



*Mangalyaan is one of the most **cost effective** inter-planetary mission ever designed in history*

Why did India launch Mangalyaan?

On November 5, 2013, the Indian Space Research Organization (ISRO) launched its first spacecraft bound for Mars. India built Mangalyaan ("Mars craft" in English) to study the Red Planet and test key technologies required for exploring the inner solar system. The Mangalyaan spacecraft successfully entered Mars orbit on September 23, 2014, making ISRO only the fourth space agency in the world to do so. Prior to India, only the United States, the Soviet Union and the European Space Agency (ESA) had successfully explored Mars.

Why did ISRO launch Mangalyaan on a PSLV rocket?

ISRO originally intended to launch Mangalyaan on their Geosynchronous Satellite Launch Vehicle (GSLV) rocket instead of the only roughly half-as-powerful Polar Satellite Launch Vehicle (PSLV). As with most Mars missions, a GSLV rocket could've boosted Mangalyaan out of Earth orbit and onto an interplanetary trajectory to the Red Planet. But the rocket suffered two failures in 2010, just as Mangalyaan was being conceptualized.

Fixing the identified issues in the rocket's design and preparing for another launch could have taken at least three years, placing it close to the time-sensitive November 2013 launch window for Mars. The next launch opportunity was in 2016, so ISRO decided to launch Mangalyaan on a PSLV rocket in 2013 instead.

However, the PSLV could only place Mangalyaan in a highly elliptical Earth orbit. It would be the spacecraft's job to fire its engines at precise points in each orbit multiple times over the next few weeks to set

itself on a trajectory to Mars, or it would miss the planet entirely. The trajectory design was highly unusual for a Mars mission but it worked. Once the spacecraft arrived at the Red Planet roughly 300 days later, it fired its engines again and successfully entered Mars orbit.



India's Mars Orbiter Mission launched successfully from Satish Dhawan Space Center on November 5, 2013 at 14:38 IST (9:08 UTC). Image: ISRO

What technologies did ISRO develop for Mangalyaan?

ISRO built upon its experience with Chandrayaan 1, India's first lunar orbiter, to develop Mangalyaan. The Mars spacecraft was a modified design of the Chandrayaan 1 spacecraft with upgraded components as required. For example, there were more and upgraded solar panels to make up for reduced solar energy available at Mars.

ISRO also developed the ability for its ground stations to communicate with a spacecraft on another planet. With Mangalyaan, there were two-way communication lags of up to 42 minutes; this gap also demanded enabling the spacecraft to make autonomous decisions for situations where there would be no time for humans to be in the loop, something that wasn't necessary for Chandrayaan 1.

National response

The fact that ISRO successfully placed a spacecraft in Mars orbit on their very first attempt garnered attention and praise from people worldwide. In India, the mission had even deeper effects, aided by ISRO's inaugural efforts to be active on social media to make people at large aware of the mission.

The mission saw several film and TV show adaptations in India, the most popular of which was the dramatized movie Mission Mangal. The national government decided to feature an illustration of Mangalyaan on the reverse side of India's highest denomination currency note of ₹2,000 (roughly \$27). Writer Minnie Vaid wrote a book called "Those Magnificent Women and their Flying Machines," which profiles the journeys of some of the key women who had leading roles in the mission.

Future missions

With the experience gained from Mangalyaan and technologies built for it, ISRO is planning more missions to explore the inner solar system, such as the Venus orbiter Shukrayaan and the Aditya-L1 solar observatory. ISRO is also planning to launch Mangalyaan 2 in 2024 or 2026 with an upgraded orbiter and 100 kilograms (about 220 pounds) of scientific instruments. A recent talk by a veteran ISRO scientist tells us that ISRO has begun working on Mars landing technologies too. In all, mission Mangalyaan has opened up the inner solar system for India's fledgling planetary program.



GLOBAL VIEW OF MARS FROM MOM: MERIDIANI PLANUM Mars Orbiter Mission caught this global view of Mars soon after arriving in orbit, on Sept 28, 2014, from an altitude of 74582 KM.