Launching the First Indian Satellite

Radio Talk recorded on January 16, 1975

1. On the outskirts of Bangalore near a small village called Peenya there is an industrial estate for electronics and related activities. A visitor entering the first set of buildings on the estate will find the place humming with rather unusual activity. In one of the rooms with super-clean atmosphere engineers and scientists of the Indian Space Research Organisation – called 'ISRO' for short – are busy working on what appears to be a large blue and violet diamond like object. This strange structure is a spacecraft with 26 faces, nearly 1½ metres in diameter and a little less in height, about 350 kg the Satellite, designed and built in India by ISRO is shortly to be placed in orbit around the Earth by a Soviet Rocket launcher.

2. In the talk I want to tell you something about the background how the Satellite project came about – how the Satellite was designed and what we hope to learn from it when it goes into outer space.

The Indian Space Programme began about 14 years ago when Dr. Homi Bhabha and Dr. Vikram Sarabhai recognised that our country with its excellent intellectual and natural resources could not afford to ignore the utilisation of the potential benefits from the spectacular and remarkable developments in Space Science & Technology. Thus the Thumba Equatorial Rocket Launching Station was established in 1963 to explore the upper atmosphere and ionosphere with sounding rockets. Such scientific studies have an important bearing on the understanding of meteorological and ionosphere phenomenon – both of which have relevance to our country's weather forecasting and radio-communications.

3. Since then our space activities have grown steadily and today we are well on the way to build our own rockets and satellites. The technology involved is very complex and

Reproduced from *Prof. S Dhawan's Articles, Papers and Lectures* (November 1966 to December 1994), (ISRO's Special Publication, July 1997) (Courtesy: ISRO, Bangalore)

demands a high degree of sophistication in a number of fields such as electronics, materials and chemicals, rocket propulsion, satellite technology, control and guidance system, etc. The chief objective of our programme is to make use of Space Science & Technology for national development. So we have selected to concentrate on those applications where satellites have a unique and specially large scale contribution to make. Specifically, these applications are in the areas of mass communications for the entire country, especially the rural areas, and in the survey and management of natural resources. Listeners are no doubt aware that the extension of telegraph, telephone, radio – not to speak of television facilities – to all parts of our country, especially the Duraland backward regions, are still a long way off. Similarly, to survey the forest, agricultural, soil and mineral wealth of even one state using conventional methods takes many years. One of the most remarkable things about Satellites is that they make it possible for communications to be established – virtually instantly – over vast areas of the globe. Also, cameras on space platforms looking down towards the earth can see virtually entire continents, detect land and water features, snow cover, cloud and storm movement and relay instantly the information to stations on the ground for practical use.

4. It is obvious that if we want to use satellites for such useful purpose we must be able to build them and place them in space. Here we come across some inherent difficulties – of technology, of resources and the like. To place a satellite into orbit one requires multistage rockets. These are not only extremely complex technologically but also expensive and, unfortunately, their military possibilities make everyone highly secretive. Thus we have to learn to do things the hard way, i.e., by ourselves. Of course, in the long run, this is not bad since it generates self-confidence and self-reliance – which in the final analysis are essential for any national task. On an analysis of the situation a few years ago we found that our scientist and engineers could design and build satellites earlier than the large rocket boosters necessary to launch them. This is especially so because the information on scientific satellites is more open and several of our scientists have been engaged in the study of advanced scientific subjects such as cosmic rays, X-ray, and radio astronomy and also because the relatively rapid strides that have been made in recent years in India in electronics. In comparison, information on rocket technology is much more restricted. Thus it came about that when in 1972 the USSR Academy of Sciences offered us assistances to launch an Indian made satellite with a Soviet rocket – the Indian Scientific Satellite Project came into being.

5. So much for the background – now a few words about how the satellite was built. The task was assigned to Prof U.R. Rao – of the Physical Research Laboratory in Ahmedabad. Prof. Rao also heads the Satellite Systems Divisions of the Vikram Sarabhai Space Centre in Trivandrum. Getting together a band of enthusiastic and bright young engineers, the Project enlisted the active cooperation of the Electronic and Aircraft establishments and Industries in Bangalore and was well on its way within six months of start.

6. A satellite has to operate under rather extreme envirormental conditions. In outer space there is practically hard vacuum with high temperatures when the sun's rays fall on the spacecraft and extreme cold when it is in the shadow of the earth. In order to ensure proper functioning of different instruments and sub-systems it is necessary to restrict the temperature changes inside the satellite to more moderate values. On the Indian Scientific Satellite this is achieved by passive thermal control system using special paints with the requisite emissivity and absorption characteristics. During the launch phase, the satellite and all its instruments and sub-systems are subjected to severe vibration and acceleration loads. In order to achieve high reliability every component of the satellite has to undergo a series of special tests. Some of the test facilities did not exist in India and the project team had to devise and build those along with the satellite itself.

