CHALLENGE OF SPACE AND SPACE RESEARCH ACTIVITIES IN INDIA

By

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Until just a few years ago, man has been confined to the Earth. All that he has learned of the universe has come from observations and investigations rooted in his own planet. Nevertheless, he has learned much about the solar system, the Milky Way, and even about other galaxies far beyond. This truly remarkable body of knowledge of the universe, attained by astronomers over thousands of years, has depended largely upon light waves gathered by telescopes. In recent years these signals have been augmented by radio waves from the stars. But even so, man's window to the universe has been restricted to a thin slit of energies, for only about twenty octaves of nature's electromagnetic spectrum, ranging from the very long radio waves at one end to the very short gamma radiations at the other end.

Thus space tools open up challenging prospects to science, and these challenges are clear and compelling in the past, man has largely had immediately before him the small, finite Earth alone, along with its lower atmosphere, for direct investigation; he has now, in principle, an infinite volume of space and matter accessible to him. This new power to penetrate directly into the interplanetary medium and to reach other bodies in the solar system has a special meaning. It means a vast extension of opportunities for detection and observation above the Earth's interfering atmosphere. But even more, it means that man is now equipped to conduct experiments in contrast to making observations. The conduct of controlled experiments leads to deduction; the passive taking of observations only permits inference.

At the present time adventure and exploration are pursued by the man-in-space programmes of the Soviet Union and the United States. Although instruments carried through space can do a lot in understanding the phenomena occurring in outer space; or through inter-planetary medium, man himself can contribute much if he can travel in the space-craft. The ultimate exploration of the Moon and planets is being done by man. This means that at first experience must be gained step by step and orbiting of man round the Earth is the first of this long sequence of steps. There are three applications of artificial Earth satellites that appeal to the practical nature of man, communications, weather forecasting, and navigation. These applications call for no new principles in science, but they do call for a great deal of developmental and engineering activity, which is gained in the pursuit of space programme.

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Several meteorological satellites have been successfully launched and their data are in use not only in the United States but in many countries throughout the world. The prospect of detecting major storms early in their history and of following them has significant human values. Thousands of lives are taken annually by the caprices of weather and the loss of property runs into hundreds of millions. Weather satellites coupled with international warning services, could provide alerts so that human beings might take suitable protective measures. Ultimately, further research with storm and cloud cover data from satellites and related meteorological studies, both experimental and theoretical, may lead to a genuine understanding of weather and climate, to vastly more effective forecasting services, and perhaps to an amelioration by man himself of the destructive energies of major storms.

Geodetic satellites—the second significant area of space application—promise both research and applied values. As to the latter, navigation and surveying come closest to the immediate interests of mankind. In principle, satellite navigational systems could become common, universal methods for all forms of surface and air navigation, with accuracies even exceeding requirements. They could also be used for surveying over difficult terrain and for tying together most effectively the geodetic nets throughout the world. These same satellites will also, however, provide fundamental information on the size, shape and composition of the Earth, including further insights into its gravitational fields.

Intensive work is also under way on the development of communication satellites. In principle, satellites can multiply the quantity of long distance communications by a factor of perhaps 10,000. Satellites can contribute to many types of communications: telephony, long-range radio communications and perhaps ultimately even international T.V. An expansion of communication services had numerous implications.

The claims of adventure and exploration, as well as the claims of practical application are readily understandable and their appeal is almost universal. But what can be said about the claims of science in the space age? In brief, I would contend that the challenges of research dwarf adventure and application and stand unparalleled in man's history. Man has successfully landed on the Moon. But even before this, tremendous amount of effort was required for acquisition of new knowledge of space and its contents. This has been achieved by sending variety of instruments launched into space far beyond the confines of the Earth and these devices yielded significant insights. The incredible vastness of space and bulk of its content mean that unlimited horizons exist for research. During the interval the first satellite was launched into near space and the time man successfully landed on the moon, very significant results have been obtained of intrinsic interest and importance demonstrating the power of space tools in research.

The discovery of the Van Allen Radiation Belts, in which both satellites and deep space probes were used, stands as one of the great discoveries in the history of geophysics. The achievement entails not only the discovery of two vast region of space and of the particle population of these regions but also provides the basis for a unified description of variation of the Earth's magnetic field, the aurora, and solar particles in a much more realistic and exciting way.

The second achievement made possible by satellites relates to the shape of Earth. Here the first small Vanguard satellite has permitted to make detailed studies of its orbits. These findings resulted in the postulation of a "pear-shaped" model of the Earth. The apparent variation from the previous theoretical model is small even in comparison to the 21 km. difference between equatorial and polar radii, but it is extremely important in terms of the Earth's structure.

