictures of the Martian surface. By looking at those pictures, scientists can study various events taking place on the surface of Mars. They can also study the surface features of Mars and try to understand the way in which they were sculpted by nature. This camera has already sent many breathtaking views of planet Mars as well as the images of its two natural satellites.

With a tongue twisting name 'Thermal Infrared Imaging Spectrometer', fortunately shortened as 'TIS', the second payload of Mars Orbiter Spacecraft helps us study and understand the minerals on the surface of Mars.

It is interesting to note that scientists recognise the existence of various minerals by studying the way they reflect or emit infrared waves.

The Martian moon Phobos, seen by Mars Colour Camera as a pebble against the background of Mars



This takes color pictures of Mars

Mars Color Camera (MCC)

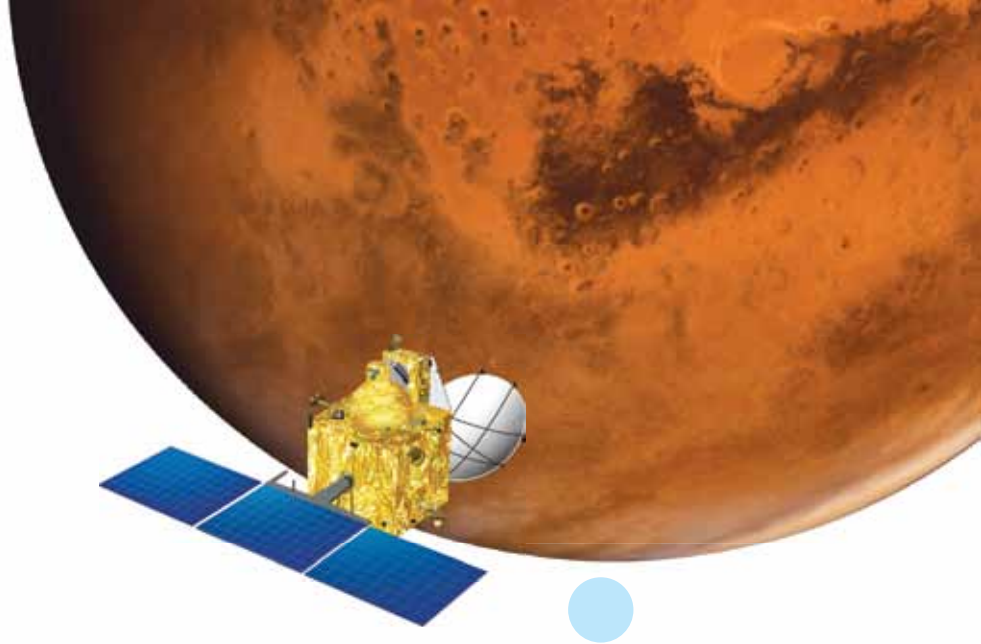
This helps us to study the minerals on Mars

Thermal Infrared Imaging Spectrometer (TIIS)

The third payload on India's first Mars spacecraft is called 'Methane Sensor for Mars'. This highly sensitive instrument is built to sense the extremely minute quantities of Methane gas possibly present in the thin atmosphere of Mars. At the same time, this scientific instrument may help us identify the source of that Methane. This is very important since Methane can be generated through geological as well as biological processes.

One of the questions haunting scientists today is about the loss of water from Mars. Lyman Alpha Photometer or LAP for short, the fourth payload of Mars Orbiter Spacecraft, may help scientists to understand the way water was lost from the Martian atmosphere in the past.

The fifth scientific instrument of Mars Orbiter Spacecraft is yet another payload with a tongue twisting name 'Mars Exospheric Neutral Composition Analyser'. Its name is also shortened as 'MENCA'. This instrument will study neutral atoms in the outer atmosphere of Mars. It is expected that MENCA may help us understand as to how most of the once thick atmosphere of Mars escaped gradually.



