

# How did ISRO manage to send a satellite mission to Mars at such a low cost?

*The original question asked "How did ISRO send an orbiter to Mars by spending just \$75 million while NASA spent more than \$700 million?"*

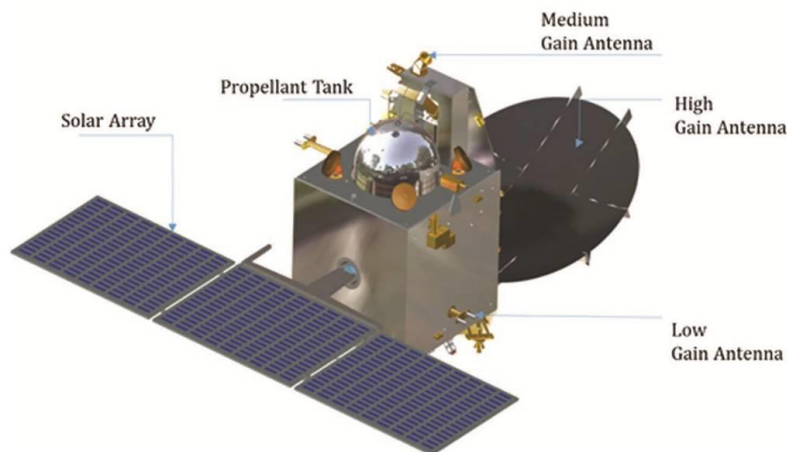
There is a large cost difference between the two missions mainly because of the different objectives, payloads, and expected operating lifespan. While Mangalyaan MOM (Mars Orbiter Mission) is a huge step for the Indian space program, its cost effectiveness is not really comparable to NASA's MAVEN (Mars Atmosphere & Volatile Evolution Mission) at all.

## **Objectives:**

MAVEN: MAVEN is the first spacecraft that will focus primarily on the state of the upper atmosphere of Mars, the processes that control it, and the overall atmospheric loss that is currently occurring. Specifically, MAVEN will explore the processes through which the top of the Martian atmosphere can be lost to space.

## Mangalyaan:

- Design and realization of a Mars orbiter with a capability to survive and perform Earth bound maneuvers, cruise phase of 300 days, Mars orbit insertion / capture, and on-orbit phase around Mars.
- Deep space communication, navigation, mission planning and management.
- Exploration of Mars surface features, morphology, mineralogy and Martian atmosphere by indigenous scientific instruments.



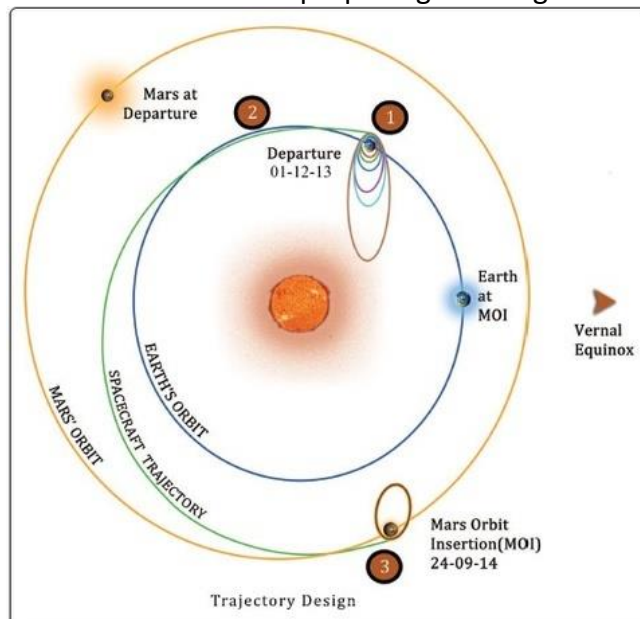
From the objectives, it is clear that MAVEN is out to perform specialized research that involves studying the atmosphere of Mars while MOM is a technology demonstrator, more focused on taking the first step towards a successful space program -- putting an orbiter successfully into Martian orbit and perform maneuvers. More than studying Mars, it was/is important for Mangalyaan to perform space maneuvers which would help in providing information for planning future missions, especially the next nearest Mars mission aimed for 2017-2020.