Satellites of both the USSR and the United States also provided valuable data on drag and density and on satellite environmental conditions—*e.g.*, temperatures. Soviet satellites, with transmissions at 20 and 40 megacycles, afford an opportunity for ionospheric studies when the receptions can be coupled with precise positional data. One of the most striking findings in the field of near-space structure relates to drag. Jacchia, in the United States, has established a correlation between the drag on a satellite and solar activity; the correlation between Vanguard I drag and (*a*) solar flux index at 10.7 cm wavelengths, and (*b*) magnetic activity index, is remarkable.

As the world has witnessed, successful landing on the Moon has been achieved by the efforts made by the United States. Thus, for the first time in history, man has shown the power to investigate other planets of the solar system and what he learns from this will be a significant addition to Man's total knowledge. The Moon was the appropriate object of study because it is tied so intimately to the Earth, in origin and history. Yet its surface layers have not weathered as have those of the Earth, and in them lie clues both to its and to the Earth's early history and development. It was once thought that although the surface of the Moon was uncongenial with temperatures of 100-124°C, and unprotected by an atmosphere from high-energy particles and the full spectrum of solar radiations, simple forms of life may exist beneath the surface or in cavities. Biologists were interested in such a possibility, an interest that argues strongly for a policy of protection against contamination of even the Moon.

Soft landing of instruments on the Moon permitted taking of photographs of surface details; the televised pictures of the Moon's surface gave some ideas of the material, X-ray analyses of the surface, hardness tests, detection of any magnetic substances, spectroscopic analyses of rocks, seismic and gravimetric determinations, etc., appeared feasible by instruments landed softly on the Moon. All these were accomplished in the erlier missions and finally with the Apollo 11, NASA landed man on the Moon. This historic Odyssey in 1969 which has been accomplished is well known the world appeared over.

The more distant planets pose problems for exploration which lie far in the future. Mars and Venus, however, are accessible by spacecraft, by one way or another, within this decade. The compositions, depth, densities, and temperature distribution of their atmospheres can be studied by space probes and planetary satellites.

Man's interest in the Sun is one of his oldest, but his knowledge of our nearest star is still fragmentary. Spectroscopy and atomic theory have lead to major advances during the last 80 years, providing quantitative knowledge of many aspects of the Sun, but much remains to be done. For example, the whole range of solar short-wave radiation—ultraviolet, X-rays and gamma rays—calls for measurements from beyond the interfering layers of the Earth's atmosphere.

As with the Sun, so too, with all stars: space tools will permit man to measure that part of the spectrum accessible only above the Earth's atmosphere. Invisible short-wave radiations can tell us much about the high-energy processes in stars and of the influence of very hot stars on interstellar gas around them.

Thus we see that the opportunities before science but also before mankind as a whole—are truly many and challenging. These opportunities exist not only in adventure and exploration, in application, but in the pursuit of new knowledge about the universe. These opportunities are not restricted only to those nations having capability of launching satellites and space probes. This fact—that only two nations are engaged in such launchings—appears on surface restrictive but it is not fully so. For one thing, space researches themselves increase the interests in potentialities of research on Earth in such fields as planetary astronomy and the physics and chemistry of the upper atmosphere. Second, the increased use of baloons and rockets for studies above the masking layers of the atmosphere represents a very large area of activity that merits support by many more nations. Third, much of the data from satellites and space probes can be acquired, either directly or indirectly, by scientists everywhere and turned to their own analytic and research purposes. Fourth, experimental ideas and experiments themselves, conceived and developed by scientists elsewhere, have good prospcts of realisation in the space programme.

The scientific study of meteorology and of the variations in the earth's magnetism were started more than a century ago in India. It is now over 100 years ago the British Scientist Allan Broun, with Indian assistants, made his important contribution to geomagnetism (J. Allan Broun, F.R.S., was the Director of the Trivandrum Observatory from 1852 to 1865 and made some fundamental contributions to geomagnetism by his work on the diurnal variations of the magnetic declination at Trivandrum near the magnetic equator). With a long established tradition of research in meteorology, ionospheric physics, geomagnetism, cosmic rays, astrophysics and solar physics, India has a good scientific base and a deep interest in the exploration of outer space.

In April 1962, Indian Natinal Committee for Space Research was constituted by the Department of Atomic Energy (DAE), Government of India, for the promotion of space research and international co-operation in exploration of space for peaceful purposes.

Thumba Equatorial Rocket Launching Station (TERLS)

In 1963, an Equatorial Rocket Launching Station was established at Thumba, near Trivandrum, which lies practically on the magnetic equator and on the West Coast of India. The main objective was to carry out scientific studies of the upper atmosphere in equatorial regions, from 30 to 200 km. altitude, using sounding rockets. With the active assistance and co-operation from France, USA and USSR, the TERLS became operational on November 21, 1963, when the first sounding rocket carrying a scientific payload was successfully launched from Thumba. TERLS has received UN sponsorship as an international range and was dedicated to the UN by the Prime Minister of India on 2nd February 1968. Bilateral agreements between India and many countries were drawn up providing for international operation for carrying out scientific experiments from Thumba.