In this way, the five scientific instruments carried by Mars Orbiter Spacecraft have been chosen for the purpose of understanding the history of Mars, especially the way it changed over time and allow us to make an attempt to indirectly probe the possibility of microscopic life there.

PSLV: The Muscle Power to Lift Mars Orbiter Spacecraft from the Mother Earth

Do you know which is the most challenging phase of the journey of a spacecraft like our Mars Orbiter Spacecraft travelling from Earth to Mars? It is the journey from the surface of the Earth to an orbit around it!

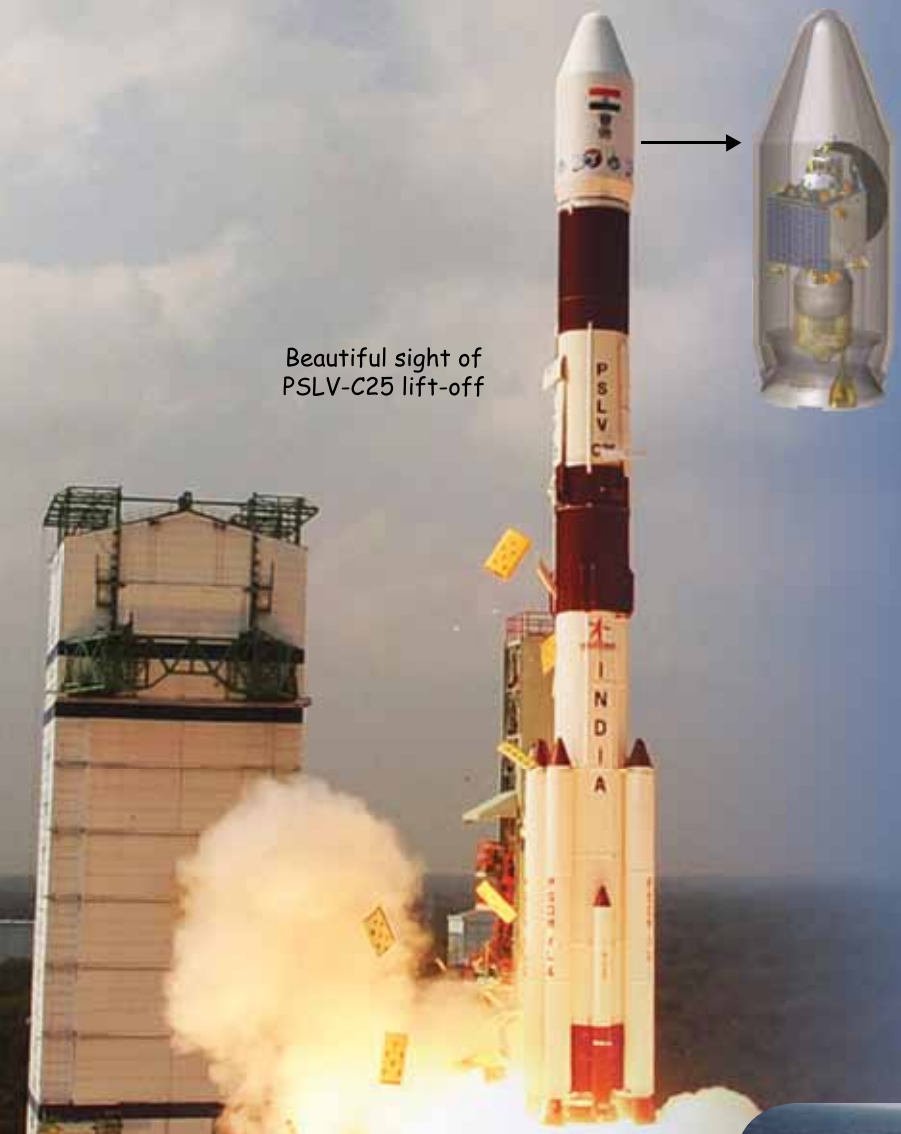
To leave the mother Earth is not easy. For that, the spacecraft has to oppose the tremendous gravity of the Earth that continuously attracts objects towards its centre. Besides, the spacecraft has to pass through Earth's thick atmosphere which also opposes the movement of a vehicle through it.