*MAVEN is being used for sophisticated, specialized research, while MOM is being used a prototype study for future Indian space missions.*

### Weight, Path, and Fuel

MAVEN: MAVEN weighed 2,500 kg when it left the Earth on Nov 18, 2013, out of which 1800kg was fuel. It was stacked atop a Centaur upper stage, both of which were ferried up on an Atlas 5. After precisely twenty seven minutes, MAVEN was ready to be on its way to Mars. The Centaur fired again and propelled it into its Martian trajectory, after which it was detached. Solar panels were then exposed, and apart from the occasional boost, MAVEN simply cruised all the way to Mars, like a free fall from its initial impetus.

Mangalyaan: Mangalyaan weighed 1350kg when it left the Earth's surface on Nov 5, 2013, out of which 850kg was fuel. MOM did not use an upper stage launcher. Instead, it used ISRO's trusty PSLV and performed a series of gradual maneuvers to raise itself to the Earth's higher orbit by going around the Earth six times and propelling itself higher with each revolution.

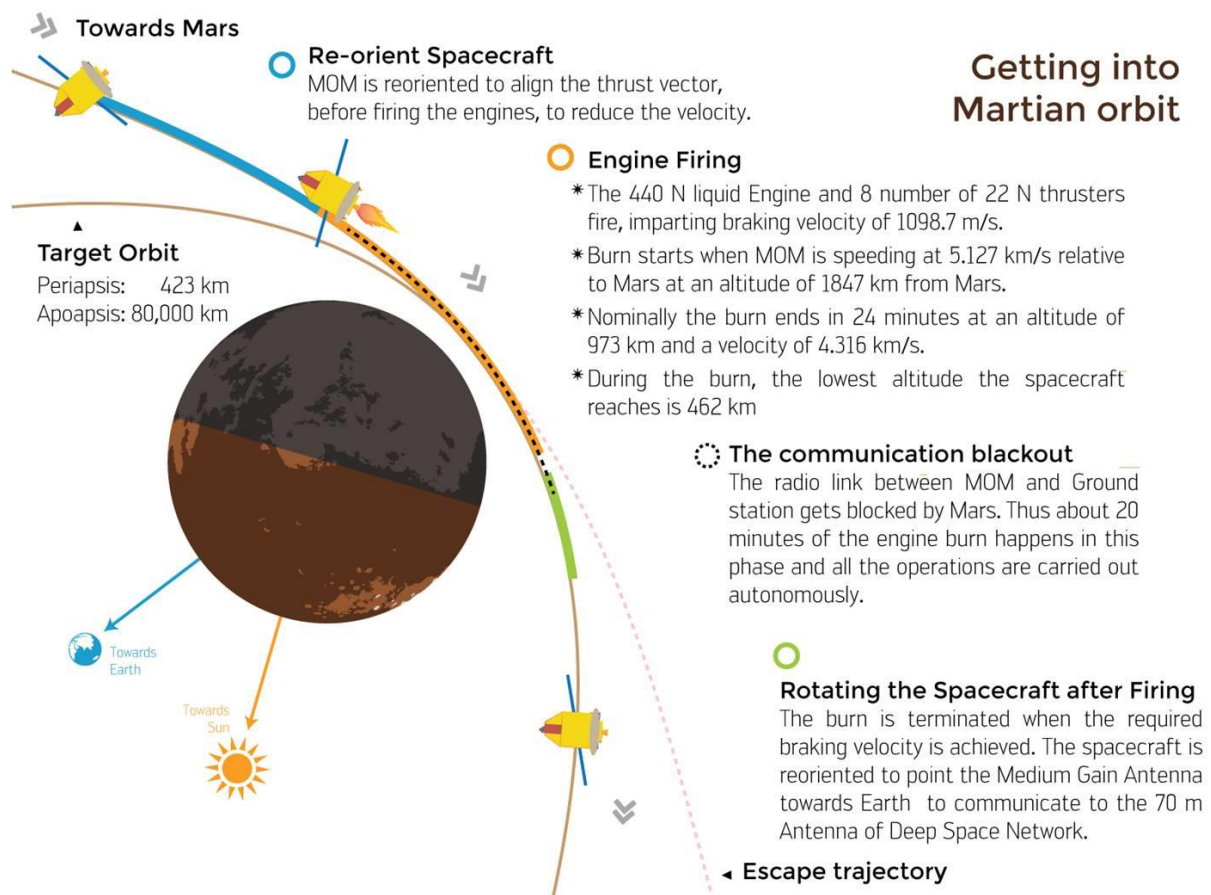


MOM remained within the Earth's gravitational field for a month before it was ready to depart for Mars. Once MOM started on its interplanetary journey, it also cruised towards Mars in a manner similar to that of MAVEN.