TERLS is now fully equipped as an international facility, to carry out rocket experiments. The facilities provided include vehicle and payload assembly, testing and check-out, ground support including radar tracking, telemetry, a DOVAP and an

AN/GMD-I equipment, range safety and met. Support, range timing, telephone and radio communications, and range clearance equipments like, helicopter and sea vessel. At TELS, certain ground based experiments are also provided as back-up for the rocket experiments. These include measurement of ionospheric drifts, recording of ionograms using an automatic ionospheric recorder, measurement of cosmic radio noise absorption by riometer technique and measurements of total electron content in the ionosphere by recording the Faraday fading of Beacon Satellite signals and a magnetometer. Shortly a back-scatter experiment is being added.

Since its nception Thumba has carried out 120 rocket experiments using single and two stage rockets like Judi-Dart, Nike-Apache, Centaure (French) and boosted ARCAS, in addition to a number of Rohini rockets. These experiments have been designed and carried out from Thumba for the study of the dynamics and composition of the upper atmosphere in the equatorial latitudes. The payloads include vapour cloud to measure winds in the neutral atmosphere using sodium, trimethyl aluminium and barium techniques; electron-ion probes and plasma noise probes for study of the nature of the ionosphere; UV detectors and ion-mass spectrometers to measure the composition of the ionosphere; proton precision magnetometers to investigate the electro-jet; X-Ray astronomy payload for measurement of X-Ray flux emanated from distant stars like Scorpio, Centaurus, Crab, etc., in the celestial sky, and chaff to measure winds in the mesosphere.

Experimental Satellite Communications Earth Station (ESCES)

To enable India to gain competence in global satellite communications, the Experimental Satellite Communications Earth Station has been established at Ahmedabad by INCOSPAR with assistance from the UN Special Fund. An important objective of ESCES is to train scientists and engineers of India and of other developing countries to enable them to make use of satellite communications. A modest beginning in space communication was made in late August 1967 when ESCES successfully transmitted and received messages and television pictures from NASA's ATS-2 satellite and established contact with Japan.

Space Science and Technology Centre (SSTC)

In 1965, the Atomic Energy Commission approved a proposal of INCOSPAR to establish a Space Science and Technology Centre with major responsibility for development of sounding rockets of superior performance and for acquiring expertise in aerospace engineering and scientific payload construction for rockets and satellites. The Centre was also to provide back-up support to space research through ground-based experiments. The Space Science and Technology Centre (SSTC) has been set up at Veli Hill, by the side of TERLS. A large group of engineers has been engaged at the SSTC to work in different disciplines of rocket technology such as propellant engineering, propulsion, structural engineering, aerodynamics, materials engineering and quality control, control and guidance, technical physics, electronics, mechanical and systems engineering. The first India-made rocket of the Rohini RH-75 series was successfully flight-tested in November 1967.

Rocket Manufacture in India

To establish rocket manufacture in India, the Department of Atomic Energy has set up in 1967 a Rocket Propellant Plant (RPP), at Thumba, for manufacture of the propellant required for the French Centaure two-stage sounding rockets under licence from M/s. Sud Aviation of France. This plant will be able to take up manufacture of large size propellant charges for indigenous rockets being developed in SSTC.

A Rocket Fabrication Facility (RFF), which can undertake manufacture of hardware for various types of rockets has been approved by the Automic Energy Commission, and will be set up at Thumba, near TERLS. This will be commissioned by January 1971.

Radio Astronomy

Scientists of PRL and other scientific institutions in India are engaged on development of scientific payloads to carry out rocket experiments from Thumba. In addition, scientists from France, USA, USSR, West Germany, Japan and UK have already participated in collaborative programmes with India under bilateral agreements and experiments have been successfully carried out from Thumba.

Future Plan

India proposes to set up another rocket launching station on the East Coast. This facility will be used in the initial stages to prove the indigenous rockets and ultimately have a capability for launching satellites.

A preliminary feasibility study of developing a modest scientific satellite is being worked out.

Satellite television can be a very powerful tool of mass communication and for promoting national integration. Its use for popularising agricultural productivity, in promoting general education and disseminating information about population control is of great significance. To demonstrate convincingly the relative advantages of this system, a pilot project was jointly undertaken in January 1967 by the Department of Atomic Energy, the All India Radio, the Indian Agricultural Research Institute and the Delhi Administration and the experiment was successful.

A satellite Communication Project on a national basis is being actively considered and a study group of engineers has been formed to go into the details.