Rockets are the only known vehicles capable of opposing the mighty gravitational force of the Earth and travel in the vacuum of space. Thus, they are utilised for launching satellites as well as manned and unmanned spacecraft to Earth orbit and beyond.

The giant rocket, to be more precise, the 'launch vehicle' that lifted Mars Orbiter Spacecraft from the surface of the Earth and put it into a 'parking orbit' around the Earth was Polar Satellite Launch Vehicle or PSLV. Before launching Mars Orbiter Spacecraft, this 'trusted work horse' of ISRO had scored 23 successes continuously.

Mars Orbiter Spacecraft mounted on top of PSLV-C25 fourth stage

As the 15 storey high PSLV stood majestically on the First Launch Pad at Sriharikota Island, it looked like a giant pencil from a distance. Placed on top of one another were the four stages of PSLV. The 1,337 kg Mars Orbiter Spacecraft was placed over the fourth stage of PSLV and was covered by the heat shield of the rocket. This would protect the spacecraft as PSLV sliced through the Earth's atmosphere at tremendous speed.



Beautiful sight of PSLV-C25 lift-off

On November 05, 2013 at 2:38 pm in the afternoon, the twenty fifth flight of PSLV (named as PSLV-C25) began. As the first stage of the rocket roared into life, it magnificently soared into the sky. In the next 9 minutes that followed, the first three stages of PSLV as well as its six smaller rockets called 'strap-ons', worked perfectly and separated from the rest of the rocket at the assigned time. In between, once the PSLV cleared thick atmosphere, the heat shield was also discarded and Mars Orbiter Spacecraft was exposed to space.

Then, for nearly 24 minutes, PSLV continued its journey without any power. Later, the two engines of the PSLV fourth stage started firing right on time. Ultimately, about 44 minutes after lift-off, PSLV provided the necessary speed (to be more precise, velocity) to Mars Orbiter Spacecraft to go round the Earth in a 'parking orbit' and separated. This speed was about 35,000 kilometres per hour!

In this highly oval shaped orbit, the spacecraft was at a distance of only 248 km from the Earth's surface at its nearest point, but 23,553 km at its farthest point. And, it took some six hours to circle the Earth once.

Two Indian ships stationed on the vast Pacific Ocean – Yamuna and Nalanda – equipped with dish shaped radio antennas, monitored the performance of the PSLV fourth stage as well as the successful entry of the spacecraft into its 'Earth Parking Orbit'.

An Indian ship carrying dish antenna to monitor the flight of PSLV-C25

Thus, the most difficult phase of the journey of Mars Orbiter Spacecraft was successfully accomplished, thanks to the highly reliable PSLV, which scored yet another sweet success!