*MAVEN used more than twice the amount of fuel that MOM did.*

*MAVEN started its journey to Mars within 28 mins of liftoff from Earth, whereas MOM took one month after liftoff.*

*MAVEN left two weeks after MOM did, and reached 24 hours before MOM did.*



**Specs**

**MAVEN:** The orbiter has a cubical shape of about 2.3 meters × 2.3 meters × 2 meters high, with two solar arrays that hold the magnetometers on both ends. The total length is 11.4 meters. [4]

**Mangalyaan:** The spacecraft is cuboid in shape, approximately 1.5 m (4 ft 11 in) across. [5 verbatim]

*MAVEN is more than four times the size of MOM.*

### **Payloads**

MAVEN: MAVEN carries eight scientific instruments devoted to understanding Mars' upper atmosphere. They are all of cutting edge technology, and very specialized in nature. MAVEN does not carry a camera, but uses a Imaging Ultraviolet Spectrograph (IUVS) instead. This is the most powerful spectrograph to be sent to another planet.

Mangalyaan: MOM carries five instruments, generic in nature, that cover a broad range of observations. MOM carries a tri-color camera with the ability to capture and observe the weather and dynamic events on the surface of Mars.

*MAVEN carries more number of cutting edge scientific instruments than MOM.*

### **Final apsides (orbital heights)**

MAVEN: At its highest, MAVEN will be at 6,200 km above Mars's surface and barely 150km above the surface at its lowest.

Mangalyaan: At its highest, MOM will be 80,000km above the surface, and 365km above the surface at its lowest height.

*MAVEN will descend to much lower altitudes in its orbit to study the Martian atmosphere and has a stronger force of gravity and greater exposure to dust to combat than MOM will.*

### **Lifespan**

MAVEN: The main mission is expected to last one Earth year. MAVEN carries enough fuel to extend that by another 29 months, making it 2.5 years. It can then position itself in a higher orbit to conserve fuel for another six years.

Mangalyaan: MOM's expected lifespan is six months, and 300 days at the maximum.

*MAVEN is expected to function for 8.5 years while MOM is expected to function for ten months.*

### **Economies of US and India:**

A large vegetarian pizza from Pizza Hut costs Rs. 475 in India and \$21 (Rs. 1280 as of 24th Sep, 2014) in the US.

PS: While India is the first *nation* to insert an orbiter into the Martian orbit successfully in the first attempt, ISRO is not the first agency to have done so. European Space Agency's (ESA) maiden orbiter mission, Mars Express, had a successful insert in 2003.

**Recycled equipment:**

This was the 25th flight of the launch vehicle PSLV (which has 95% success rate, one of the highest in world)

**Minimum Fuel Usage:**

The actual distance between earth and mars is 55 million kms when they are closest. The MOM will travel 690 million kms in an elliptical manner because a straight-line travel would not have been as energy efficient as this one.

The MOM will circle earth several times and its orbit and speed will be raised in six stages until it reached the maximum point of 1.92 lakh km from Earth.

**Swadesi Technology:**

Almost all the parts of MOM and the people used to develop them are entirely Indian. ISRO has always adhered its core principles of adapting existing technology as much as possible, minimize all sorts of physical models, make testing effort optimal and work round the clock. Adaptation is an old method that has now been perfected to an art in ISRO since its establishment.

**Some quick facts about MOM's inexpensiveness:**

- MOM cheaper than Boeing's cheapest aircraft
- Costs just a fraction of what India will spend on Statue of Unity (Rs 2600 Cr vs Rs 450 Cr)
- NASA's MAVEN six time expensive as India's MOM
- Constitutes 2.1% of \$3.5bn aid contributions done by India to other nations.
- Costs less than 2% of the estimated £2.5bn in salaries paid to UK employees by Indian companies
- Is equivalent to 0.3 % of India's \$24bn IMF bailout contribution to the Eurozone crisis
- India's budget for FY 2013-14: Rs 16,65,297 crores;  
Budget per head: Rs 14,500 per person.  
With MOM costing Rs 450 Cr, it comes to Rs 4 per head which won't fetch you more than one or two onions.