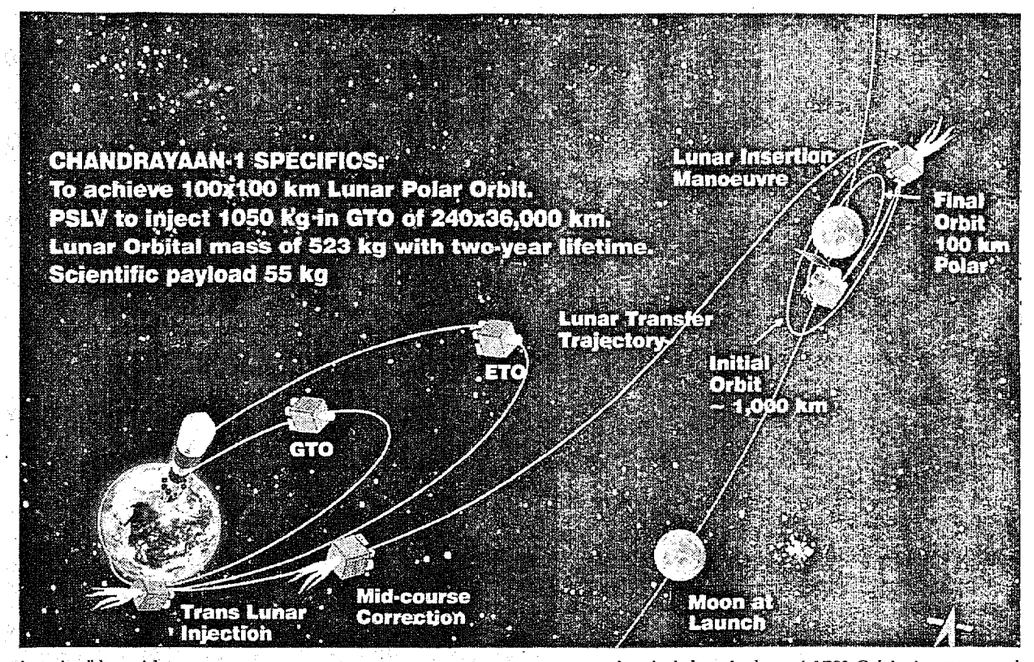
Lunar levitation

That the moon may contain water in some form, holding out the possibility of human colonisation, has accelerated interest away from the major players. **TV Jayan** explores the science and politics of the ambitions of India and other countries



TILL 1999, India's space programme was focussed on application-driven projects — sending satellites into space with an eye on immediate benefits — but that didn't mean its scientists weren't nursing the desire to explore space from a pure science perspective.

At an annual meeting of the Indian Academy of Sciences in October of that year, a symposium was organised to discuss moon exploration, says V Adimurthy, whose team is designing Chandrayaan-1 — the rocket for India's proposed lunar orbiter — slated for launch by 2008 at the Vikram Sarabhai Space Centre in Thiruvananthapuram. There was widespread support from the scientific community despite the popular belief that the Apollo and Luna missions of the 1960s and early 1970s had gathered whatever information necessary. It was felt that an Indian mission would only "reinvent the wheel".

"This was a misconception that was cleared because we could explain the gaps in the knowledge about the moon," says Adimurthy.

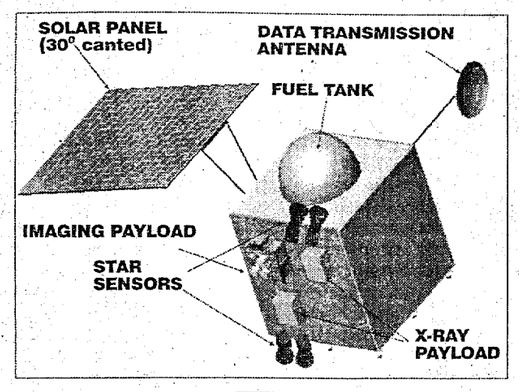
Three missions in the 1990s — two by the USA and one by Japan — substantiated this. Subsequently, the Indian Space Research Organisation set up a task force headed by George Joseph, former director of the Space Applications Centre, Ahmedabad. It was asked to prepare a moon mission plan, work out cost estimates, and suggest scientific experiments, taking into account technical resources available within and outside ISRO. Its report came out in 2001 and two years later the Union government cleared the mission. It is now expected to cost Rs 380 crore, the cheapest-ever lunar mission.

But the Indian mission got a fillip in May 2006 when it signed a formal agreement with the National Aeronautics and Space Administration to carry two scientific instruments on the Chandrayaan-1 mission. More significant was an understanding between the two space agencies on broader collaboration in space exploration, which was being hammered out from June 2004.

But many continue to question whether even this expenditure is justified, especially when existing satellite programmes may need more funds and work to fulfil their potential. ISRO officials say one reason for backing the lunar mission is that talented young scientists who join the organisation do not find building and launching rockets and satellites challenging because the template is now in place. To retain them requires the offer of more challenging tasks. "We can't offer them big money as private sector firms do, but we can certainly offer exciting opportunities," says M Annadurai, project director for Chandrayaan.

Planetary sciences have always been a stimulating subject and venturing into this arena will also attract more bright students, says Adimurthy.

G Madhavan Nair, ISRO chairperson, says the space organisation is not spending much on the lunar mission. "The total being spent on Chandrayaan-1 is around two per cent of the ISRO budget in the 10th Plan."