Spacecraft's Odyssey from Earth to Mars

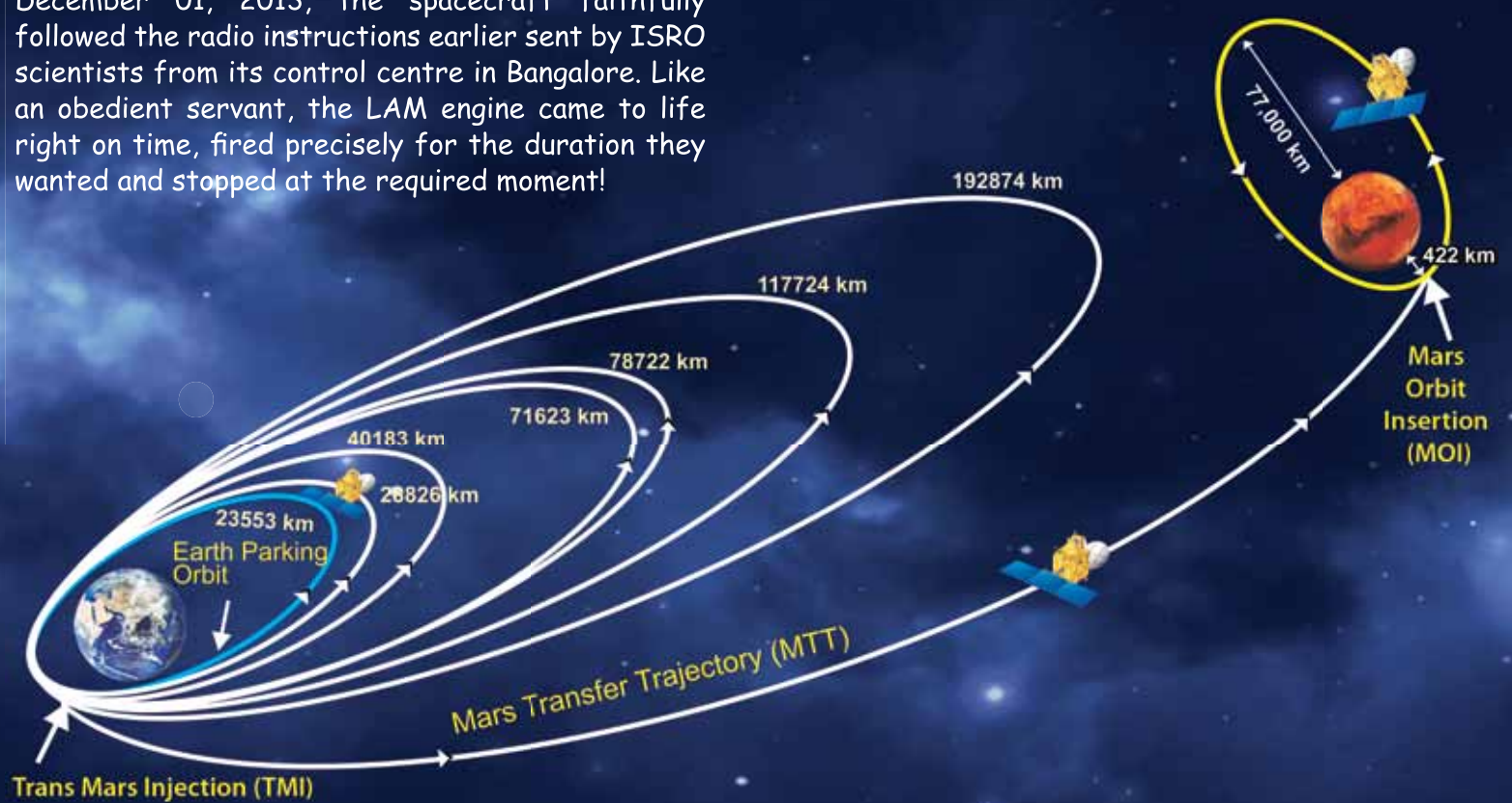
Following the successful completion of the first phase of its long journey to Mars, the Mars Orbiter Spacecraft was ready for the next step. That was known as 'orbit raising'.

During that phase, the main liquid rocket engine (LAM) of the spacecraft was fired six times. This was done during November 7th to 16th of 2013, when the spacecraft was at its nearest point to earth. Each time when LAM was fired, the farthest point of the orbit climbed higher and higher, finally reaching almost 193,000 km!

And now, the time was ripe for yet another important step. In the early morning hours of December 01, 2013, the spacecraft faithfully followed the radio instructions earlier sent by ISRO scientists from its control centre in Bangalore. Like an obedient servant, the LAM engine came to life right on time, fired precisely for the duration they wanted and stopped at the required moment!