7. The primary objectives of the Satellite Project were:

(1) To conduct worthwhile scientific experiments in space and

(2) To build indigenous capability in satellite technology.

The flight mode of the satellite – i.e., the one which will go into space, was preceded by the construction of several prototypes each with a definite objective to prove a particular aspect of the final design. Thus the mechanical prototype provided the shape, size and configuration of the structure – the multifaceted diamond shape. The mechanical prototype has also been tested for compatibility with the Soviet Rocket which will launch the satellite. The electrical prototype qualified all the electronic and electrical systems. These include the power supply which is a combination of Silicon Solar Cells and Nickel Cadmium batteries. The blue-violet silicon cells – there are some 18,500 of them – mounted on the outside surfaces directly convert the Sun's energy into electricity. During orbit when the satellite is eclipsed from the Sun by the Earth the

Nickel Cadmium batteries switch on and continue the supply of power – they get charged in turn when the satellite is in sunlight again. The electrical prototype has been flown at Sriharikota suspended from a helicopter to check out the compatibility of the telemetry and telecommand systems between the satellite and the ground station.

8. The satellite when launched is expected to be in a near circular orbit of 600 km height at an inclination of 51 to the equator. Each orbit around the earth will be completed in 93 minutes. The satellite will pass over India for about three orbits every day each orbit taking only a few minutes. In order to enhance the amount of data a tape recorder on the satellite will store the information over a longer period and then on command from the ground station at Sriharikota on the east coast of India near Madras, the information will be relayed rapidly – at 10 times the recording speed – to the ground.

9. In order that the satellite keeps its orientation in space a spin-up system keeps it rotating like a top. Moving through space the rotation of the satellite would gradually decrease because of magnetic fields and drag. Six spherical titanium bottles in the lower shell of the satellite filled with nitrogen at high pressure and connected to reaction jets – somewhat like a rotating lawn sprinkler – spin up the spacecraft periodically on command from the ground.

The orientation of the axis of the spinning satellite in orbit is determined by special sensors – two of these called magnetometers determine the direction of the earth's magnetic field – somewhat like a compass – and the third a Solar Sensor, measures the angle of the spin axis with respect to the Sun-Satellite line. The directions determined are accurate to about one degree.

10. There are three scientific experiments on the satellite. All three have been designed and built by Indian Scientists. The first experiment is on X-ray astronomy and is being conducted by Prof. U R Rao who also directs the Satellite project. This experiment will detect a measure X-radiation from stars in our galaxy known as the Milky Way. It will also seek information on X-ray sources outside the galaxy. With a bit of luck Prof. Rao hopes to find some new X-ray sources. The second scientific experiment on solar physics has been developed by Prof. Daniels and his group of the Tata Institute of Fundamental Research. This experiment is concerned with the processes that go on inside the Sun. In particular, the experiment aims to detect the emission of high energy neutrons and gamma-rays at times of violent solar activity called solar flares. The third scientific experiment, relating to Aeronomy, is being conducted by Prof. Satya Prakash

and his group of the Physical Research Laboratory using electron traps and ultraviolet detectors the experiments seek data on the heat balance in the ionosphere and particle flux and other information in the equatorial latitudes.

11. Once the satellite is in orbit the only link with it for receiving information is through the Ground Telemetry & Telecommand Stations. The main station at Sriharikota has a steerable antenna – called a Yagi Array – and equipment for receiving the telemetry signals from the satellites, processing them and displaying them quickly from the state of health of the satellite can be judged. A tracking network gives the satellite position and its movement in orbit. From the station, radio commands can be transmitted to the satellite to carry out various operations. In all, 35 types of commands can be executed.

A second ground station has been set up near Moscow in cooperation with the Soviet Academy of Sciences. To further increase the data coverage a third telemetry station in Toulouse in France will receive data and send it to the Project team.

During the launch, and afterwards, information from the ground stations will be continuously flowing via communication links to Peenya where the Mission Control Centre of the project has been established. The critical phase of launch operations occurs in the period about a week before and about a week after the time of launching. During this period the engineers and scientists at the launching pad, the ground stations and the mission control centre have to be continuously in touch to exchange information and confirm that everything on the satellite as well as on the rocket and the ground stations is in working order. The check lists run into literally hundreds of items. The Peenya Mission Control Center and the Launch Station in the USSR will be linked through direct links which will make two way telephone & teleprinter communication possible.

12. The flight model of the satellite and the ground stations are now complete and are undergoing the final round of checks and tests. In less than two months the satellite will be airlifted to a cosmodrome in the Soviet Union and another series of intensive tests conducted. The Indian Project Director and his Soviet counterpart will then set the precise date and time of launch and the first Indian Satellite will be in orbit around the earth – a culmination of intense effort by a dedicated team and an important step in India's effort at harnessing space for national development.

Jai Hind