EXPLAINING THE GAPS: Craft designer V Adimurthy.

OPPORTUNITIES: Project director M Annadurai.

But experts say the problem with these missions is that they never stop at one. For such research missions to succeeed, ISRO may have to launch several probes, ranging from orbiters to landers, which is going to cost huge sums. ISRO officials, though, argue that such cutting-edge scientific endeavours can generate a number of spinoff technologies that can be applied in other areas. For example, a satellite launch requires reliable information about the weather around the launching station. ISRO has developed an automatic weather station around its launch pad in Sriharikota that can automatically download and relay data to a central location to be used for meteorological forecasting. While an imported station costs anything between Rs 10-20 lakh, the one developed by ISRO is available for Rs 3 lakh. If India were to modernise its weather data collection comprehensively, it might require more than 2,000 such stations, which translates into huge savings, the officials say.

Annadurai says path-breaking ventures such as the lunar mission always yield several offshoot products. The possibility of finding water (in the form of ice) in the polar regions has been the trigger for the current rush in lunar exploration, he says. The presence of water could possibly help colonise the moon, an idea found to be an exorbitant proposition in 1974. Apart from being available for drinking, water in any form can be split into oxygen for breathing and hydrogen as fuel for rockets as well as land rovers. It can result in substantial cost saving, if permanent human residence is planned. Carrying a litre of water from earth could cost about Rs 30 lakh.

Past missions, including several Apollo and Luna landers, collected a huge amount of data, covering chemical, geophysical and geochronological aspects. These missions had also brought back nearly 380 kg of moon rock and dust, collected from nine different locations in the equatorial regions of the near side of earth's only satellite. But scientists found the data wanting for accurate modelling of the chemical and physical evolution of the moon. The details of these chemical and physical processes, their time scales and the extent to which the moon was subjected to them have not been fully understood.

According to Clive R Neal, a geologist at the University of Notre Dame, USA, knowledge about the lunar interior is also close to zero. "This is the biggest gap, in my opinion. We need a long-lived geophysical network (seismometer, heat flow, magnetometer) to better understand the lunar interior," he said.

Nair says the Chandrayaan-1 project offers two challenges. One is technological: designing the mission without outside support. "The farthest we have gone in space is 36,000 km (the Indian communication satellites of the INSAT family are parked at geosynchronous orbits 36,000 km away). Chandrayaan-1 has to travel 384,000 km," he says. ISRO also needs to have control over the spacecraft during its planned two-year span. This means further work on orbital control and manoeuvring the probe. ISRO is currently setting up a deep-space tracking network closer to Bangalore at a cost of Rs 100 crore for command, control and tracking operations for Chandrayaan-1 and other spacecraft India may decide to launch later.

Indian scientists have also designed and are building all scientific instruments needed by Chandrayaan-1. "It's a great challenge to build specialised cameras and gauges like spectrometers and altimeters at a scale that is suitable to the moon probe," says Annadurai. He adds that these sophisticated gadgets have to be at least one-tenth the size used in normal satellites because of the much larger distances involved in a lunar mission and the larger costs involved. Besides, the instruments on the orbiter have to be more reliable than those on board remote-sensing satellites, because Chandrayaan-1 will not have any back-up.

Chandrayaan-1, which will have a mass of 590 kg when it reaches its destined orbit 100 km above the moon, will carry scientific payloads for chemical, mineralogical and topographic studies of the lunar surface weighing 90 kg. While Indian scientists have designed all the equipment required for meeting the goals of the Indian lunar mission, some is also being acquired from the USA, the European Space Agency, Germany and Belgium.

The main questions that Indian scientists will seek to answer concern the origin and evolution of the moon and whether its polar regions actually contain water. Scientists have for long been wondering how the earth acquired such a large satellite that resembles the composition of our planet's mantle.

According to Bhandari, there could be water on the moon in spite of its weak gravity, because comets and meteorites containing water have been hitting the moon all through its history. In addition, some juvenile water existing since its formation may still be preserved. Also, solar-wind protons impinging on the moon can reduce the presence of oxides present on its surface and produce some water molecules.

However, even trace amounts of water have not been found in lunar rocks and soils. Since the lunar surface has high temperatures (approximately 130° Celsius) on the sunlit face and low temperatures on the dark hemisphere (-170° Celsius), water and other volatiles are deposited in the cooler hemisphere, the permanently shadowed polar regions.

The Lunar Prospector carrying a neutron spectrometer (a sophisticated instrument that detects water even if it constitutes only 0.5 per cent of surface material, by tracking hydrogen atoms in water molecules) found a reduction of warm neutrons around the north and south poles of the moon, which shed a significant part of their thermal energy when they collide with particles of similar size. This could be because of the presence of hydrogen particles in the polar regions. Whether this hydrogen is from water has not been ascertained. Assuming the signal to be entirely due to water, it is estimated that approximately $2x10^9$ tonnes of water is spread over $2.2x10^3$ sq km and 103 sq km of the south and north poles respectively. This would translate into two trillion litres.

According to Annadurai, another Chandrayaan-1 objective will be to produce a gravity map of the moon. It is known that the moon has one-sixth the gravity of earth. Scientists also know that it is not uniformly distributed because it does not have a core with a strong enough gravitational pull and the lunar surface has mounds of iron-rich minerals distorting the magnetic force. "If we have to plan a landing mission or fly closer to the lunar surface in future, we need to have a precise gravity map worked out," he says.

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