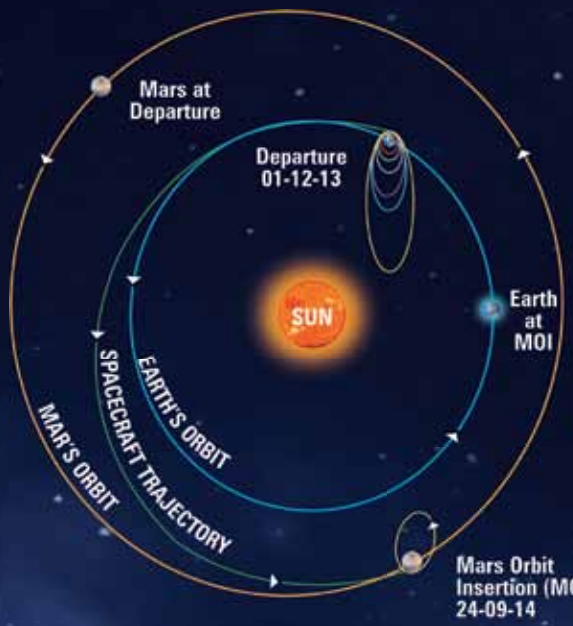
With this precise rocket firing, Mars Orbiter Spacecraft acquired sufficient energy to escape from circling the Earth and followed a path ('Mars Transfer Trajectory') that would take it near Mars on September 24, 2014.

A few days after its escape from the Earth orbit, as it crossed a distance of about a million kilometres from the Earth, the spacecraft left Earth's sphere of influence. In the following 300 days or so, it would have to travel a distance of about 667 million kilometres (nearly 67 crore kilometres) to reach Mars.



The progress of Mars Orbiter Mission

As it sped towards its target point in deep space, scientists who built that spacecraft thoroughly tested it. Besides, its scientific instruments (remember, they are referred to as 'payloads' by scientists) were also checked out thoroughly. On April 09, 2014, Mars Orbiter Spacecraft successfully crossed half way mark in its journey to Mars.



Shri Narendra Modi, Honourable Prime Minister of India, addressing from the Spacecraft Control Centre after the successful Mars Orbit Insertion on September 24, 2014

By September 15, 2014, India's Mars Orbiter Spacecraft had covered about 653 million kilometres (65.3 crore kilometres) from Earth in its curved path around the Sun. This was 98% of its total travel distance to Mars. On that day, a radio message from Earth to spacecraft took about 12 minutes to reach it and again the same time to reach the Earth back!

So, after saying 'hello' to the spacecraft through radio, one had to wait for about 24 minutes to receive the acknowledgement of that 'hello' from the spacecraft on that day!

On the early morning of September 24, 2014, the spacecraft was made to slowly turn and orient its LAM in the required direction. This was to ensure that the firing of LAM would put a break to the speed of the spacecraft.

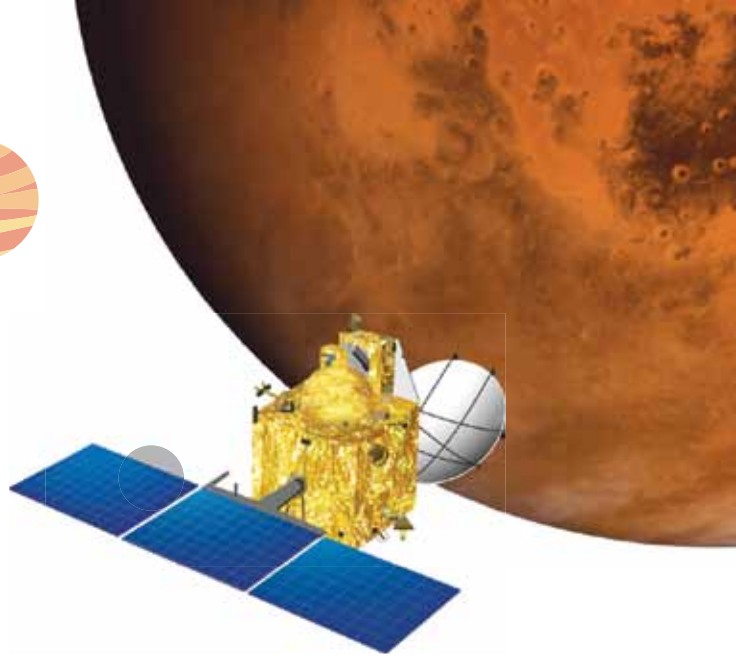
Then at 7:17 am IST on that day, as the spacecraft passed close to Mars, its main rocket engine (LAM) fired once again, right on time!. Along with it, eight 'thrusters' of the spacecraft also fired.

This LAM firing, which lasted for about 24 minutes, slowed down the spacecraft sufficiently and allowed the weak gravity of Mars (compared to Earth) to 'capture' the spacecraft in a highly oval shaped orbit around that planet.

Thus, India achieved a roaring success in its very first attempt to put a spacecraft into an orbit around Mars. The Prime Minister of India was present at the satellite control centre to witness this momentous event.

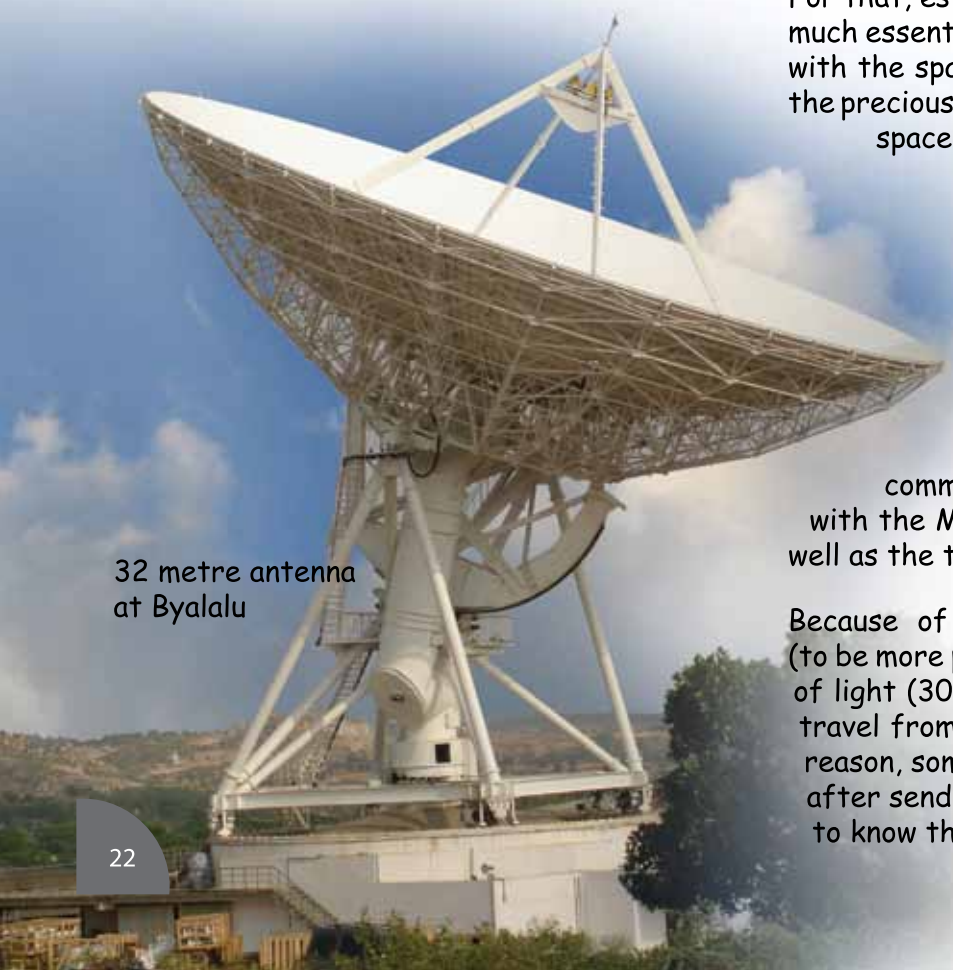
Later, ISRO scientists began the observation of Mars in a methodical way with the help of the spacecraft's five payloads.

Ground Facilities:
The Vital Link Between the Spacecraft and Earth



Building a spacecraft capable of travelling to planet Mars and explore the red planet while circling it, is undoubtedly a complex task indeed. Besides, perfecting a giant rocket capable of very accurately launching that spacecraft into Earth orbit as a first step in sending the spacecraft towards Mars, is yet another herculean task. Though these two tasks are necessary, they are not sufficient to realise the goal of successfully exploring Mars with that spacecraft.

For that, establishing well-equipped ground facilities becomes very much essential. Those facilities should be capable of communicating with the spacecraft, controlling it as well as receiving and storing the precious information sent by that spacecraft from the depths of space. ISRO has well established ground facilities capable of performing these tasks. They had proved their worth during Chandrayaan-1, India's first mission to explore the Moon. And, those facilities were suitably upgraded for the Mars Orbiter Mission.



32 metre antenna at Byalalu

Remember, even at its nearest, Mars is about 150 times as far from the Earth as the Moon is! This complicates the task of building radio communication equipment that can help us to be in touch with the Mars Orbiter Spacecraft during its journey to Mars as well as the time during which it circles Mars.

Because of the enormous distance involved, even radio waves (to be more precise, in this case microwaves) travelling at the speed of light (300,000 kilometres per second!) take tens of minutes to travel from Earth to a spacecraft orbiting Mars. Because of this reason, sometimes ISRO Scientists have to wait up to 42 minutes after sending a radio instruction to the Mars Orbiter Spacecraft to know the result of their action!

ISRO scientists at Mars Orbiter Spacecraft Control Centre

For communicating with the Mars Orbiter Spacecraft, ISRO scientists have been mainly using a giant dish shaped radio antenna which is 32 metre (105 feet) wide. This was conceived and built by Indian Engineers.

Equipped with special mirror like devices, this ground antenna acts as the 'sensitive ear' to listen to the faint radio signals 'whispered' by Mars Orbiter Spacecraft. Those unbelievably faint radio signals carry information about the health of the spacecraft as well as the precious information gathered by the spacecraft's scientific instruments.

Besides, this antenna behaves like a 'loud mouth' to transmit radio instructions to that spacecraft. This huge antenna is situated in a place called Byalalu, about 35 km from Bangalore. Another nearby antenna which is 18 metre wide was also used for this work. These two antennas are part of what is known as 'Indian Deep Space Network'.

Besides these antennas, Byalalu has yet another important facility. This obtains, processes, systematically stores and distributes the precious scientific information from Mars Orbiter Spacecraft received by ground antennas.

It is called Indian Space Science Data Centre. This sophisticated digital 'library' also contains the precious data (scientific information) sent by the earlier Chandrayaan-1 during its active life in 2008-09.

The 'nerve centre' of all the important activities of Mars Orbiter Mission is a very high tech Spacecraft Control Centre situated at Peenya, in North Bangalore.

Engineers who guide and control Mars Orbiter Spacecraft work there 24 hours a day and seven days a week! They cautiously monitor the health of Mars Orbiter Spacecraft as well as the progress of its flight and maintain it safely in space.

Thus, ISRO has a set of highly capable ground facilities as well to realise the goals of Mars Orbiter Mission.

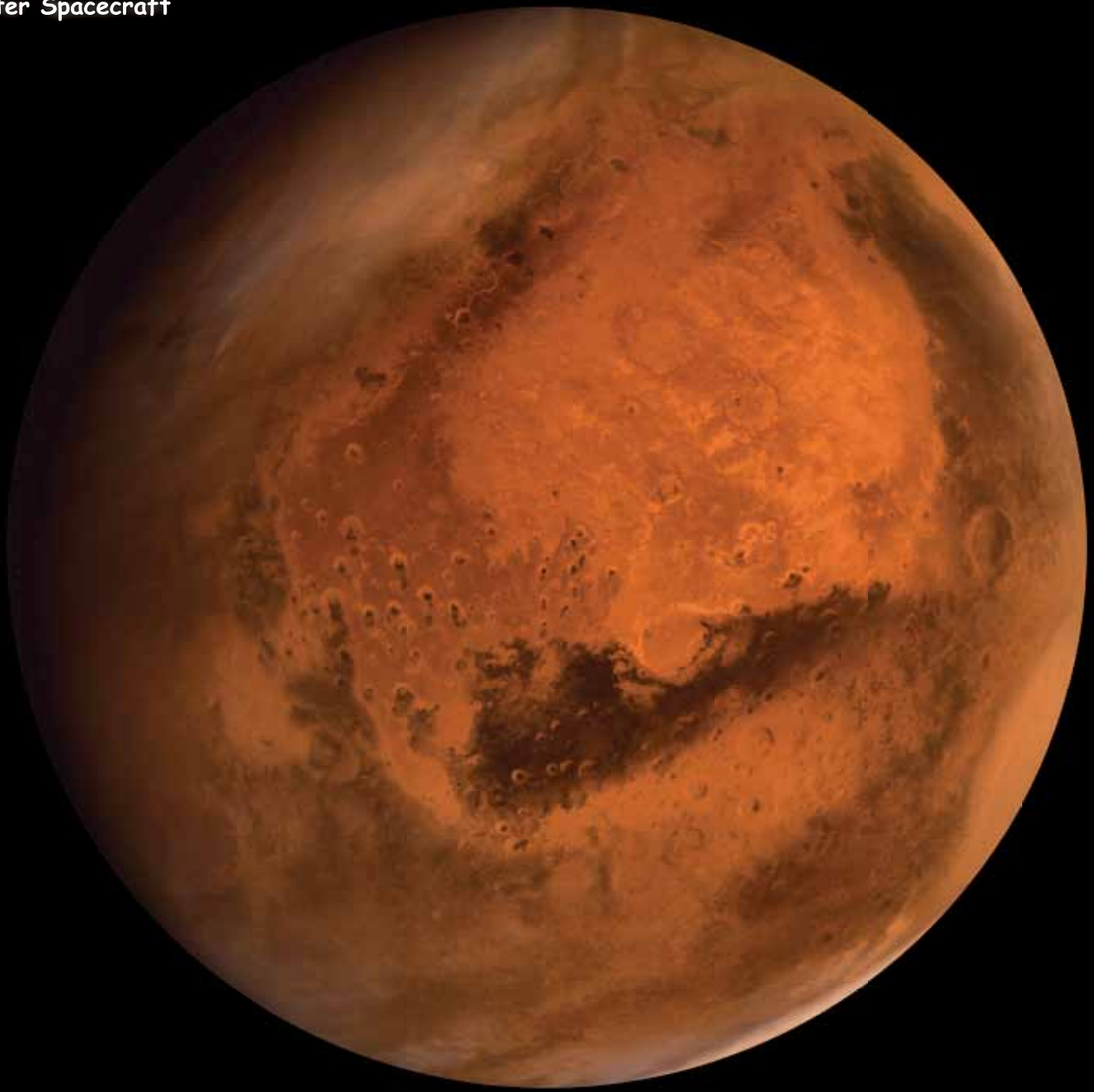
A view of Indian Space Science Data Centre

Having patiently struggled to make Mars Orbiter Mission a success, ISRO is now filled with a sense of immense satisfaction after the safe entry of Mars Orbiter Spacecraft into the desired orbit around planet Mars on September 24, 2014 and the spacecraft's successful completion of six months in that orbit.

This is understandable since ISRO has achieved grand success in its very first attempt to send a robotic spacecraft to the distant Mars as well as to make it to go round the red planet.

Undoubtedly, Mars Orbiter Mission is one of the greatest achievements of modern India. This should inspire our younger generation to take up more challenging space endeavours in future.

Picture of the Full disc of Mars sent by
Mars Orbiter Spacecraft



INDIAN SPACE RESEARCH ORGANISATION

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